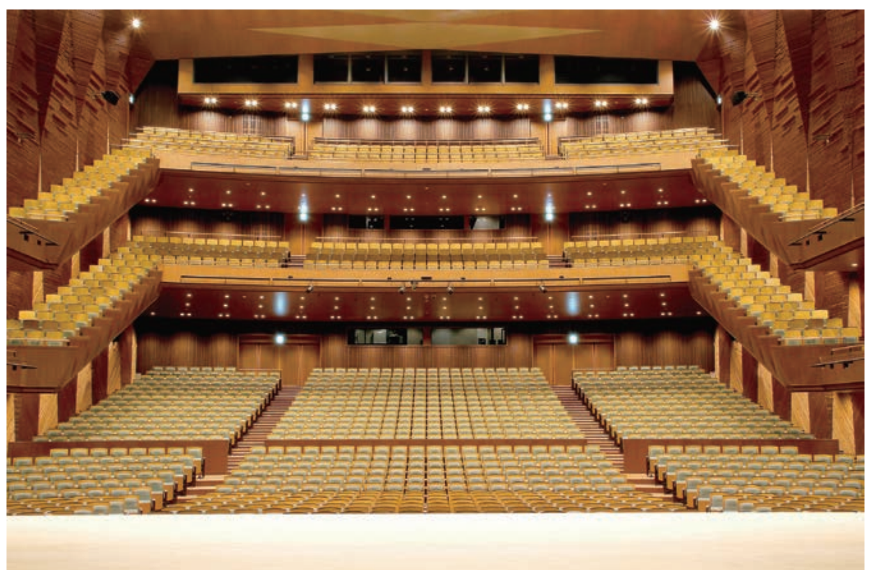

KYB Corporation

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CONTENTS

(**Cover Photograph**: Aim for Gold Medal in 2018 Pyeongchang Paralympics [see p. 55, 56], Theater Equipment Operation System [see p. 17])

Foreword

Application of Fluid Power to Robot Systems

KAWASHIMA Kenji*

Nowadays, many people are probably under the impression that fluid power systems are being replaced by electric systems. However, the robot industry, which is regaining attention due to aspects such as a decreasing birthrate and aging population, is experiencing a phenomenon that we can call the "revival hit" of fluid power.

The U.S. venture company Boston Dynamics' quadrupedal robot "Big Dog", the video of which was released in 2008, is a famous robot that surprised robot researchers. The robot is controlled by a hydraulic servo and moves like a real animal. Its movements feel almost eerie. It is known that we experience such feelings when robot movements become too close to organisms. This is a fine example that fully demonstrates the attractions of hydraulic servo control, such as its great output. I think the streamlining and miniaturization of factors, such as valves and pumps, have also greatly contributed to this trend.

In recent years, the "Tough Robotics Challenge" program has been implemented in the Impulsing Paradigm Change through Disruptive Technologies Program (ImPACT), which is a large-scale national project [Note 1]. Its objective is to develop robots that can undertake difficult work in disaster-affected areas. The Robotics and Mechatronics Conference 2016 (sponsored by the Robotics and Mechatronics Division, The Japan Society of Mechanical Engineers), which is the largest academic conference in the field of robots, was held in Yokohama in June. An ImPACT session was held, and a number of presentations were given on hydraulic drive robot research and development cases.

Furthermore, research and development in the field of "soft robotics", which has softness that is highly compatible with humans, is becoming more popular than robots that consist of conventional rigid bodies. In this field, the roles of fluid power – especially pneumatic drive – are growing. The aforementioned academic conference also held a session on fluid power robotics, and a number of robot research cases using pneumatic actuators were presented. Research using pneumatic rubber artificial muscles is especially increasing.

Research and development of technologies that are applied to robots, which support human movements, are especially active. One of the famous domestic examples is the muscle suit, which Professor Hiroshi Kobayashi and others at Tokyo University of Science have commercialized through a venture company [Note 2]. This robot assists the lower back area of people make lifting movements, and its practical use is being promoted in the field of nursing care, etc.

Overseas, researchers at Harvard University and other organizations have established the "Soft Robotics Toolkit" website to build soft robots [Note 3]. I expect that this is largely influenced by the fact that 3D printers have become more popular, enabling users to easily produce molds. Active research, such as the results of Harvard University [Note 4] that were featured in the scientific magazine "Science", is being promoted

The authors promote research and development to apply robots, which utilize pneumatic drives, to medical fields. They have commercialized a robot arm to maintain and operate endoscopes in minimally invasive surgery [Note 5]. This system uses a gyro sensor, which is attached to the operator's head, and the arm moves in conjunction with the head movements. It controls four degrees of freedom through direct drive without a gear reducer, due to the soft pneumatic actuator and relatively large force.

This direct drive is quite attractive as an actuator for robots. Possessing back-drivability to directly project the external force information to the pressure on the drive is critical when collaborating with humans or in terms of robot safety, which is connected to humans. Not having the risk of damaging the gear reducer due to spontaneous shock, etc., is a great advantage for robots in extreme environments.

We hope that application and deployment of fluid power systems will accelerate in the robot industry in the future.

Note 1) http://www.jst.go.jp/impact/program/07.html
Note 2) http://innophys.jp/
Note 3) http://softroboticstoolkit.com/
Note 4) Stephen A. et.al., Camouflage and Display for Soft Machines, Science, (Aug. 2012).
Note 5) HARAGUCHI Daisuke et.al., Robot arm for endoscope, Hydraulics & Pneumatics, Vol. 55, No. 3, pp. 18-22 (2016)

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Essay

Pied kingfisher

Gujarat Natural Life Story Vol. 2: Birds

ISHIKAWA Teruyuki

White-throated kingfisher

1. Introduction

In the previous volume, I introduced animals seen in Vadodara City, Gujarat and the surrounding area in west India, where KYB-Conmat Pvt. Ltd. is located. In this volume, I would like to introduce some of about 90 species of birds I saw in the area. Before that, I would like to write about two events that occurred after submitting the article on animals.

The first one occurred while I was in a company-owned car on a national road. A herd of cows was moving along the road. Suddenly, one of them made a dash for me. Driver hit the brakes, but it was too late, and the car crashed into the cow. The bonnet was dented. Fortunately, both the driver and I weren't injured and the cow also seemed all right as it stood up immediately. I have had a few car and minor motorcycle accidents in the past three years, but this was the first experience in India.

The second one was witnessing a wild cat, the "Caracal," which can jump more than two meters into the air, during a bird-watching trip in the suburbs of Ahmedabad. And I could see "Nilgai" near Vadodara (Photo 1).

Photo 1 Caracal and nilgai

2. Birds

2.1 Coppersmith Barbet (Megalaima haemacephala)

The coppersmith barbet is a short, stocky bird, about the size of a sparrow, with a crimson forehead and breast. Its body is colorful and bright. The bird is known for its persistent and metronomic "tuk tuk tuk" call that has been likened to a coppersmith striking metal with a hammer.

I am most familiar with this bird among many birds. At dawn, a coppersmith barbet used to peck at the glass window of my bedroom. It might have been alarmed at the reflection of itself in the glass and tried to attack it. It put on a mischievous face when it sat on the windowsill and peeked at me, but made a surprisingly stern face when it gave a big yawn.

Photo 2 Coppersmith barbet giving a big yawn

Photo 3 Coppersmith barbet pecking at the glass

I enjoyed the bird's visit every day between February and August. Then it only came after longer intervals. Although I moaned about its noise and droppings, I found myself waiting for the next visit.

One Sunday evening, I heard a loud crash from my bedroom. I found the coppersmith lying on the balcony, bleeding from the mouth and anus. Its mouth was open and twitching its stomach. Apparently, it had smashed into the glass, and looked in pain (Photo 4).

I was afraid that it was going to die. Twenty minutes later, however, it got up, and after another ten minutes or so flew off. The coppersmith hasn't come back since. I hope it got better and is still alive.

Photo 4 Breathless coppersmith barbet

One morning at the end of October, when the sky was blue and the temperature was nice and cool, I heard repeated hiccups. It was a young bird on an electric wire trying to chatter, struggling to make the right sound. I wished the bird that was unconscious on my balcony had come back.

2.2 Indian Silverbill (Euodice malabarica)

This bird was born on the balcony of my colleague who lived downstairs. There was an awning on his balcony and a nest was made on the loose part where the baby birds hatched. These baby birds visited my room upstairs. They look simple, but are adorable.

Photo 5 Baby birds sitting on the sash of a glass window

2.3 Red-vented bulbul (Pycnonotus cafer)

This type of bird can often be seen in the city center, suburbs, and fields. It has a black head and the crest looks like a hood. The name is derived from the red undertail covert. While Japanese bulbuls chatter cheerfully and loudly, these bulbuls make charming sounds at dawn.

Photo 6 Happy red-vented bulbul couple

2.4 House crow (Corvus splendens)

In India, there are many small house crows with gray necks and chests. Black crows can also be seen. They are probably jungle crows and are smaller than Japanese ones. They are similar to Japanese jungle crows in that they have a menacing look when their haws are closed and often bother black kites and other birds.

Photo 7 House crows

Photo 8 House crows (left) bothering an Indian pond heron (right)

2.5 Jungle babbler (Turdoides striata)

The jungle babbler is a member of the family Leiothrichidae. It is a domesticated bird and the number is increasing in Japan. They live in flocks and have no regard for others, making loud noises. They are not scared of people. Their skipping gives me the impression of them being lightweight, while their eyes are dreadful. I have an antipathy against this bird as it drives other birds out.

Photo 9 Jungle babblers chattering loudly in a flock

2.6 Indian pond heron (Ardeola grayii)

Many types of herons can be seen in Japan, except Indian pond heron. They look plain and undistinguishable from the ground. When they are flying in the sky, their white wings are noticeable.

Photo 10 Indian pond heron flying through the air

2.7 Red avadavat (Amandava amandava)

Ajwa Lake in Vadodara is a large reservoir located 25 km east of the town. It is the water source of the Vishwamitri River that runs through the town and is where crocodiles live. Some also live in the lake. There is a marsh filled with cattail and pond lily in the south of the lake. Crocodiles may well live here. Tentatively, I tried to go to the bank of the canal. Flocks of weaverbirds and purple swamphens flew from the grass. Herons were watching their prey here and there. Swamphens were in the distance. On the further side, people were catching something from a small raft.

On the grass by the canal, I saw a deep red bird with white spots. It was the first time to see this species. It was elegant, pretty and beautiful. It looked to have the breeding plumage of male birds. A female bird nearby was grayish green and brown. Part of its feathers was red. This also looked elegant. As soon as I came home, I looked it up in an encyclopedia. It was a red avadavat. They are sold in bird shops in Japan. I didn't know this, but I vaguely remember that an album by Matsutoya Yumi had the same name.

This bird is native to India and other countries, and it was imported to Japan as a pet during the Edo Period. The binomial name is Amandava, which comes from the city of Ahmedabad from where this species was exported. The city is located about 100 km northwest of Vadodara and is the largest city in Gujarat. I am pleased that I could see this bird in a place I am familiar with. I wonder how this bird traveled over 6,000 km to Japan in the 18th century - by sea or on the back of camels by land. They might even have evolved. They must have a DNA connection with the red avadavat I saw today.

Photo 11 Red avadavat having a rest

2.8 Common hoopoe (Upupa epops)

Hoopoes can only be seen on rare occasions in Japan. If a hoopoe is found, the event is covered by the media. Its body is a beautiful light brown and the wings and lower body have black and white stripes. Its long beak and crown are eye-catching. Japanese name "Yatsugashira (means eight heads)" derives from occasionally standing its crests like unfolding a fan.

The Showa Emperor saw the bird when he was digging taro (Colocasia esculenta) in the field in the Imperial Palace. He asked the chamberlain to bring binoculars. The chamberlain didn't know why, and asked the Emperor "Why do you need binoculars to dig taro?" However, this is what you would expect of the Emperor as he was a biologist. It is unknown whether the name of taro that he was digging was "Yatugashira" (same as the Japanese name of common hoopoe). For the imperial family, the inlay of a hoopoe was used on some of the Shosoin Gyobutsu (items belonging to the Imperial family) biwas (lutes).

I was looking forward to seeing hoopoes as their habitat is spread throughout India. I could see them near Vadhavana Lake, a large agricultural reservoir located about 40 km southeast of Vadodara and 20 km east of KCPL. This is my favorite place. In winter, vast numbers of geese and ducks migrate here.

It was pecking the ground for worms with its long beak in the grass on the sloped bank of the pond. It is not so cautious but it won't open its crown so easily. Although it opens the crown for a brief second when it landed, it is difficult to capture the moment in a photo.

Photo 12 Hoopoe looking for worms in the ground

2.9 Indian roller (Coracias benghalensis)

I saw this bird in the fields around Vadhavana Lake. Once you see its bright blue wings and purple seen through the light brown neck feathers, you will fall in love with its beauty. It watches the ground while sitting on a favorite branch and will fly away when it finds a worm. It is not easily alarmed and often swoops down in front of you. I could not focus on it as it was too close. I came here again and again to find this bird and the hoopoe.

Photo 13 Indian roller flying through the air

2.10 Feral pigeon (Columba livia domestica)

You cannot fail to see these pigeons in Vadodara. They are the same species as the pigeons in Ueno Park. They flock on roofs, handrails and electric wires. In the street, they cluster around beans people bought from stalls. On the other hand, some are unscrupulous and go for beans directly from stalls. When I leave my windows open, they come inside the room and sit on the air conditioning unit or on a wing of the ceiling fan. When I send them away, they fly to the neighborhood roof. I get offended when they act as if they know me. When black kites appear in the air, the pigeons fly away. Although being scavengers, black kites are raptors. The pigeons need to escape.

Photo 14 Feral pigeons sitting on beans in a stall.

2.11 Spotted dove (Streptopelia chinensis)

Spotted doves and laughing doves are correspondent to turtle doves in Japan. Spotted doves have spots like deer on the neck instead of the black-and-white spots of turtle doves. Laughing doves are smaller and have darker brown bodies. Unlike feral pigeons, they don't have the cheek to come inside the room, and they have a soft colored body and sound.

Photo 15 Spotted dove resting on a branch of a drumstick tree

2.12 Asian koel (Eudynamys scolopaceus)

The male koel is black and about the size of a cuckoo. It has a grayish white beak and red eyes. The female koel has black and white spots all over her body. They make various sounds including a discouraging, mournful one at dawn, but my householder disliked its tone. They are the same species as cuckoos and are also brood-parasitic. Spotted doves were sitting on their eggs in an Ashoka bush. When the parent birds went away for a minute, a female koel flew in the nest. After a few dozen seconds, it flew away holding an egg in its beak. It laid an egg quickly and then took away a pigeon egg for fixing the original number of them in the nest.

Photo 16 Koel spitting out a large seed

2.13 Black-headed ibis (Threskiornis melanocephalus), red-naped ibis (Pseudibis papillosa), glossy ibis (Plegadis falcinellus)

The ibis seen in Japan is the Nipponia nippon. After they went extinct in the wild in Sado, ibis from China were bred artificially. Naturally bred ibis were seen this year. In Japan, they inhabited across the country until the 19th century. The same species is often seen in India now.

Photo 17 Black-headed ibis (left) and red-naped ibis (middle, right)

Photo 18 Flock of glossy ibises

The black-headed ibis— its Japanese name "Kurotoki" means "black ibis," its head is black, whereas the body is white; the red-naped ibis— its Japanese name "Aka-ashitoki" means red-legs ibis, the whole body is black, red at back of the head and reddish legs; and the glossy ibis— its Japanese name "buronzu-toki" means bronze ibis, whole of the body is blackish brown with a metal-like gloss. Their English names are simple but the Japanese names can cause misunderstandings. Many glossy ibis forage in flocks in the fields in winter. When they take to the air, it is a magnificent view.

2.14 Greater flamingo (Phoenicopterus roseus)

Although you might associate flamingos with Africa or tropical regions, they make their habitat in west India. I could see greater flamingos in the Thol Lake Bird Sanctuary located about 20 km west of Ahmedabad. The rose pink in their bodies is beautiful. They forage putting their head in water for a long time. I wonder if blood gets stuck in their heads.

Photo 19 Greater flamingos (left) and Ruddy shelducks

2.15 Demoiselle Crane (Grus virgo)

The sarus crane (Grus antigone), a resident bird, the common crane (Grus grus), a migrant bird, and the demoiselle crane (Anthropoides virgo) could be seen in India.

In the middle of March, a large flock of demoiselle cranes took to the air at the same time near Nalsalovar Lake, a registered wetland under the Ramsar Convention, located about 100 km northwest of Vadodara. They caught an updraft and flew up in a spiral. After a few minutes, they headed north in a complicated v-shaped formation. They were going over the Himalayas toward Tibet and Mongolia. The view was magnificent and filled my heart with joy.

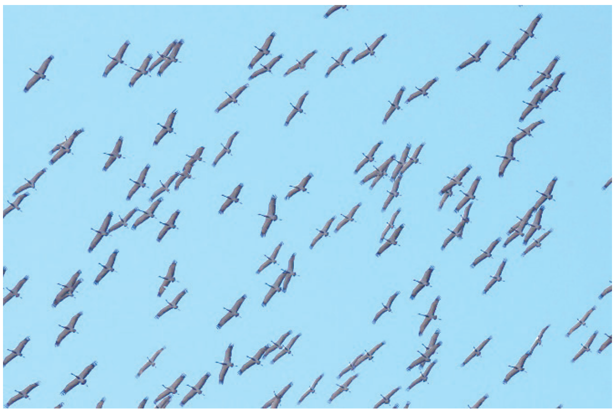

Photo 20 Demoiselle cranes going up in a spiral

2.16 Indian peafowl (Pavo cristatus)

The national bird of India is the Indian peafowl. In Japan, they are kept in zoos and parks, but in India, they can often be seen in fields, parks and golf courses. There are domestic peafowls in cages in zoos and wild peacocks on the grass outside Sayaji Baug Park. Male peacocks walk while swaying their beautiful tail feathers that look heavy. Many of them rest in trees.

After the breeding season, the tail feathers molt, and it temporarily looks embarrassing for the birds without tail feathers. I often see vendors selling bunches of feathers throughout the town. They must have collected the feathers that had fallen off.

Photo 21 Indian peafowl opening feathers

3. In Closing

As is usual, I have many stories mingled with feelings of joy and sorrow during my work abroad. I returned to Japan on May 4, 2016, ending my 3-year expatriate life. It was a pity that I could only observe birds in my 58 days of annual holiday, Sundays, a few public holidays, and short times in the mornings and evenings, but it was a highlight of my expatriate life.

This time, I felt that it was easy to gather information thanks to the Internet. I could immediately compare English and Japanese names. It was greater benefits of IT than 10 years ago. However, the quotes can be quoted, and original sources can be the same, and there could be many obvious mistakes. A good judge of users is required. Although it might sound paradoxical, even though I included photos, I recommend to go and see these birds – the impression is incomparable, as in the proverb “seeing is believing.”

I believe I took great care in writing the names of the birds; however, you may see some errors and misunderstandings. Your corrections are appreciated.

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Technology Explanation

Characteristics Prediction of Vane Pump by CFD Analysis

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WATANABE Hirohito, NAKAMURA Kazuhisa

Abstract

Due to the reduction in vehicle fuel consumption in recent years, a need has arisen for high-speed rotation and miniaturization of vane pumps for in-vehicle use. CFD analysis can be utilized as one effective tool for meeting higher performance requirements in pump design and development. In order to improve pump performance, it is important to precisely predict pump characteristics, such as the rotational speed/flow rate characteristic, and the internal pressure in the vane chamber. However, when a pump is driven at high rotational speed, prediction of pump characteristics is often difficult due to behavior of gases contained in the oil. A precise model for CFD analysis must be derived to capture the actual phenomena in the vane pump. Therefore, it is important to consider both the gases contained in the oil and the rotation movement of the vane chamber.

This paper reports on detailed measurements to confirm internal phenomena of the pump, and discusses the results of CFD analysis using a two phase homogeneous fluid model of gas-containing oil.

1 Introduction

In response to the increasing demand for improved fuel consumption of vehicles, needs to reduce the size of components, such as in-vehicle power steering systems and hydraulic vane pumps used in the CVT (Continuously Variable Transmission) system, are also increasing with the aim of reducing energy loss. Furthermore, higher rotating speed of the pump is also required in order to maintain pump characteristics. In light of this situation so far, we strive to enhance the characteristics in vane pump design and development by utilizing prototype evaluation [1] based on development experience and knowledge as well as CFD analysis. However, when a pump rotates at high speed, suction failures can easily occur due to steam caused by cavitation in the oil and the large amount of gases in oil, which is a unique requirement for the CVT system. In designing and developing of the vane pump, intricate modifications are required more than ever in, for example, oil flow design in suction channel in order to overcome such issues. It has reached the point in which such requirements cannot be met with conventional design technologies alone. Due to this, sophistication of CFD analysis technologies, such as prediction of the amount and behavior of gases in the hydraulic oil, is required in order to further improve pump characteristics. In recent CFD analysis, cavitation models [2] [3] have been developed that consider gases precipitation and dissipation as well as gas-liquid two-phase flow models that consider gases and fluid have been developed. These technologies are being implemented in CFD analysis software (ANSYS®/Fluent and PumpLinx®, for example) in the market. In addition, implementations of rotational movement of vane chamber, and prediction of the amount and behavior of gases, which are required in design and development, have also been available for practical use by advancement of commercial analysis software. These technological advancements utilize many research achievements and findings, such as basic observation on cavitation mechanism [4] and experimental verifications of CFD analysis accuracy [5] [6] [7] [8]. Currently no investigation, however, has been done that characteristics prediction of vane pumps with the premise that a large amount of gases is contained within hydraulic oil, nor experimental investigation of such conditions.

In this review, we would like to explain technologies that KYB as a pump manufacturer continues to develop with the aim of overcoming above mentioned issues. By focusing on when pump rotates at high speed, especially, we would like to introduce the CFD analysis of the amount and behavior of gases in hydraulic oil as well as experimental evaluation results on prediction accuracy of CFD. Finally, we would also like to mention our discussion on the relationship between gas behaviors in pumps and pump characteristics.

2 Comprehending Experimental Phenomena

2.1 Vane pump

The pump for the test is a balanced-type vane pump and its structure is shown in Fig. 1. The rotary parts of the pump are 12 vanes, a rotor, and a shaft. The 12 vanes and a rotor are located between two valve plates with some notches.

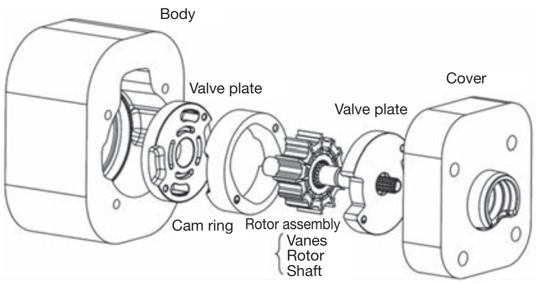


Fig. 1 Structure of the vane pump

2.2 Experiment circuit

As shown in Fig. 2, the hydraulic circuit used in the experiment is composed of the following three components.

(A) Circuit to measure the characteristics of the pump
(B) Circuit of gases mixing into oil inside the tank
(C) Circuit to measure the gas-injecting amount

Below is the explanation for these hydraulic circuits.

2.2.1 (A) Circuit to measure the characteristics of the trial pump

The characteristics between rotational speed and flow rate were measured with a volumetric flow meter installed on the pump delivery line, by using a servo motor to control the rotational speed of the pump. The oil temperature was that of oil inside the tank, and it was consistently controlled.

To measure the internal pressure in the vane chamber, pressure transducers was incorporated in the rotary parts, as shown in Photo 1. The lead wires from the pressure transducer are passed through a long narrow hole in the shaft, and then are connected onto the slip ring through the inside of the mechanical coupling (Fig. 3). Since the slip ring is a brush type, heat at the brush's rotational contact face is generated, causing a pressure measurement error due to change in electrical contact resistance. Therefore, we secured the measurement accuracy with preventing the heat generation during experiment by cooling down the temperature with air from an external blower.

2.2.2 (B) Circuit of gases mixing into oil in the tank

If gas is injected into the oil inside the tank, the gas in the oil do not instantly dissolve but remain as bubbles [4]. The bigger the bubble is, the more it tends to float due to

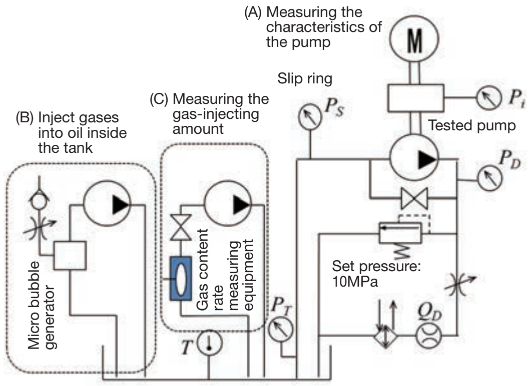


Fig. 2 Experimental hydraulic circuit

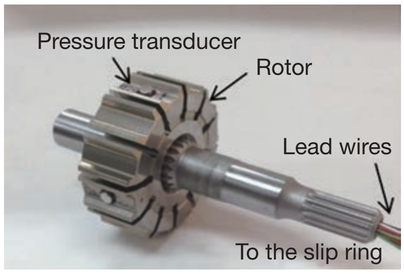


Photo 1 Pressure transducer for internal pressure measurement

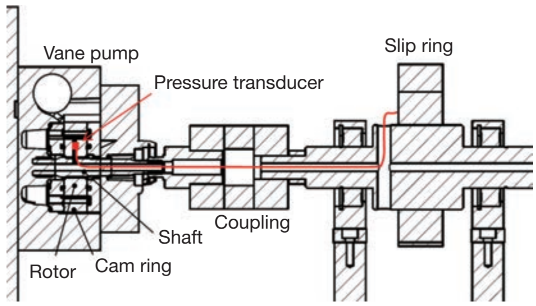


Fig. 3 Pressure transducer installation

buoyancy and dissipate toward atmosphere quickly. In the experiment, we therefore prepared a separate circulation circuit in order to retain bubbles within the oil in the tank and control a condition in which the bubbles are contained evenly. In this circuit, a micro bubble generator (bubble size: 10-30μm) was installed on the suction line of the circulation pump to inject micro bubbles in the oil. The amount of gas within oil (gas content rate) was adjusted with the amount of gas sent through the micro bubble generator. By breaking in the device prior to the experiment, we ensured that the gas content rate within the circuit was made consistent.

2.2.3 (C) Circuit to measure the mixed gas amount

The gas content rate is conventionally conducted by sampling oil from the tank with a syringe and measuring the gas volume with a measuring cylinder. However, using a syringe can cause gas precipitation and dissolution due to pressure changes, affecting the gas content rate.

Therefore, in this experiment, we measured the gas content rate in the tank on a real-time basis by connecting measuring equipment (Table 1), which can measure the gas content rate from oil impedance, to the hydraulic tank. This measuring method utilizes the fact that the sum of oil admittance Y_{OIL} and gas admittance Y_{GAS} in the sensor part is constantly conserved according to formula (1). Concerning the hydraulic oil actually used in the experiment, the relationship between temperature and Y_{GAS} as well as Y_{OIL} was conducted in advance, and then the gas content rate within the oil was calculated based on the conducted value.

$$Y_{OIL}+Y_{GAS}=\text{Const.} \qquad (1)$$

Table 1 Specifications of measuring equipment for gas content rate

Measurement range	0 to 100%
Reproducibility	+/-1%
Measured medium	Liquid
Temperature measurement	+/-0.1°C
Temperature range	20 to 180°C
Maximum pressure range	Maximum of 1 MPa

2.3 Experiment result (Rotation number-flow characteristics)

Fig. 4 shows the experimental result of characteristics between rotational speed and flow rate at an oil temperature of 55°C and delivery pressure of 2.5 MPa. The horizontal axis R is non-dimensionalized at the rotational speed R_{ref} when the flow rate is 5% less than the theoretical flow rate Q_{ref} against the measured rotational speed (Q_D = (1 -0.05) Q_{ref}). Vertical axis Q is non-dimensionalized at the theoretical flow rate Q_{ref} when the non-dimensional rotational speed R is 1.0 against the measured flow. The black line in the figure shows the experimental result when gas was not injected. The average value of gas content rate value was γ_0 (Details to be mentioned later). The green line shows the experimental result when gas was injected. The average value of gas content rate was γ_1. The dotted line is plotted the values obtained by subtracting the amount of contained gas from the theoretical flow rate of each gas content rate. Both the experimental results, when R is 1.0 or less, are slightly lower than each theoretical flow rate. This difference is occurred due to leakage with inside the pump. When R exceeds 1.0, however, the flow rate rapidly decreases. It is assumed that this is caused by lack of suction. Furthermore, the flow reduction of green line, when gas is injected, becomes greater.

Fig. 5 shows the experimental waveform of the gas content rate during the experiment. The fact that the gas content rate when gas isn't injected is γ_0 rather than 0% indicates that oil already contains gas in the normal state. On the other hand, the gas content rate when gas is injected was γ_1, which is approximately five times as much as γ_0.

Photo 2 shows the oil surface conditions of the tank during the experiment. In Photo (b), we can observe white microscopic gas in the oil as a result of gas being injected.

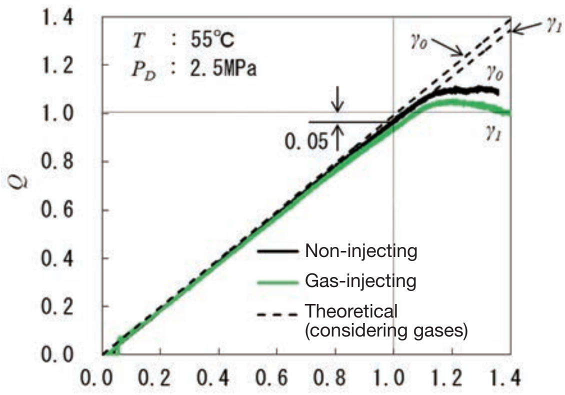


Fig. 4 Characteristics between rotational speed and flow rate

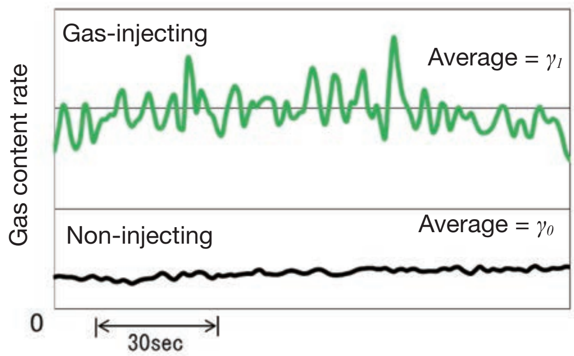
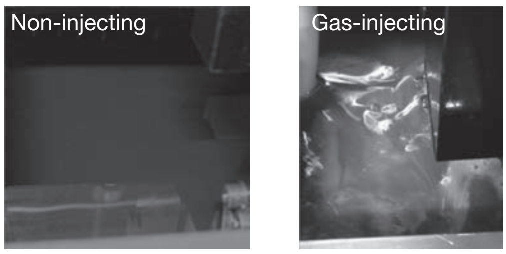


Fig. 5 Measurement results of gas content rate



(a) Gas content rate γ_0 (b) Gas content rate γ_1

Photo 2 Oil surface condition in the tank

2.4 Experiment result (internal pressure in the vane chamber)

Next, we focused on one vane chamber in the pump with a fixed rotational speed without gas injected (gas content rate = γ_0) and measured the internal pressure of a chamber from the suction process to the delivery process. Fig. 6 shows the result. When R is 1.0 or less, the change of internal pressure tends to be similar even though some difference in the composition of the pulsation. The internal pressure at R=1.2, however, does not rise even when the process transitions to the compression process after the suction process, indicating that the status inside of the vane chamber has changed compared to when *R* is 1.0 or less. It is assumed that cavitation vapor occurred due to the suction pressure decrease caused by high speed rotation and the gases in the oil simultaneously expanded, preventing a pressure rise with the compressibility of these gases.

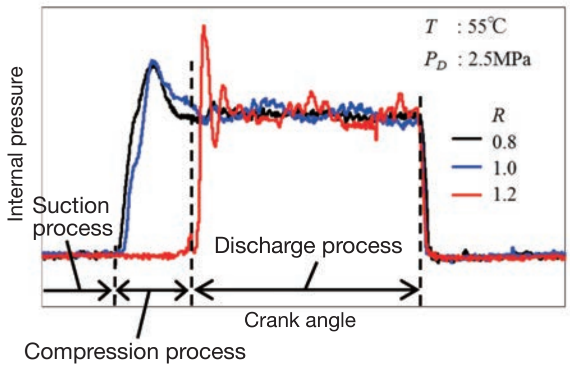


Fig. 6 Experimental results of internal pressure in vane chamber

3 CFD Analysis Technology

3.1 Conventional analysis technology (lumped constant model)

As a technology to predict the average of internal pressure in a vane chamber, we have developed a simulation tool [9) 10)] to predict the internal pressure of a vane pump by utilizing a lumped-parameter model. Prediction of the aforementioned experiment result based on this technology is as shown in Fig. 7. When we compare this to the experimental result in Fig. 6, we observe a great difference in the surge pressure when *R* is 1.2 (red line). Furthermore, pressure fluctuations in the delivery process are also not predicted. This is caused by the facts that it is difficult to determine gas behavior in the lumped-parameter model and that cavitation, which occurs in the vane chamber as mentioned in 2.4, cannot be predicted accurately. Therefore, predicting the internal pressure requires a CFD model that can high-accuracy simulate the gas behavior and status changes inside of the pump.

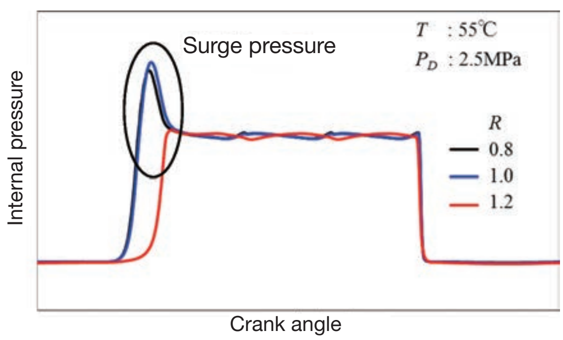


Fig. 7 Simulation results of internal pressure in vane chamber

Table 2 List of analysis setting

Fluid parameter			Unit
Oil	Temperature	55	°C
	Density	815	kg/m³
	Viscosity	0.0032	Pa/s
	Bulk modulus	1.52	GPa
	Vaporized pressure	400	Pa (Abs.)
Gas	Density	1.23	Kg/m³
	Viscosity	1.79×10-5	Pa/s
Boundary condition			
Entry pressure		0	MPa (Gage)
Discharge pressure		2.5	MPa (Gage)
Rotation number R		0.8 - 1.4	-
Mathematical model			
Two-phase flow		Homogeneous model	
Viscosity		Non-turbulent	
Cavitation		Singhal model	
Computational Grid			
Moving boundary		Sliding mesh method	
Vane chamber		Hexahedral grids	
Other		Tetrahedral grids	
Size of the smallest cell		1 x 10-5	m
Total number of cells		Approximately 3 million cells	
Calculation			
CPU (64bit PC)		E5-1650V3, 32GB RAM	
Time		2-4 days	

3.2 CFD analysis

For the CFD analysis, we utilized commercial software PumpLinx® (by Simerics). Table 2 shows a list of major analysis settings.

In this analysis, we handled two-phase flow as a homogeneous model by using the Singhal model to predict the cavitation. Furthermore, we also considered the rotational motion of the vane chamber in the unsteady analysis. Due to the fact that the grid shape changes along with rotation in this vane chamber model, we used hexahedral grids with the aim of reducing the calculation load and improving the analytical accuracy. Fig. 8 shows an example of computational grid using in the analysis. The number of the computational grids in this analysis was approximately three million cells, and the vane chamber covers approximately 30% of the overall cells. We also ensured accuracy by dividing finer the computational grids with a high rotational speed range.

3.3 CFD results (characteristics between rotational speed and flow rate)

The analysis model of CFD is the vane pump same as

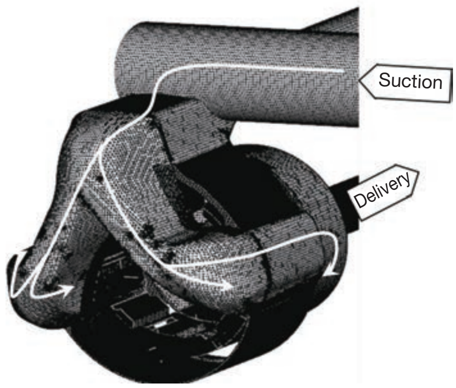


Fig. 8 Computational grids

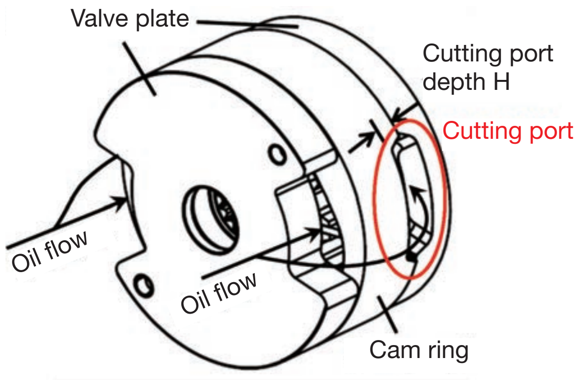


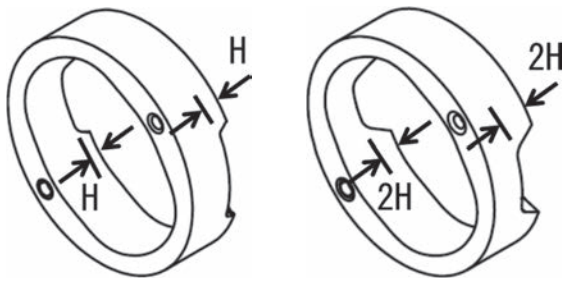
Fig. 9 Cutting port on cam ring

the experiment, indicated in Fig. 1. We used the cam ring cutting port (Fig. 9), which makes the oil channel to the vane chamber, as a parameter and compared the results. Cam ring without a cutting port is Type A, and two types of cam rings with a cutting port are Type B and Type C in Fig. 10. In addition, the depth of the cutting port is different between cam rings Type B and C. Type C's cutting port was twice as deep as Type B. We used these three cam rings and conducted a CFD analysis without gas injected in oil (gas content rate = γ_0) in order to obtain the per-rotation average of the delivery flow rate. With cam ring Type A, the CFD result without consideration for the cavitation model is plotted with outlined circles in Fig. 11. This is close to the dotted line, which expresses the theoretical flow without cavitation, and was not agreement with the experimental result (black line) in the high-speed rotation region. Therefore, we decided to conduct the analysis by considering the cavitation model next. As a result, we can see that the result drawn with black dots efficiently reproduces the experiment result, even with significant flow reduction when R is 1.0 or above.

In the same manner, the experiment/CFD result of cam rings Type B and C are individually shown in purple and orange. With these cam rings, the flow increased when R was 1 or above in the high-speed rotational region, compared to Type A. You can see that the CFD result was also predicted with high accuracy. In addition, the flow rate difference caused by cutting port depth was small both in the experimental result and in the CFD result.

Next, Fig. 12 shows the result in which gas was injected into oil (gas content rate = γ_1). The experimental result and CFD result were seen to be approximately the same in this case as well. With gas injected in oil, the effect of the cam ring became more obvious. A difference in the flow rate occurred (when R was 1.1 or above) due to be dependent on the cutting depth, which was not seen in Fig. 11. We can also see that the pump of Type C suctions more oil compared to the pump of Type B. As these results, you can see, CFD analysis with consideration of the cavitation model has enabled us to predict the experimental result with more accuracy with rotational speed-flow rate characteristics. Fig. 13 shows the flow prediction error

(a) Type A



(b) Type B (c) Type C

Fig. 10 Configurations of cam ring

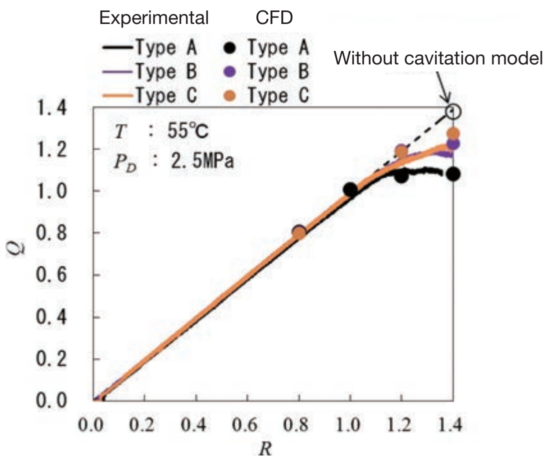


Fig. 11 Comparison of rotational speed-flow rate characteristics (Gas content rate γ_0)

with cam ring Type C when R is 1.4. Here, γ_2 is a gas content rate that is approximately 15 times more than γ_0. In each condition, the prediction was made with 5% or less error.

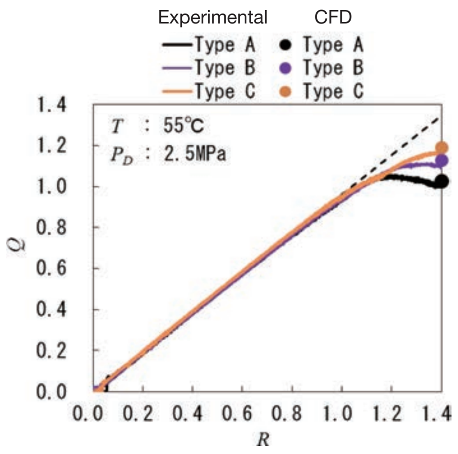


Fig. 12 Comparison of rotational speed-flow rate characteristics (Gas content rate γ_1)

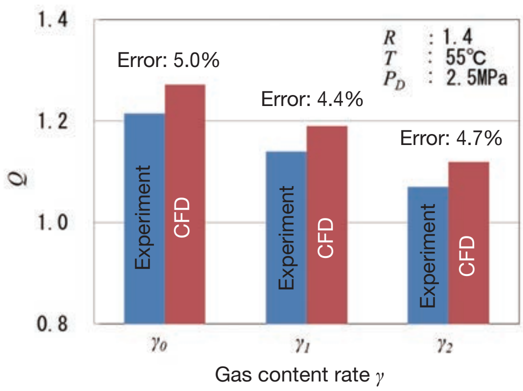


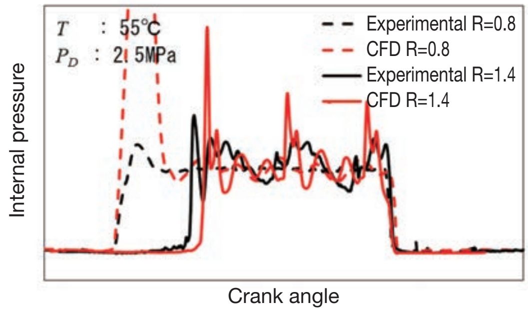
Fig. 13 Prediction error of flow rate by gas content rate

3.4 CFD results (internal pressure in the vane chamber)

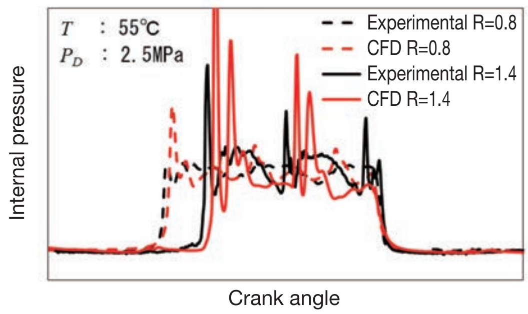
The comparison of the experimental result and CFD result on the internal pressure in the vane chamber is shown in Fig. 14. The cam ring used for the experiment and analysis was Type C. Fig. 14 (a) is when the gas content rate is γ_0, and (b) is when the gas content rate is γ_2. When the experimental result and CFD result are compared, the surge pressure is greater in the CFD result. This is due to the fact that the leakage amount within the pump was not considered. In an actual pump, pressure decreases due to oil leakage from clearance, such as the tip of the vane and rotor side. The surge pressure is greater in the CFD analysis compared to the experiment. On the other hand, the lag behind in the pressure rising point and pressure fluctuations are relatively noticeable in the same manner as the experimental result. The prediction accuracy is improved compared to the lumped-parameter simulation.

Next, the gas content rate in the analysis is displayed in a contour diagram (Fig. 15) to analyze the gas status in the vane chamber. The vaporized pressure of the oil is the isosurface in this contour diagram. Fig. 15 shows the CFD result of the internal status of the vane chamber when R is 1.4. Fig. 15 (a) uses cam ring Type B, and (b) uses Type C. The area shown in the contour diagram is the area when gases are occurred, and warm color areas represent greater gas content rates. We can see in the figure that gases (cavitation) are generated when the rotation is faster due to the fact that the vane movement speed increases and the pressure for suction port decreases in both (a) and (b). With cam ring Type B, oil is not sufficiently filled with the vane chamber due to lack of suction. This causes the internal pressure of the vane chamber to decrease, remaining large clouds of gases toward the back of the vane. As a result, the amount of filled oil decreases, especially in areas away from the suction port (middle of the vane chamber), reducing the suction amount of the pump. On the other hand, by increasing the depth of the cutting port in cam ring Type C, it becomes easier for oil to be filled into the vane chamber compared to Type B. We have discovered that this reduces the gas clouds toward the back of the vane, increasing the oil suction amount.

As you can see, CFD analysis has enabled us to analyze even the state of gases inside of vane chambers. We can now consider theoretical designs to increase the rotational speed.

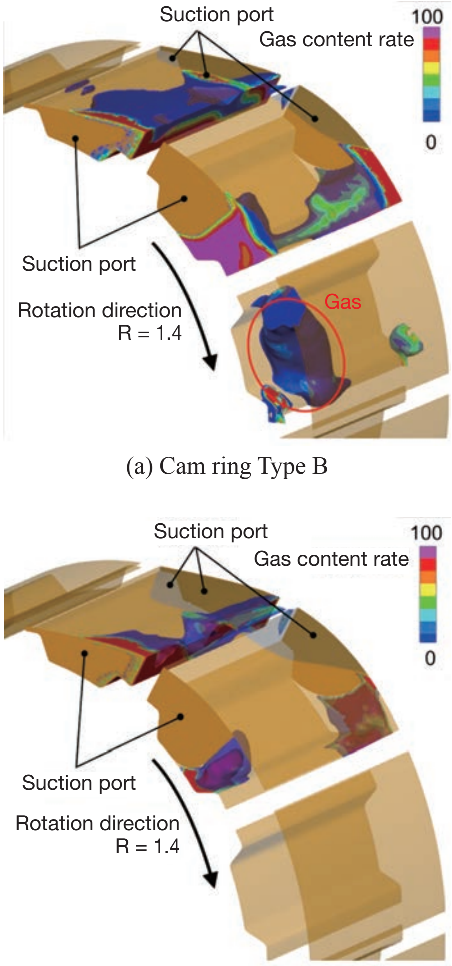


(a) Gas content rate: γ_0



(b) Gas content rate: γ_2

Fig. 14 Comparison of internal pressure in vane chamber



(a) Cam ring Type B

(b) Cam ring Type C

Fig. 15 Gas clouds in vane chamber

4 Concluding Remarks

In this review, we introduced our work with CFD analysis, including experimental verification, with the aim of improving vane pump performance by using the examples of rotational speed-flow rate characteristics and internal pressure of vane chamber.

Below are the results of these activities.

① We conducted a CFD analysis with consideration of gases in oil. This enabled us to conduct high-precision analysis on rotational speed-flow rate characteristics with 5% or less prediction error.

② We demonstrated in the experiment and analysis regarding vane chamber internal pressure that the pressure rising point is lagged behind as the pump rotational speed and gas content rate in oil increase.

③ We have discovered that the suction amount decreases due to the cavitation, which occurs in the suctioning process, and gases in the vane chamber during high-speed rotation.

In the future, we will promote the modeling of internal leakage in pump and parameters optimization of cavitation model in order to achieve higher accuracy on internal pressure prediction. In the future, we aim to contribute to the sophistication of vane pumps by applying the prediction technologies not only to driving torque but also quality characteristics, such as vibrations and noise.

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Product Introduction

Theater Equipment Operation System (K-compo SysteM)

SUZUKI Shinya

1 Introduction

Fig. 1 shows an overview of a theater. Around the time KAYABA SYSTEM MACHINERY entered the market of theater equipment in 1983, control of theater equipment, such as flying equipment and floor equipment, was starting to shift to computer control.

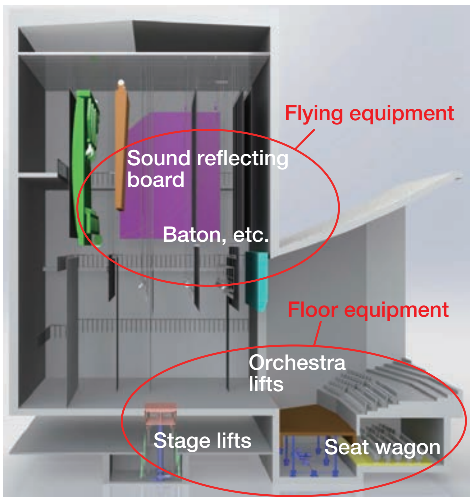

Fig. 1 Theater overview

KAYABA SYSTEM MACHINERY started with the operation system (1st generation), which was developed in 1993 for full-scale theaters, and has since developed the operation system "K-compo SysteM" (Photo 1), which

Photo 1 K-compo SysteM

can be called the 3rd generation system, after the 2nd generation system. In this review, I would like to introduce the overview of this operation system, which was introduced to the market in October 2014 in the Ueda Performing Arts & Cultural Center and has now been well received in three theaters, including Tokai City Arts Theatre (introduced in October 2015) and Nagano City Arts Center (introduced in May 2016).

We chose the registered trademark of "K-compo SysteM", which is reminiscent of the abbreviation (KSM) of our company name (KAYABA SYSTEM MACHINERY).

We are currently applying to register the exterior design.

2 Shifts in KSM's Theater Equipment Operation Systems and Background of Development

2.1 First generation (1993 – 2006): Dedicated operation system

This was the era in which theater equipment made a drastic leap as computer control was incorporated into theater equipment. Back then, dedicated operation systems were used for the theater equipment specifications of each theater (Photo 2).

Photo 2 First generation operation system (desk type)

2.2 Second generation (2007 – 2013): Mobile operation system

We have moved the reduced-size operation system to the stage side for safe operation of theater equipment and developed a mobile operation system that allows users to operate while checking the movements of theater equipment. In the 1st generation operation system, the manual operation Note 1) and program operation (CUE operation) Note 2) were integrated. In the 2nd generation operation system, we successfully reduced the size by separating the two components. We especially reduced the size of the manual operation component by aggregating the majority of operation equipment into the touch panel, making it portable. We also standardized the form so that the same operation system can be delivered to all theaters (Photo 3).

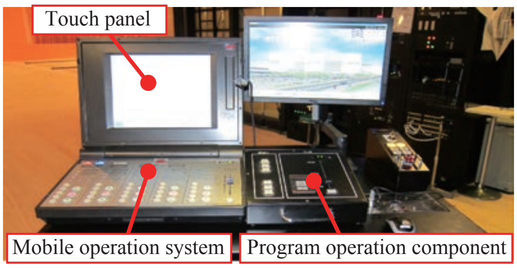

Photo 3 Second generation operation system (mobile operation system)

2.3 Third generation (2014 -): K-compo SysteM

The 2nd generation mobile operation system has the advantage of being compact and portable. However, due to the fact that it was made with molded resin, it could not respond to the needs of enlarging the screen to improve the performance. It also had the issue that it could not respond to customer needs, such as increasing operation features.

Furthermore, screen design and software were made for each theater, presenting the issue that we were unable to reduce the software production fee and inspection/calibration time.

In order to develop K-compo SysteM, we established the following three objectives to overcome the issues while maintaining the small size and form standardization, which were characteristics of the mobile operation system.

(1) Create a system that easily incorporates control technology advancement (enlarged screen and high-speed process enabled by CPU performance enhancement)

(2) Enable users to choose different combinations of feature variations for the operation component

(3) Make the basic software so that it can be standardized for all theaters

Note 1) Operation to select the equipment to move and raise or lower it. You sometimes enter the target position and specify the movement speed before operation.

Note 2) Operation in which you register the equipment to move, target position, and movement speed beforehand and initiate the movement by pressing the "GO" button at the desired timing

3 Overview of K-compo SysteM

3.1 System that allows different combinations of operation features

We have separated the "screen component" and "operation component" so that users can combine/add the operation components (modules) (Fig. 2).

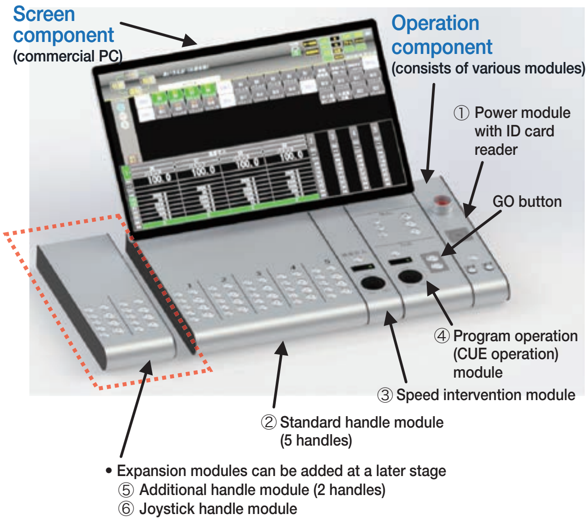

Fig. 2 K-compo SysteM structure

3.2 Screen component

While the screen of the mobile operation system (2nd generation) was 15 inches, we have made the screen 23 – 27 inches in order to improve the operability and visibility. We have enlarged the screen touch switches and used different colors so that each piece of equipment can be easily differentiated. We have also utilized commercial PCs to create a system that enables us to flexibly respond to changes, such as model changes, increased screen size due to technology advancement, and CPU performance enhancement.

Fig. 3 shows an example of the operation screen.

Fig. 3 Operation screen for K-compo SysteM

3.3 Operation component

With the "operation component", we organized/categorized operation features and turned the below operation features into modules.

① Power module (with ID card reader)
② Standard handle module (5 handles)
③ Speed intervention module
④ Program operation (CUE operation) module
⑤ Additional handle module (2 handles)
⑥ Joystick handle module

The main characteristic is that users can change module configuration or add expansion modules (additional handles/joystick) at a later stage depending on the theater size and customer needs.

Another advantage is that modules alone can be removed in case of failure, meaning that the whole system does not need to be repaired.

Below is an example of an additional handle module (2 handles), which has been added to the standard configuration (Photo 4).

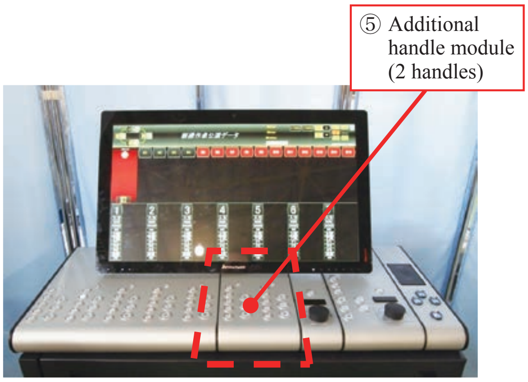

Photo 4 Example of the additional handle module

Fig. 4 Screen showing a list of theater settings

Fig. 5 18: Display color setting 1 (manual operation) screen

4 Standardization of Software

We have reviewed the operation methods and display methods, which used to be made for each theater. By turning the basic specifications and screen display methods into parameters, we have standardized these methods for all theaters.

By using 26 parameters for the number of equipment, specification differences, and type differences, a screen suitable for each theater can be created.

Below are three objectives of software standardization.

(1) Reduction of software production fee
(2) Improvement of software reliability
(3) Flexible setup changes after delivery by turning basic specifications and screen display specifications into parameters

Fig. 4 shows the screen showing a list of theater settings.

Fig. 5 shows the example of display color setting 1 (manual operation) screen for “18: Display color setting 1 (manual operation) screen theater setting”.

On this screen, you can change the color setting of buttons and characters on the screen.

5 Other Operation Features

5.1 Adding the operator recognition feature

The safety manager used to turn the power on/off for conventional operation systems by using a key. We have changed the key to an ID card and enhanced the security function by restricting the access. We have also added the login feature to the ID card to enable the management of “who used the system when”. Furthermore, we have made improvements to the ID card so that operation can be restricted according to the operator’s skills, such as “restriction of operable equipment”, “restriction of displayed screens”, and “restriction of operation of acoustic reflection boards”. (Fig. 6)

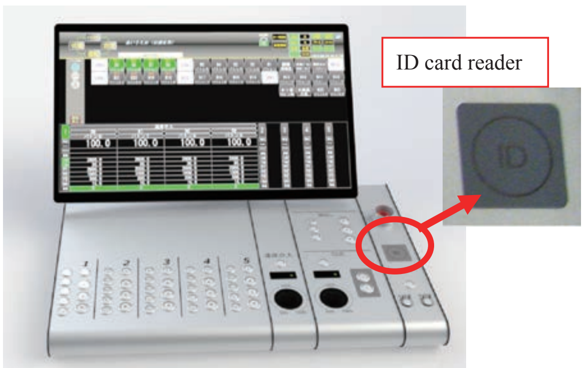

Fig. 6 ID card reader

5.2 Reviewing the sound reflection board operation method

Setup/storing operation of sound reflection boards needs to be done based on thorough understanding of their movements, as they are large pieces of equipment that move above the stage.

The steps of the operation of sound reflection boards from setup to storing are displayed, and the movements in each step are displayed in 3D images. We strived to make the operation safe and easy for operators (Fig. 7).

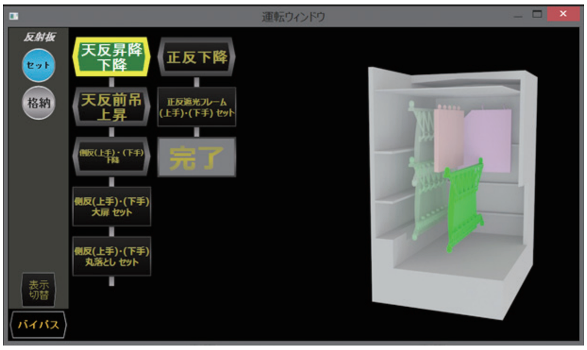

Fig. 7 Acoustic reflection board operation screen

5.3 Standard installation of program operation (CUE operation)

Program operation (CUE operation) was installed as a standard feature in order to smoothly carry out performances.

By registering performance data and operating the "GO" button, you can move the equipment, which you want to move in the particular scene, to the target position at the specified speed. The screen automatically switches to the next scene according to the progress of the performance. By repeating this operation, you can accurately move the equipment at the registered position/speed. "Cued operation [Note 3)]", in anticipation for rehearsals, is also installed as a standard feature.

5.4 Adding expansion monitors

In order to be able to see various types of information at once, many customers have the needs to enlarge the display screens. Due to this, we have decided to employ the system that enables people to add monitors (Photo 5).

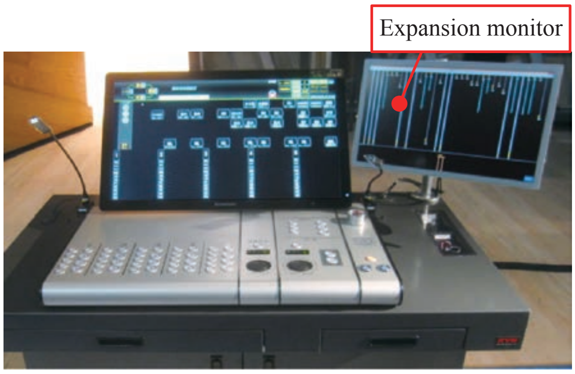

Photo 5 Example of an additional expansion monitor

Expansion monitors can display the current position, cross-section, failure history, interlock, etc.

Note 3) Operation to move the equipment to the target position in the previous scene when you specify from which scene to start the rehearsal in preparation for a performance

6 In Closing

The idea to build the operation component by combining operation function modules was unprecedented not only in Japan but also overseas. We take pride in the fact that our theater equipment operation system became a unique system.

We hope to be able to offer detailed services in the future by increasing module types and improving the operability by upgrading software.

We hope that the K-compo SysteM will be utilized in a number of theaters and become a standard operation system in this industry.

Finally, I would like to mention that many theater-related people have given us valuable advice and cooperation when developing this K-compo SysteM, and I would like to take this opportunity to express my deepest gratitude to everyone.

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Product Introduction

Track Motor for 7-9-ton Excavators, MAG-50VP-1100

KAWABATA Kaori, MATSUZAKA Keita, SAKAI Yuki

1 Introduction

In recent years, excavator weight has tended to increase due to operability enhancement and additional functions. In the market, needs for traveling and running-through performance have been increasing, leading to increased needs for higher-output torque of hydraulic motors for traveling.

In this review, we would like to introduce the characteristics/structure/specifications of the Track Motor for 7-9-ton Excavators, the MAG-50VP-1100 series.

2 Overview of the Product

2.1 Internal structure of the product

This product is a hydraulic motor with a gear reducer with a rotational case for crawlers. The KYB product lineup is shown in Fig. 1. The output torque (8.83 kN·m) of the conventional product (MAG-50VP-900 series) cannot respond to the torque required by excavator manufacturers (approximately 10 kN·m). Therefore, we urgently needed to develop this product (MAG-50VP-1100 series) with higher-output torque based on the conventional product.

Applicable vehicle weight (t) 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0	Model	Maximum output torque (kN·m)
	MAG-12V-120	1.18
	MAG-18V-230	2.16
	MAG-18V-350	3.14
	MAG-26V-400	3.92
	MAG-33V-650	6.37
	MAG-50V-900	8.83
MAG-50VP-1100	MAG-50VP-1100	10.8

Applicable vehicle weight (t) 10 15 20 25 30 35 40 40 and above	Model	Maximum output torque (kN·m)
	MAG-85VP-1800	17.7
	MAG-85VP-2400	23.5
	MAG-170VP-3800	36.8
	MAG-180VP-6000	56.0
	MSF-340VP	1.58 (Motor alone)

Fig. 1 Product lineup for track motors

The appearance of this product is as shown in Fig. 2. The internal structure of the track motor consists of the control valve component, swashplate-type piston motor component, and gear reducer, as Fig. 3 shows.

Fig. 2 Appearance of MAG-50VP-1100

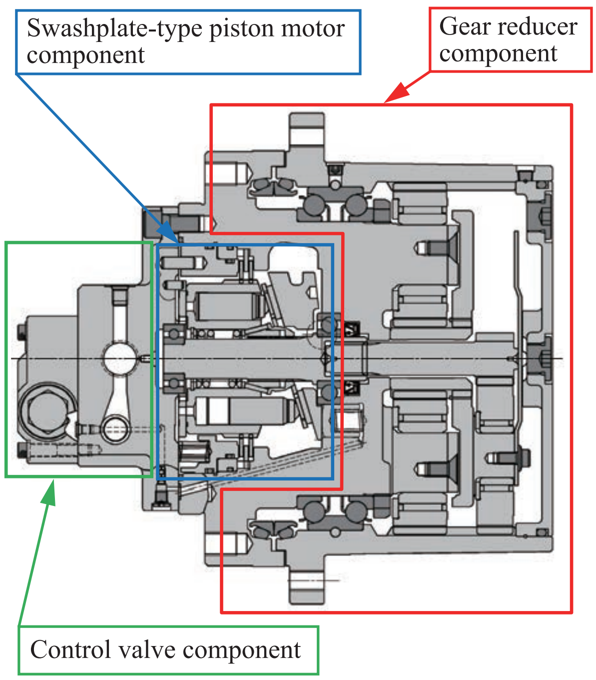

Fig. 3 Cross-section of a track motor

2.2 Main characteristics

Below are the main characteristics of our traveling motor.

① This motor with a rotational case was specially designed to be optimal for a crawler drive. Its compact design fits within the crawler width.

② We achieved that the running-through performance (=high output) required in excavators by utilizing a case rotation type simple planetary reduction gear and hydraulic piston motor.

③ It comes with a runaway-prevention mechanism for downhill traveling with a counter-balance valve.

④ It comes with a shifting system for transport mode and traction mode. An automatic shifting system, which detects the load and shifts to the traction mode in case of a heavy load, is also available. The transport mode and traction mode enable high-speed transportation up to twice the speed with the same flow by utilizing the shifting system.

⑤ Depending on the working condition of excavators, operability and retention performance on angled surfaces are required. With the parking brake feature, users can operate/park on slope. In addition, some areas control the parking brake feature.

3 Tasks to Increase Output

The gear reducer component must be strengthened in order to increase the output of track motors. Reinforcing the weak points with the existing method would result in the size being too large. The outer dimension comparison with the existing product is as shown in Fig. 4.

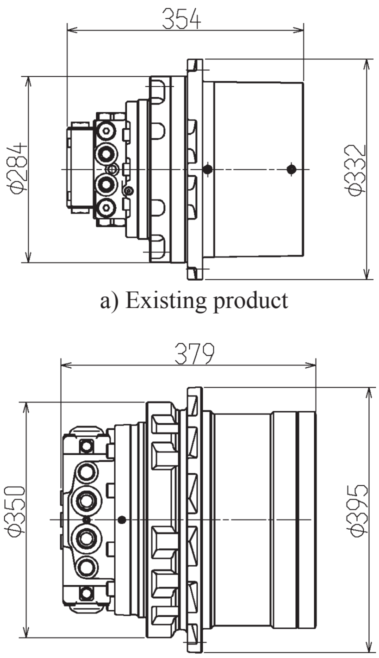

Fig. 4 Comparison of outer dimensions

One of the excavator manufacturers' requirements is maintenance of interchangeability with the existing product that allows the new product to be mounted on the existing unit. Therefore, it required "higher output" without changing the fit diameter on the vehicle side and the fit diameter on the output side that are shown in Fig. 5.

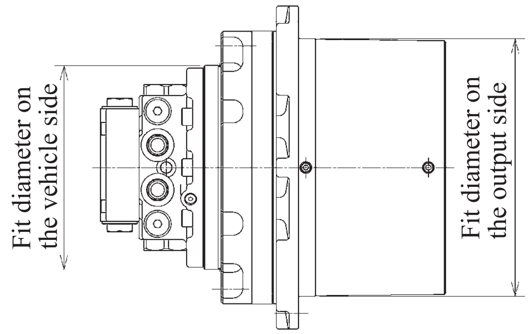

Fig. 5 Fit diameter for verticle mounting

4 Specification Target of This Product

Fig. 6 shows the distribution of the output torque required by mother machine manufacturers and vehicle weight. Excavator mass has been on an upward trend due to the enhancement of excavator work efficiency. As a result, output torque required by mother machine manufacturers has also been on an upward trend.

With this MAG-50VP-1100, we aimed to increase the output torque by at least approximately 20% compared to the current product without changing the mounting dimensions of the current product, based on the trend of the future market.

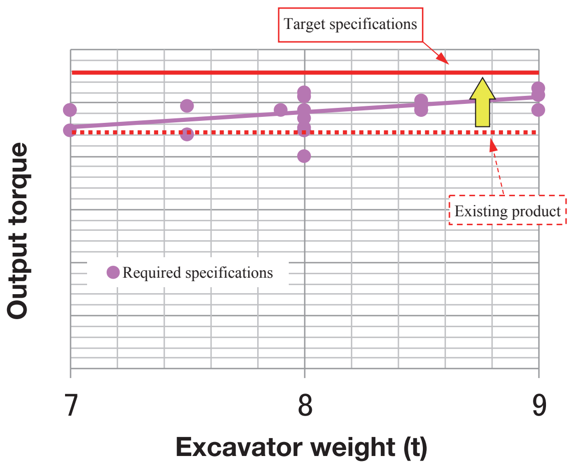

Fig. 6 Output torque required by 7-9-ton excavator manufacturers and excavator weight

5 Development Technology for Higher Output

5.1 Principle of gear reducer functions

Let us explain the principle of how a case rotation type simple planetary reduction gear works.

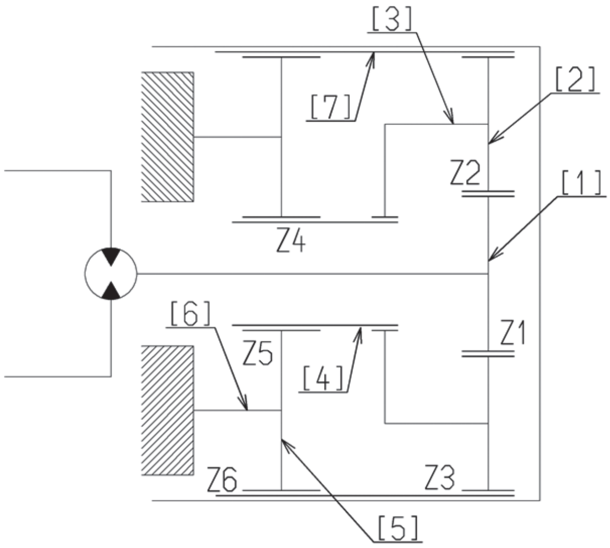

Fig. 7 Gear reducer skeleton diagram

Fig. 7 shows the skeleton diagram Note 1) of a planetary dual gear reducer.

[1] The drive gear engages with the [2] planetary gear A contained in the [3] holder, and [4] the sun gear engages with [5] planetary gear B. [6] The flange holder is fixed on the equipment body, and [2] and [5] planetary gears engage with the [7] ring gear. The driving force from the piston motor is transmitted to the [1] drive gear, and the speed is decelerated by each gear. Due to this, the driving force is transmitted to the [7] ring gear via [5] planetary gear B in the [6] flange holder, which is fixed onto the equipment body on the last level. The driving force is also transmitted from [2] planetary gear A.

Note 1) "Skeleton diagram" refers to schematic diagrams that simply describes structures.

5.2 Method to increase the output

With this MAG-50VP-1100, we enhanced the output without changing the current outer dimensions. Let us explain part of the modification contents below:

(1) Gear strength

The larger the module is, the greater the strength/durability of a gear is. However, changing the module would enlarge the gear reducer in the perpendicular direction. This would make it difficult to make up the system with the same mounting dimensions as the existing product.

Therefore, we enhanced the rigidity of the gear shaft by reviewing the gear shape and changing the layout and simultaneously optimized the engagement between gears in order to increase the output.

(2) Gear shaft rigidity

Even if the strength of gears itself improves, the gear surface would be damaged due to pitching, etc., unless the engagement between gears is appropriate. In this case, we cannot improve the durability. In order to ensure appropriate engagement, shaft rigidity becomes an important factor.

Therefore, we ensured the shaft rigidity that can maintain the same level of shaft deflection as the existing product even under the higher output condition by considering and optimizing the overall rigidity balance while combining the gear reducer components.

(3) Bearings

As the output increases, high-load capacity-type bearings become more necessary. However, high-load/capacity-type bearings that can withstand the required load would be bigger, meaning that we have no choice but to also increase the product dimensions. With this product, we ensured the durability by optimizing the roller shape.

(4) Vehicle mounting part

As the torque increases, the reaction force on the vehicle mounting part also increases. Due to this, the number of fastening bolt holes on the vehicle side as well as the output side needs to be increased. On the vehicle side, we added the fastening holes without changing the locations of the fastening bolt holes of the existing product. On the output side, we increased the number of fastening bolts by using the same fastening bolt spacing (refer to Fig. 8) as the existing products. This provided compatibility with the existing product, ensuring a wide scope of mounting flexibility.

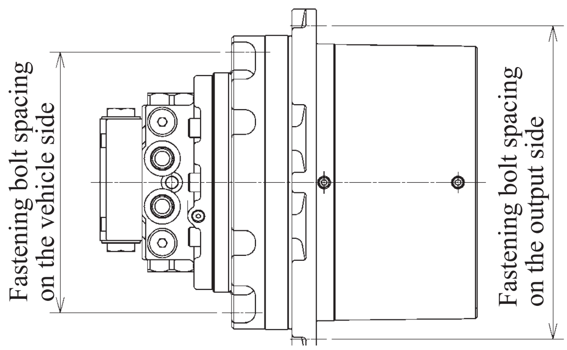

Fig. 8 Fastening bolt spacing for vehicle mounting

6 Characteristics of MAG-50VP-1100

The main characteristics of this product are as shown in Table 1. We have achieved approximately 20% higher output compared to conventional motors while maintaining the exact outer dimensions. While we have increased the number of fastened bolts to enhance the torque, the fit diameter on the vehicle side and output side is the same.

7 Future Tasks

In recent years, people's awareness toward the environment is becoming more and more heightened. The market also requires higher efficiency in traveling motors for energy saving.

While there are currently not many needs for higher efficiency in traveling motors for 7-9-ton excavators and mini excavators, we expect that needs for higher efficiency will increase along with higher torque in the future. We hope to promote product development with the aim of swiftly responding to such needs, and we hope to continue producing products that always respond to market needs.

Table 1 List of specifications of MAG-50VP-1100 and existing product

Model		Existing product	This product (higher output)
		MAG-50VP-900	MAG-50VP-1100
Maximum equivalency capacity (cm³/rev)		2574	3038
Maximum motor capacity (cm³/rev)		50.9	<-
Maximum pressure (MPa)		32.0	<-
Maximum volume (L/min)		92.0	<-
Maximum motor speed (rpm)		3600	<-
Reduction ratio		50.579	50.579 59.716
Maximum output (kN·m)		8.826	10.787 (22% up)
Outer dimension (height x maximum outer diameter)		354 x ø332	356.5 x ø332
Installation dimensions (vehicle side)		Fit diameter: ø210 Number of fastening holes: 12 x M16 x 2.0	<- Number of fastening holes: 14 x M16 x 2.0
Installation dimensions (output side)		Fit diameter: ø265 Number of fastening holes: 12 x M14 x 2.0	<- Number of fastening holes: 16 x M14 x 2.0
Peripheral features	Shifting system	Available	<-
	Parking brake feature	Standard equipment	<-
	Relief valve	Standard equipment (shock-less)	<-
Product weight (kg)		86.0	<-

8 In Closing

Development of this product has allowed us to enhance our track motor product lineup. We have already started delivering this product to customers.

As shown in Table 2, the completion of the development of this product has enabled us to provide the hydraulic system as a set of a pump, control valve, cylinder, swing motor, and traveling motor for 7-9-ton excavators.

Finally, we would like to express our sincere gratitude for the great support and cooperation of everyone involved in the development and mass production.

Table 2 Hydraulic equipment for 7-9-ton excavators

Category	For 7-9-ton excavator	
	For load sensing	For open center
Control valve	KVMX-18-14	KVMM-80-XD
Pump	PSVL-84	PSVD2-42
Cylinder	KCM	
Swing motor	MSG-44P	
Traveling motor	MAG-50VP-1100	

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Product Introduction

Development of MR8040X and MR7000X for India

IWANAMI Shigeru

1 Introduction

KYB-Conmat Pvt. Ltd. (hereinafter referred to as "KCPL") (Photo 1) has been manufacturing and selling concrete mixer trucks (hereinafter referred to as "mixer trucks") with 6 m^3 load since October 2013. In the Indian market, needs for large drums with 7 - 8 m^3 load and above have been gradually increasing. Our competitors offer large-scale truck product lineups, and they have been exhibiting and promoting large-scale mixer trucks in domestic exhibitions in India. KCPL has also developed 7 - 8 m^3 mixer trucks in order to add them to the product lineup and lead to sales expansion. These are the newly developed models: 8 m^3 mixer truck "MR8040X" and 7 m^3 mixer truck "MR7000X".

Photo 1 KYB-Conmat Pvt. Ltd.

2 Mixer Truck Configuration and Specifications

Specifications of MR8040X and MR7000X (Photo 2) are as shown in Table 1. These are additions to the lineup of MR6010X, which had already been released, but they were newly developed by changing the drum size, main frame, fastening structure, water tank, etc.

The outer diameter of the center shell of MR8040X and MR7000X drums was not changed from MR6010X. The drum was extended in the front-back direction of the vehicle to secure the required load. We aimed to standardize drum components other than the center shell by employing the specifications that satisfy the discharge performance, load performance, mixing performance, stirring performance, etc. (Fig. 1).

In addition, by extending the center shell and standardizing the mixer frame, we were able to drastically reduce the development period.

Photo 2 MR8040X

Table 1 Specification table

	MR6010X	MR7000X	MR8040X
Total drum capacity	11.9 m^3	12.5 m^3	14.4 m^3
Ready-Mixed concrete load capacity	6 m^3	7 m^3	8 m^3
Drum rotation speed	1-15 rpm		
Blade	Two-spiral form, Cross-section C-type, with bead		
Seal pipe	None, open hopper		
Mixer frame	Front frame: U bolted		U bolted
	Roller frame: Welded structure		
Drive system	Sub engine		
	P.T.O. (drive shaft)		
Hydraulic pump, motor	Utilizing motor swash plate pump, inclined motor		
Oil cooler	Yes		
Water pump	Volute water pump		
Water tank	450 L	450 L	600 L
Chute	Removable sub chute		
Operation lever	One location on the right		

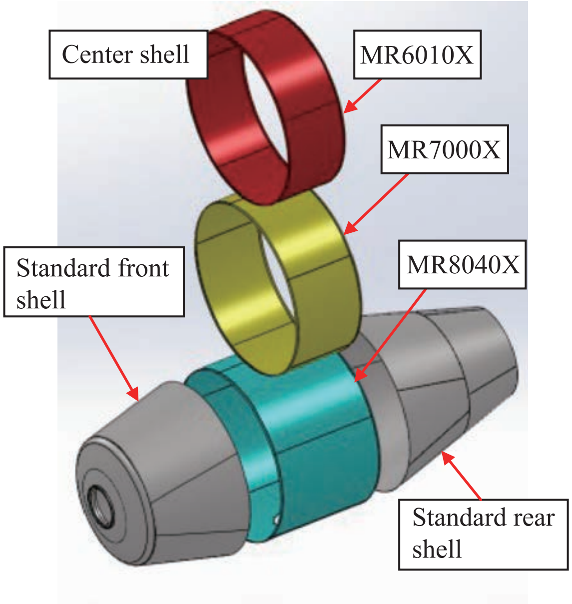

Fig. 1 Standardization of drum components

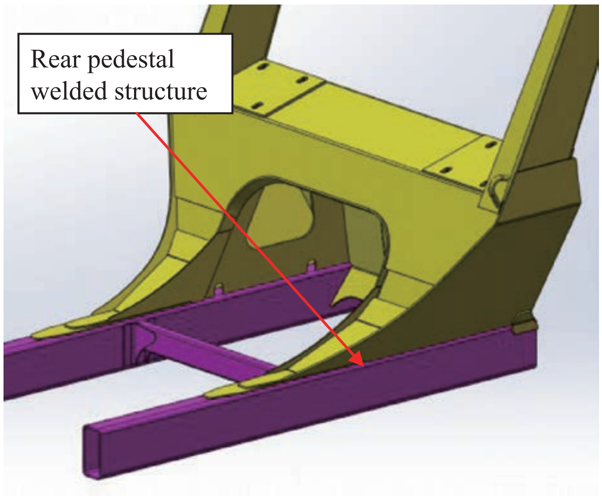

Fig. 2 MR6010X rear pedestal welded structure

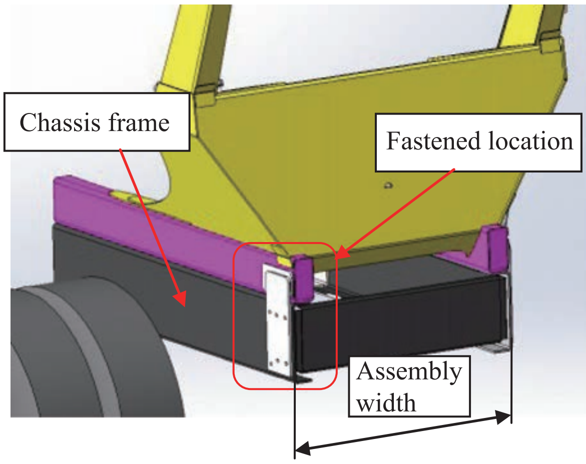

Fig. 3 Fastened locations of chassis frame

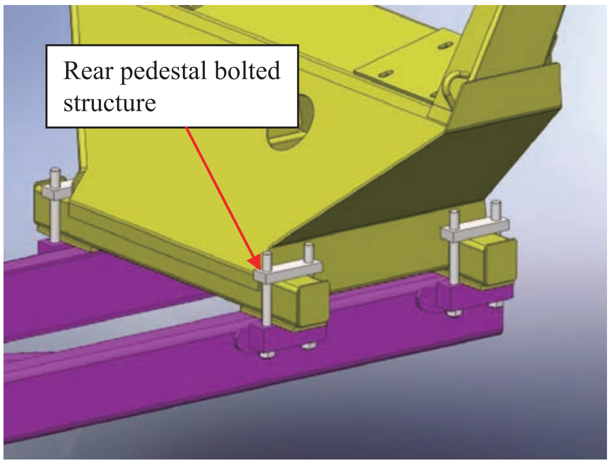

Fig. 4 MR8040X rear pedestal bolted structure

3 Frame Development

3.1 Frame structure

The MR6010X rear pedestal is welded and integrated (Fig. 2), and the chassis frame and the mounted feature are fastened with bolts (Fig. 3). The rear pedestal assembly width is fixed by welding, and we manufacture two types of rear pedestals depending on the chassis frame assembly width due to the fact that the mounted chassis frame assembly width differs for each chassis manufacturer. With MR8040X, we changed the welded structure to a bolted structure (Fig. 4) in order to standardize the fixture method of different chassis types. We have also divided the mounted feature, which used to be one component, into three components, including the front pedestal, rear pedestal, and long member (Fig. 5). With this structural change, the front pedestal and rear pedestal were made standard, and we reduced the number of special components used to fasten each chassis frame by changing the long member assembly width according to the chassis assembly width. Since MR6010X uses a welded structure, we will divide the mounted feature in the same manner as MR8040X and change it to a bolted structure in the future.

In addition, some of the chassis distributed in the Indian market have less strength in chassis frame compared to chassis distributed in Japan. Weaker chassis frame has a greater impact on a mixer frame when wet concrete is loaded and during traveling, etc. In order to also respond to such chassis, we have reinforced the frame by installing cross bars (Fig. 5) on long members. We have enhanced the rigidity of the fastening performance with the chassis frame by increasing the fastening locations as shown in Fig. 3.

3.2 Stress evaluation

Normally, development in Japan involves the design, prototype, and testing conducted within Japan. However, for MR8040X, the basic design formulation and FEM structure analysis (Fig. 6) were promoted in Japan, and prototypes were made in KCPL. We conducted real unit tests in India using prototypes with mounted features. This was due to the fact that we needed to conduct tests suitable for the local situation and conduct a performance evaluation because the environments, such as the road

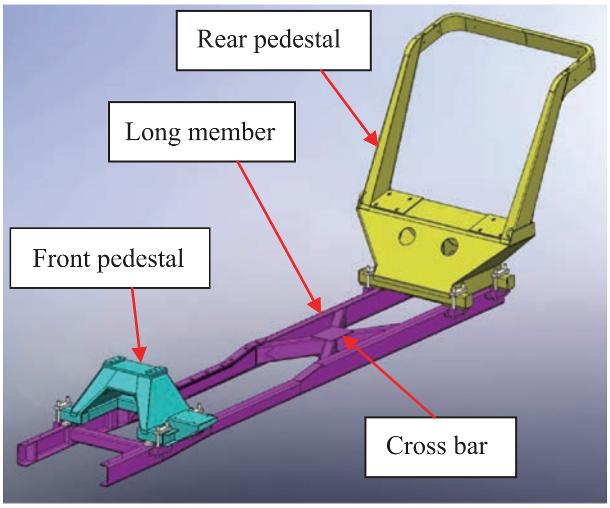

Fig. 5 Mounted feature divided into three components

Photo 4 Speed bump

condition and plants that inject Ready-Mixed concrete are different from Japan (Photo 3).

Road conditions in India are more severe than Japan, and there are also a number of speed bumps (Photo 4), which are not common on regular roads in Japan.

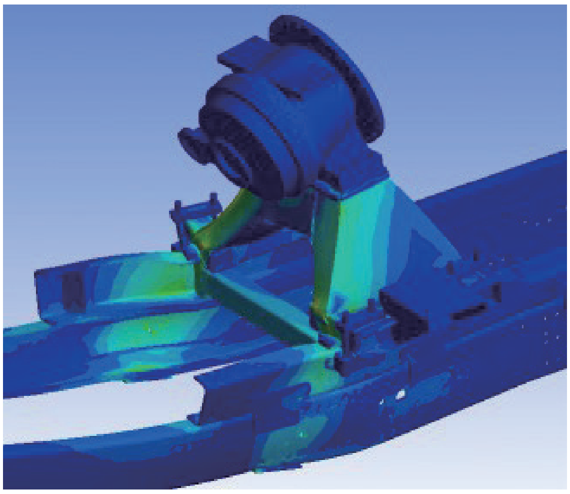

Fig. 6 FEM structural analysis

Photo 3 Ready-Mixed concrete plant

4 Drive Method

Mixer trucks in India have a small engine output of approximately 180PS, so MR6010X obtains the power for the hydraulic pump for drum rotation and water pump from the sub-engine (Fig.7) for the drum, which is installed on the mounted feature side. However, chassis of various European truck manufacturers, which have been entering the Indian market in the last few years, have great engine output. They often utilize the P.T.O. Note 1) drive method. On a global standard, the P.T.O. drive method is the mainstream method and is expected to have more demand in India in the future. Due to this, we have utilized the P.T.O. method for MR8040X and MR7000X (Fig. 8). Considering this background, we have also added the P.T.O. drive method to the MR6010X lineup, allowing us to offer products that meet the needs of customers.

Note 1) P.T.O. (Abbreviation of "Power take off"). Equipment used to extract power from the engine.

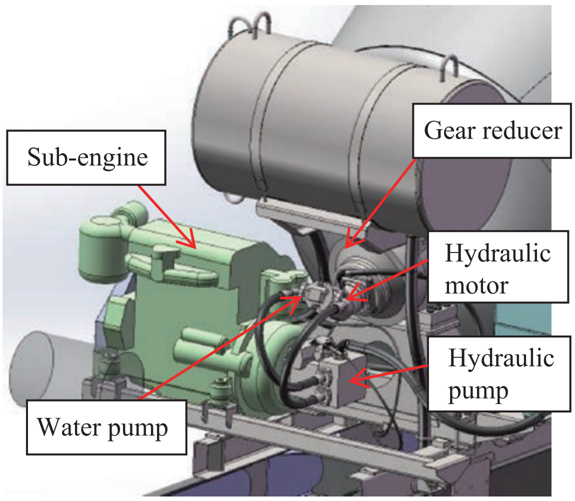

Fig. 7 Sub-engine drive

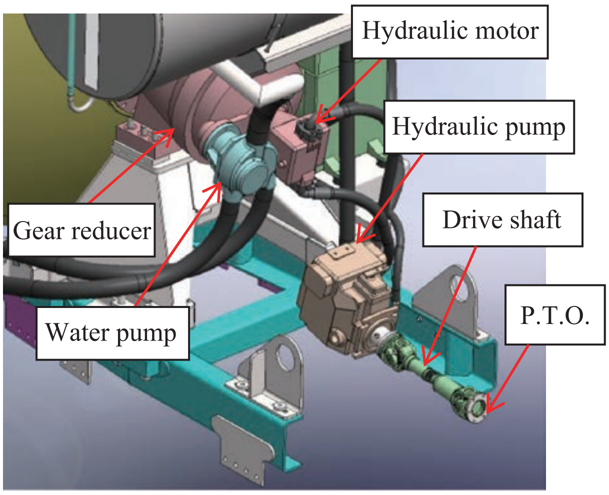

Fig. 8 P.T.O. drive

5 Performance Evaluation

5.1 Drum performance

In terms of drum performance, we check the load performance, mixing performance, stirring performance, and discharge performance. The test result value satisfied the maximum load requirement with both MR7000X (7 m^3) and MR8040X (8 m^3). In terms of the mixing performance, we determine if the slump value Note 2) changes between the time Ready-Mixed concrete is charged and is discharged. In the stirring performance evaluation, we sample Ready-Mixed concrete in the middle of the discharge process in the same manner as the mixing performance evaluation, and we evaluate the aggregate distribution amount. Aggregates must be evenly mixed in the beginning through the end of discharge. All of the tests satisfied the evaluation criteria. Finally, the discharge performance is evaluated by counting the rotation number required to discharge 1 m^3 for each slump. Discharging more Ready-Mixed concrete with fewer rotations is preferred.

The great discharge performance is one of the characteristics of KYB drums. They can discharge Ready-Mixed concrete faster than standard mixer trucks in India.

Note 2) A value that represents the hardness of wet concrete. The smaller the value is, the harder it is.

5.2 Hydraulic equipment durability

We measured the pump pressure for a mixer truck to complete one cycle from Ready-Mixed concrete in charge to discharge and cleaning. We conducted a bench durability test based on the measurement results. The test proved that the hydraulic pump and hydraulic motor of MR8040X and MR7000X possess sufficient durability even in usage conditions in India.

6 In Closing

The basic structures of MR8040X and MR7000X were designed based on Japanese specifications, but local investigations have been gradually revealing unique usage of trucks in India. In the future, KCPL and the Special Purpose Vehicles Div. hope to work together and promote product improvement to offer products that respond to the needs of customers in India as well as surrounding areas that receive exported trucks from India.

Finally, I would like to express my sincere gratitude for everyone who has cooperated with this development.

Author

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Joined the company in 2013. Engineering Dept., Kumagaya Plant, Special Purpose Vehicles Div. Engaged in designing mounted mixer feature and development design.

Technology Introduction

A Study of Vehicle Control Technology Using Image Processing

SASAKI Kei

1 Introduction

In recent years, research to promote the practical use of the autonomous operation of automobiles, construction equipment, farming equipment, etc., has been active. As represented by the autonomous operation of automobiles, not only mother machine manufacturers but also many different industries, including IT companies, have entered the market. Research to automate machine operation, for which we used to depend on people, is being promoted by utilizing sophisticated intelligence. KYB also needs to start proposing systems among our various products to mother machine manufacturers to follow this flow of automation and intelligence. More relatively inexpensive cameras are starting to be used for autonomous operation, and image processing technologies to recognize the surrounding environment based on camera images are becoming increasingly more important.

Therefore, we decided to focus our research on the automobile auto-parking system, which operates in limited environments while possessing factors of autonomous operation, in order to master the surrounding environment recognition technology and the vehicle control technology, which are element technologies in autonomous operation, and technology to configure them as a system. In our research, we utilized the white line control system, which uses cameras to recognize white line markers, in order to master the autonomous operation technology with the focus on image-processing technology. In this article, I would like to introduce the vehicle control technology using image processing.

2 System Overview

2.1 How auto-parking by white line control works

Fig. 1 shows the flow of entry/parking/exit in auto-parking by white line control. The cameras on the vehicle recognize the white line control markers, which are installed in the parking lot. The vehicle autonomously drives to enter/exit the lot by following the instructions indicated by the marker. Fig. 2 shows an example of markers defined in the white line control markers. Upon constructing auto-parking functions, we assumed the usage that the driver exits the vehicle at the entrance of the parking lot and instructs the vehicle to enter the lot to

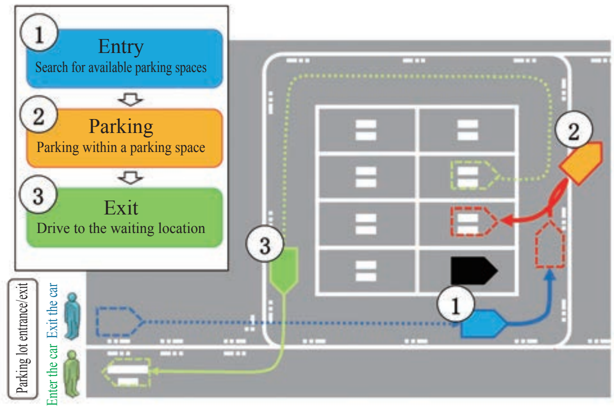

Fig. 1 Auto-parking flow

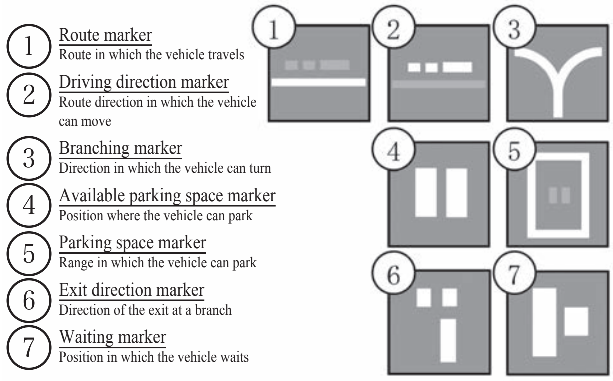

Fig. 2 Marker examples

autonomously park the vehicle. When the driver wants to ride the vehicle again, the driver instructs the vehicle to exit the lot beforehand so that the vehicle travels to the front of the parking lot.

2.2 Hardware configuration

Fig. 3 shows the hardware configuration. For the base vehicle, we utilized the RoboCar®MV2 Autonomous Driving Package, which is an electric vehicle for research released by ZMP Inc. This base vehicle can control the steering, accelerator, and brake by using CAN signals. On this base vehicle, we installed four monocular cameras that take images of the front/back/sides of the vehicle, an image-processing PC to recognize white line control markers based on the images, and a vehicle control PC that controls operation systems, such as vehicle steering, based on the recognition results.

In this research, we have created the marker recognition program, which recognizes the white line control markers captured by the cameras, and the vehicle control program, which controls the vehicle based on the recognition results. Each PC utilizes an open-sourced OS and image-processing library.

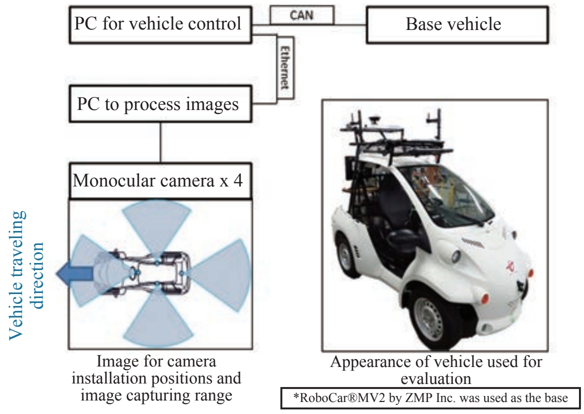

Fig. 3 Hardware configuration

3 How Vehicle Control Works

In vehicle control, the vehicle's target track is generated by the positions/angles/types of various white line control markers, which are recognized periodically. The system calculates commands for steering, accelerator, etc., to follow this target track and control the vehicle by transmitting these commands to the base vehicle via CAN.

Fig. 4 shows the vehicle control flow when the vehicle follows the route. First, it recognizes the positions and angles of route markers, which are captured with the front camera, against the vehicle. It then corrects the horizontal deviation from the route and generates the target track in which the route and vehicle are parallel (① in Fig. 4). When doing so, the target track is generated by calculating the clothoid curve Note 1) that connects the positions and angles of the vehicle at the beginning and end of the drive. The vehicle drives by following this target track and confirms the marker recognition result when it reaches the target point (② in Fig. 4). After this, it continues to follow the route periodically in the timing that markers are recognized (③ and ④ in Fig. 4).

When branching markers are detected, the vehicle generates the track to turn in the available direction based on the branching marker positions/angles and available branching direction information.

Available parking space markers are recognized by cameras on either side of the vehicle. When the marker is recognized, the vehicle shifts to the parking movement. In the parking movement, the vehicle moves to the position in which the available parking space marker can be captured in the back camera. After this, it generates the track by reconfirming the available parking space marker position again with the back camera and parks directly above the available parking space marker.

Note 1) Curve that is approximated as the track followed by a vehicle when the steering wheel of the vehicle, which is driving at a certain speed, is turned at a constant speed.

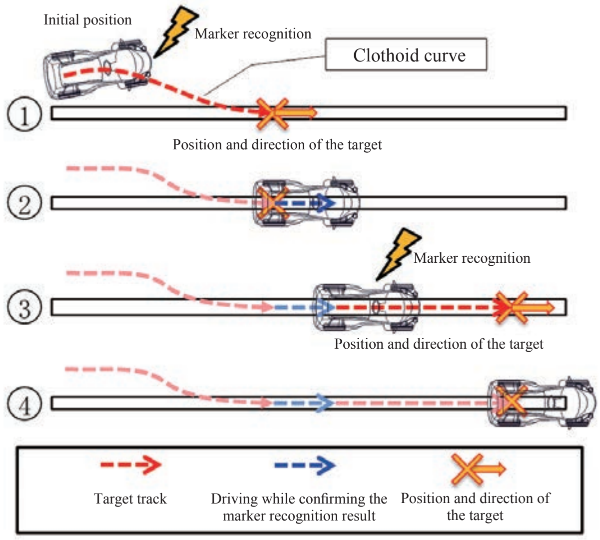

Fig. 4 Flow of driving that follows the route

4 Flow of Image Processing

Fig. 5 shows the flow of image processing in marker recognition. Image processing is mainly divided into three processes – pre-process, main process, and post-process. In response to images obtained from cameras (① in Fig. 5), the pre-process converts the road surface image taken directly above the road into a bird's-eye image (② in Fig. 5) and performs the filtering process (③ in Fig. 5) to extract white lines. The main process detects the outlines of the extracted white lines (④ in Fig. 5) and recognizes white line control markers based on the shapes and positions (⑤ in Fig. 5). The post-process performs tasks, such as converting the recognized marker positions and angles to coordinates (⑥ in Fig. 5).

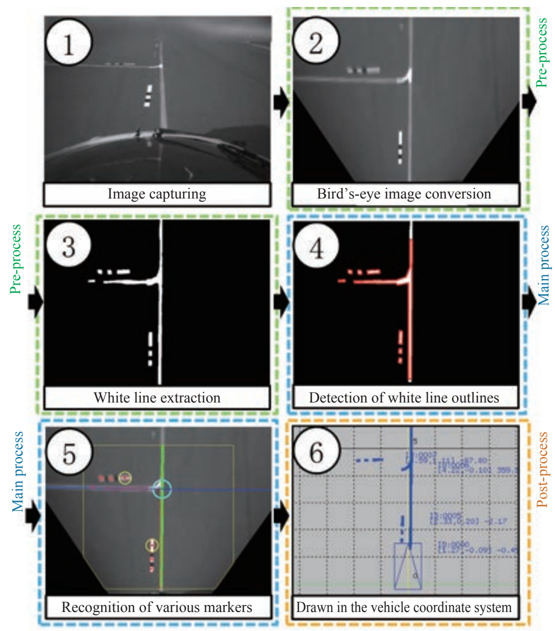

Fig. 5 Flow of image processing with marker recognition

5 Element Technologies in Image Processing

The main process in image processing includes outline detection and recognition of various markers by utilizing a method called "grid template matching" in this review.

5.1 Marker recognition using outline detection

Outline detection is the process to detect the shape/position of a specific segment on the screen. With this process, the white lines are detected and various white line control marker types are recognized.

Fig. 6 shows how white line outlines are detected. First, white lines are extracted through a binarization process to convert the image into two colors: white and black. Next, white line outlines are detected from these white line extraction images. Among the detected outlines, only quadrangles are extracted as candidates for white line control markers. When doing so, outlines that are close to quadrangles are also approximated as quadrangles.

Various marker types are recognized based on the shapes of extracted white line outlines (outline length, length of each side, etc.) and positional relations. Fig. 7 shows the flow to recognize the driving direction markers (markers that define the direction in which the vehicle can move, in relation to the route markers) as an example. Driving direction markers are shaped with three large and small rectangles in a row. The system searches white lines with the same positioning as these shapes from the screen. If the conditions match, the white lines are recognized as driving direction markers.

Route markers are recognized by detecting a thin and long white line that extends from the bottom edge of the screen.

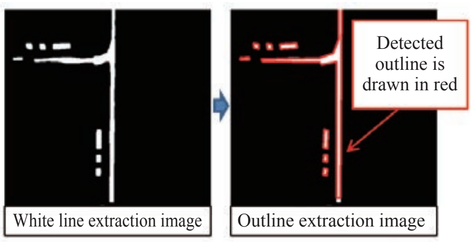

Fig. 6 Outline detection of white lines within images

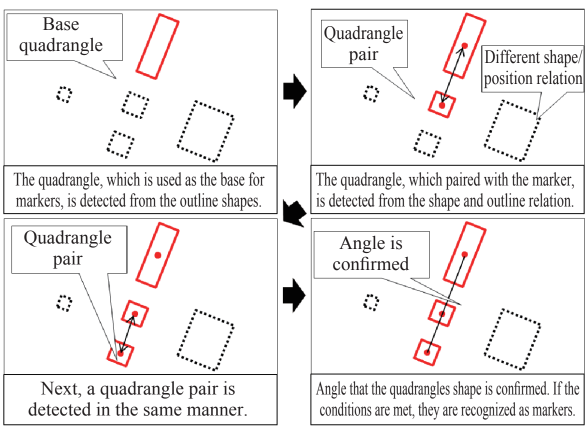

Fig. 7 Process in which markers are recognized from outlines

5.2 Branching marker recognition through grid template matching

Branching markers are shaped uniquely with curves. Vehicles can move forward in the direction that is smoothly connected with a curve or straight line from the entry direction. Vehicles must recognize the characteristics of these unique shapes. Therefore, we are using a system called "grid sensor" that divides markers into nine segments as shown as ① - ⑨ in Fig. 8. In order for the vehicle to easily capture the white line, which runs in the middle of branching markers, and curves that branch out from the white line, the grid sensor divides segments so that the center is narrow and the sides are wide. In addition, by limiting the branching marker candidates with prior conditions of whether or not there is a white line inside of the segment (shown in Fig. 8), we reduce the erroneous recognition rate and process load for pattern matching.

The vehicle detects branching markers and recognizes the branch types by using this grid sensor to search the screen and perform the matching process to determine whether or not there is a white line in each segment, as shown in Fig. 9.

In addition, the system efficiently performs search and simultaneously reduces erroneous recognition when searching for branching markers on the screen with the grid sensor by performing the search along the route markers, which were recognized in the aforementioned outline detection.

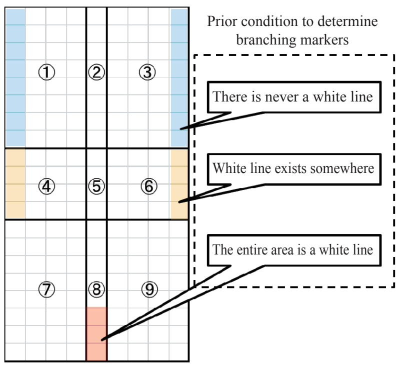

Fig. 8 Grid sensor

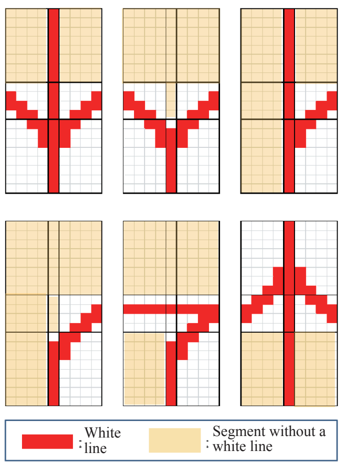

Fig. 9 Branching marker pattern examples

6 Experiment Result

In order to confirm the auto-parking functions, we conducted a demonstrative evaluation by installing a simulated parking lot in our test course. Fig. 10 shows the rough appearance of the installed simulated parking lot. Fig. 11 shows scenes from the experiment in the simulated parking lot.

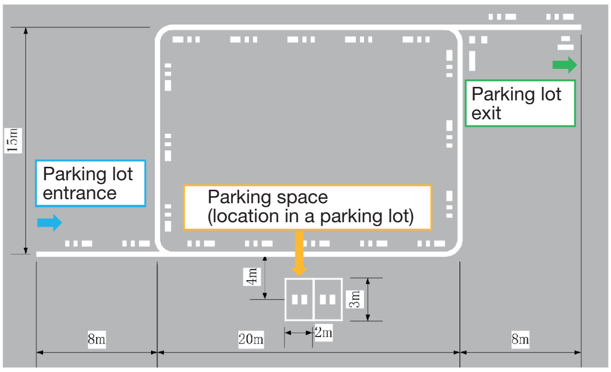

Fig. 10 Overview of the simulated parking lot

Fig. 11 Scenes from the experiment in the simulated parking lot

We confirmed the movements of the vehicle, which searched through the parking lot once after entering the lot, found an available parking space, parked, and drove to the exit after receiving the user's instruction. During the experiment, we made the vehicle move as mentioned above by hiding the available parking space marker when it first passed the parking space and replacing the marker when it passed the space again after driving through the parking lot once. We set the speed at approximately [5km/h] by assuming slow speed to thoroughly ensure safety.

As a result of the evaluation, we confirmed that the vehicle can drive according to the instructions given by the installed white line control markers, enter the parking lot, park, and exit.

The precision to follow the routes was approximately 43 [mm] on average, and the parking position precision was approximately 34 [mm] on average in the lateral direction and 174 [mm] in the longitudinal direction. We have learned that the main reason for the errors in the overall result was vibrations in the vehicle during driving. In addition, we have learned that the error in the longitudinal direction during parking was caused by the fact that we weren't able to reflect the physical characteristics of a vehicle behaving differently when it moves forward and backward on vehicle control.

7 In Closing

In this research, we have established an auto-parking system that uses white line control by utilizing the surrounding environment recognition technology using images and the vehicle control technology, as a first step to proposing systems for sophisticated automation and intelligence. While there are still issues in the recognition precision and vehicle control precision, we were able to confirm that parking is possible by using an actual vehicle in a simulated parking lot.

We can expect that the element technologies of autonomous operation, which we have obtained in this research, will be applicable to not only vehicles but also a wide range of equipment, such as construction equipment and farming equipment. In the future, we plan to apply the findings from the surrounding environment recognition technology using image processing and the vehicle control technology, which we have obtained through the research, to other various products of KYB.

Author

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Motion control engineering Sect., Basic Technology R&D Center, Engineering Div.
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Technology Introduction

Development of Quality Data Control System

FURUKAWA Akira

1 Introduction

The Casting Center of KYB-YS Co., Ltd. manufactures casted materials for valve housings (Photo 1) for control valves used in hydraulic excavators. Since a valve housing controls various actuators, such as hydraulic cylinders and hydraulic motors, it houses complex hydraulic circuits (Photo 2). In addition, casted materials are manufactured by setting the core in a mold and pouring in molten metal. However, sophisticated manufacturing technologies and quality control systems are required for production, due to the fact that we cannot manufacture stable products if there is the slightest deterioration in any of the manufacturing conditions.

Photo 1 Valve housing

Photo 2 Product cut sample

However, our quality control had depended on the experience and intuition of expert engineers in conventional production. We did not used to be able to perform sufficient quality control utilizing quality data from manufacturing. Since quality data was actually only collected from processes that were deemed important, it sometimes required a lot of time to identify the cause in the case of a product failure or prevented us from identifying the true cause because we could not trace the problem sufficiently.

Therefore, we have developed a system to collect the manufacturing quality data from all processes on all products that can be traced back at a later stage. I would like to introduce this system.

2 Objective of System Introduction

While the ultimate objective for this system introduction was to reduce the defect rate, we developed the system by following the below steps incrementally.

① Collection/visualization of quality data
② Identification of failure cause
③ Prevention of failures

In this review, I would like to introduce the contents of the above ①.

3 Overview of Production Lines

Fig. 1 shows the flow of all production lines in the Casting Center of KYB-YS Co., Ltd.

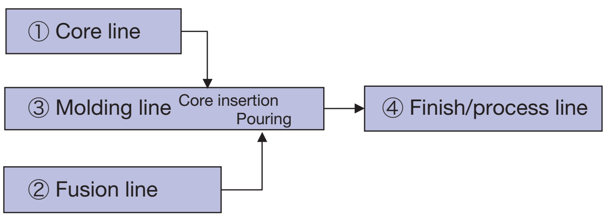

Fig. 1 Flow of all production lines

Main contents of production for each line are as follows:

① Core line
A cast is filled with sand and fired. Following this, the core is produced after assembly and finishing work (Photo 3).

② Fusion line
Metal and various materials are melted at high temperature to produce molten metal.

③ Molding line
Sand is packed in the cast and cured to produce the mold. After this, we set the core, which was produced in process ①, in the core-setting process. In the pouring process, the molten metal, which was produced in process ②, is poured into the mold. It is then cooled down, and the casted product is removed by dissembling the mold.

④ Finish/process line
Shot/inspection/machine processes are performed on the casted product, which has been taken out of the mold, and the product is finished.

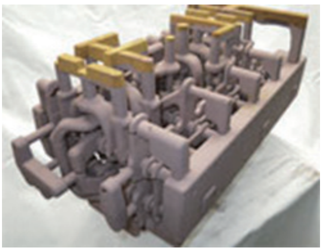

Photo 3 Completed core

This system targets collection of all data from all production lines. Especially with the core, mold, and molten metal, we ultimately do not have the actual objects in the end due to the nature of the casting method. Therefore, it is difficult to trace them back at a later stage even if we collect quality data. The key to this technology development is to enable us to trace them back.

4 System Configuration

Fig. 2 shows the system configuration. The basic flow of the system is to collect the quality data on a real-time basis from the touch panels, which are installed in facilities or in manufacturing sites, and to enter the data in the database (hereinafter referred to as "DB") server. We have also established a system to instruct the production part numbers and sequence by registering the production plans (plans for the molding line and fusion line) on a PC beforehand and forwarding the plans to touch panels and facilities (details are explained in Section 6).

Overview of each piece of equipment is as follows:

① DB server
Used to integrally manage various types of master data related to this system as well as collected quality data.

② PC
Used to browse collected quality data and register production plans and various types of master data by using the software for PCs used in this system.

③ Touch panel
Used to input items that require decisions by people that cannot be collected from facilities (notice information Note 1), failure location, evaluation result, etc.) and display production plans, work standards, etc.

④ Facility
Used to collect quality data measured by sensors and measuring equipment at the time of production.

Note 1) Refers to information that workers notice or were concerned about in the course of performing tasks.

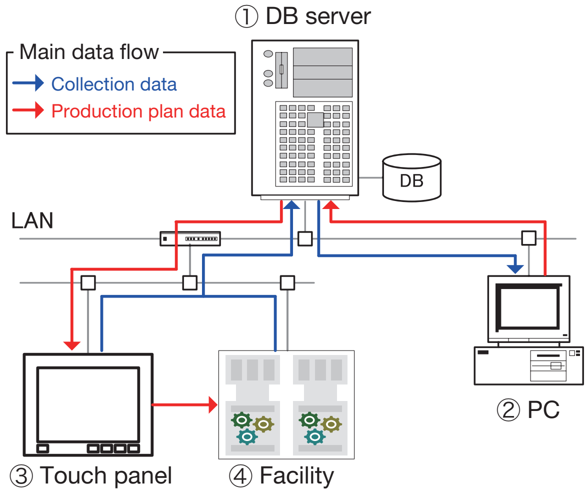

Fig. 2 System configuration

5 Systems to Identify Individual Items and Link Data

5.1 Overview of serial number generation and linking

In order to trace quality data, which is collected in each process, from produced products, we need to link quality data with information that enables us to identify the product. Therefore, we decided to generate a serial number Note 2) for each product and intermediate product Note 3) produced in each line and link it with quality data to collect data. Fig. 3 shows the flow of serial number generation and linking flow.

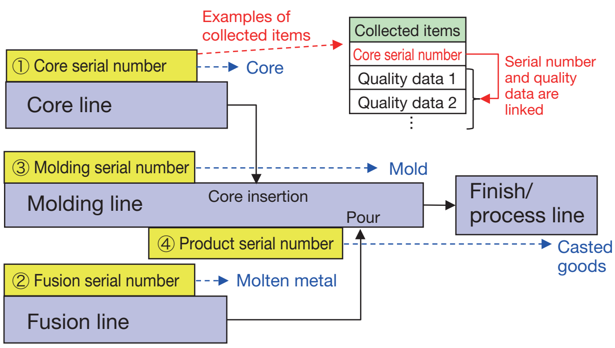

Fig. 3 Flow of serial number generation and linking

Serial numbers are generated for each of the cores, molds, molten metal, and casted goods (products). When a product and each intermediate product are combined, each serial number is linked. The linking process applies to the core insertion process in the molding line and the pouring process. Linking information for each serial number is saved on the DB server so that relevant serial numbers can be searched among serial numbers as necessary. Through this process, the system enables quality data tracing (trace back) in each process from casted products as well as casted products tracing (trace forward) from intermediate products, such as molten metal.

Note 2) Refers to unique numbers that are not redundant with others. In this system, they are generated in the format of "manufacturing symbol-production date-additional number".

Note 3) Refers to products, such as cores, molds, and molten metal, that are produced in the middle of production processes, rather than final products.

5.2 How to link serial numbers to actual products

The generated serial numbers must always be linked with the target products/intermediate products. The common method is to directly print serial numbers on actual products, and we actually use this method to link serial numbers to casted products. However, it was technically and physically difficult to directly print numbers on other intermediate products due to the fact that the actual products were sand and molten metal. Therefore, we used another method to link serial numbers.

Fig. 4 shows how serial numbers are linked with cores.

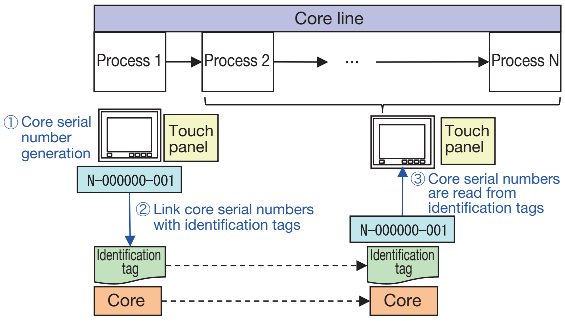

Fig. 4 How serial numbers are linked with cores

At the core line, we attach identification tags to each core so that we can identify the core at one glance. The identification tags include information, such as the part number and identification number to identify the identification tag, as well as the QR code that contains such information (Fig. 5). In this development, we have linked a serial number with each core by using this identification tag. Below is the flow of linking.

① The core serial number is generated by using the touch panel, which is installed in the first process, when the production of the process is completed.

② The QR code on the identification tag, which is attached to the core, is read by the barcode reader connected to the touch panel. This work links the core serial number with the identification tag.

③ In processes following the next process, the core serial number is called by scanning the QR code on the identification tag with the barcode reader.

In addition, this method has also enabled us to thoroughly collect data (link quality data and serial number) within a short period of time.

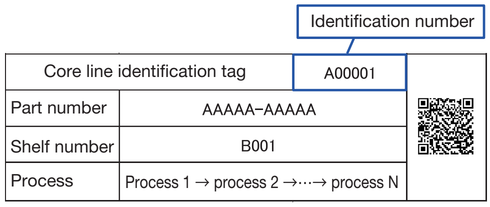

Fig. 5 Identification tag image

Fig. 6 shows how serial numbers are linked with molds.

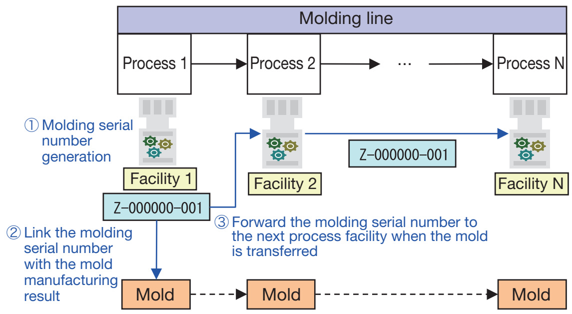

Fig. 6 How serial numbers are liked with molds

In this development, we link serial numbers to molds by using facilities in each process. Below is the flow of linking.

① Facility in the first process automatically generates the mold serial number when the production of the process is completed.

② The generated mold serial number is linked with the mold manufacturing result (quality data), which is held in the facility.

③ When the mold moves to the next process, the mold serial number is forwarded to the facility in the next process. When the production in the next process ends, the mold serial number is linked with the manufacturing result. The same flow is repeated until the last process.

The main characteristic is that the serial numbers are linked with manufacturing results rather than actual goods. With this method, we can link them by simply controlling facilities. Therefore, we have the advantages that workers are not given extra work and linking errors are also prevented. In addition, serial numbers are also linked in the fusion line with the same method as the molding line. The reason that the linking method differs for the core line is because the core line involves many manual processes and processes without facilities.

6 Production Instruction Structure

In this development, we established a system that issues production instructions to facilities and workers by forwarding the production plans, which were prepared beforehand, for the modeling line and fusion line to the facility and touch panel of each line as part of quality data control. Fig. 7 shows the flow of production instructions.

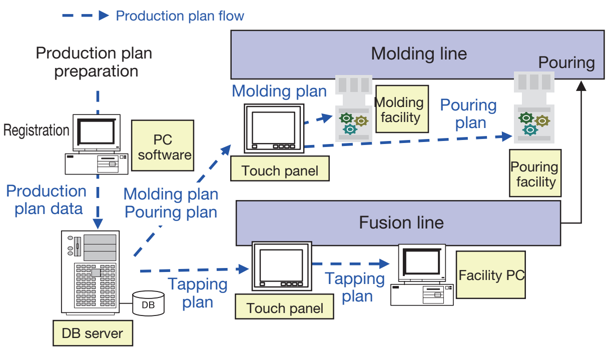

Fig. 7 Flow of production instructions

Molding plans and pouring plans are forwarded to the molding line. Molding plans include part numbers to be molded, production sequence, etc. Pouring plans include part numbers to be produced, production sequence, pouring pattern number Note 4), etc. In addition, the reason that molding plans and pouring plans are divided is because the molding sequence and pouring sequence sometimes differ due to the nature of the molten metal. Facilities perform controls so that they automatically transfer molds and pour molten metal based on these plans. In addition, Tapping plans are forwarded to the fusion line. Tapping plans include the material and weight of molten metal, which is to be tapped, target part number to be poured, etc. Facilities perform controls so that they automatically calculate the materials to add as well as their volume and inject them into the furnace based on the tapping plans. As you can see, automatic control of facilities through production instructions has reduced the number of workers and contributed to the prevention of human errors. Furthermore, we have also been generating fusion serial numbers for the fusion line based on these production plans and also linking part number information with quality data. They play major roles in quality data control.

Note 4) Numbers used to identify facility conditions when pouring. Different numbers represent different pouring volume, pouring speed, etc.

7 Features of Developed Software

In this development, we have developed software for touch panels and PCs as screen software to be operated by users. The main features are as explained below.

7.1 Software for touch panels

7.1.1 Production plan display feature

Fig. 8 is a screen that displays production plans displayed at the molding line. The screen displays part numbers to be produced, sequence, and progress (● and ▲ in the image), enabling users to comprehend the current production progress at a glance. In addition, the charge number (CH) represents the unit of molten metal, which is produced in the fusion furnace of the fusion line per production, and users can confirm the production plan for the fusion line on this screen. Therefore, in case of a problem in a molding line, you can understand which charge in the fusion line is affected and take action on the fusion line beforehand.

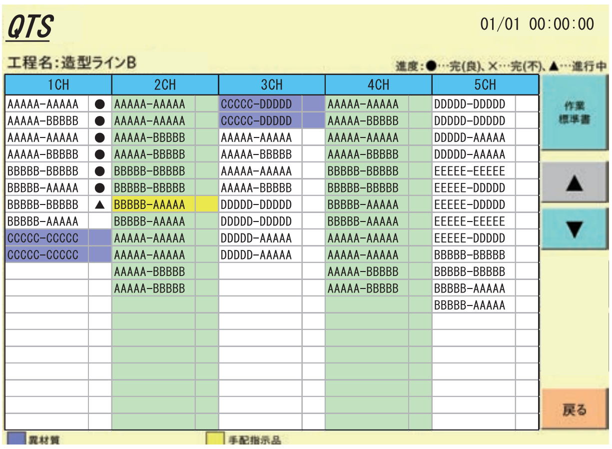

Fig. 8 Display screen for molding line production plans

Fig. 9 is the production plan screen displayed at the fusion line. The top of the screen shows charge number, process number that indicates the tapping unit per production, material, weight, etc. The tapped weight in the fusion line is different in each production, and added materials also differ depending on the nature of the material. Therefore, we must prepare by considering these aspects. You can understand the contents of preparation, which should be taken in the next step, on this screen.

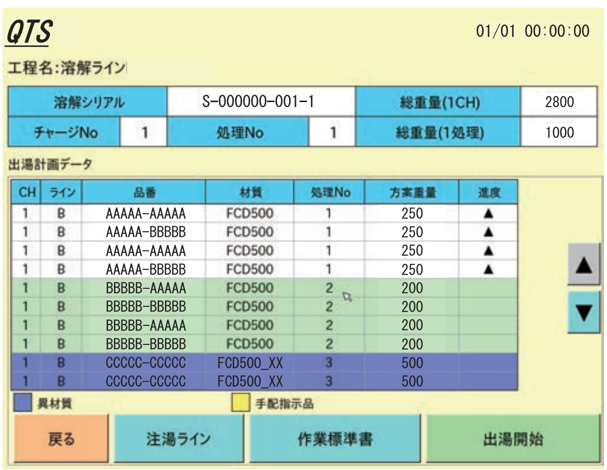

Fig. 9 Display screen for fusion line production plans

7.1.2 Notice information entry feature

Fig. 10 is the screen into which workers input information that they notice.

The screen displays a list of notice information registered for each process. Workers can input notice information by simply touching the arbitrary notice information from the list. In addition, due to the fact that notice information may be added at a later stage as necessary, you can collect information that is more accurate for the reality of the field as you operate.

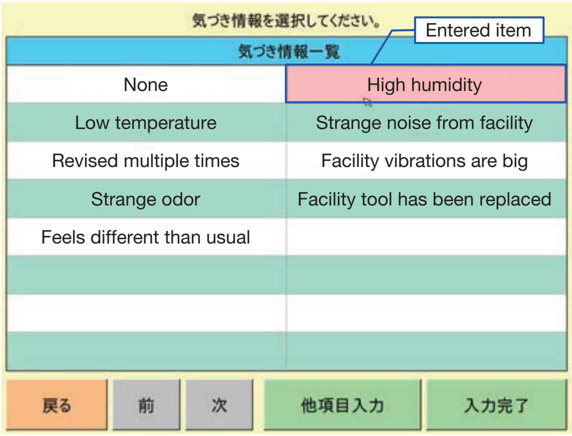

Fig. 10 Notice information entry screen

7.2 PC software

7.2.1 Collected data browsing feature

Fig. 11 is a screen that displays a list of quality data collected from facilities and touch panels. You can use this screen to confirm who produced each product, when, and under what conditions. In addition, you can not only search arbitrary processes and line results but also all of the processes. The all-process search displays a list of all quality data for cores, fusion, and molding related to casted products. You can confirm which data in what process is problematic for defective casted products. In addition, due to the fact that quality data is collected on a real-time basis, you can also understand the current production status.

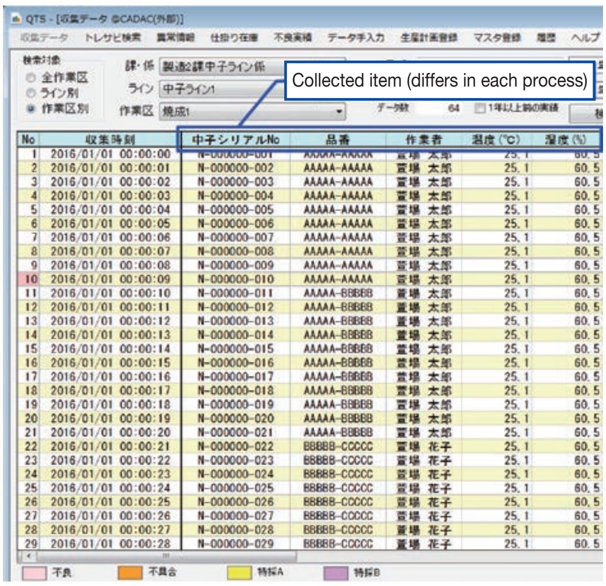

Fig. 11 Collected data display screen

7.2.2 Data trend confirmation feature

Fig. 12 and Fig. 13 show screens that display collected arbitrary data shifts and dispersion in X-Rs control charts and histograms. By managing the trend of collected data every day on these screens, you can instantly detect abnormal data and study data characteristics in the case of a failure to lead to identification of the failure cause, etc.

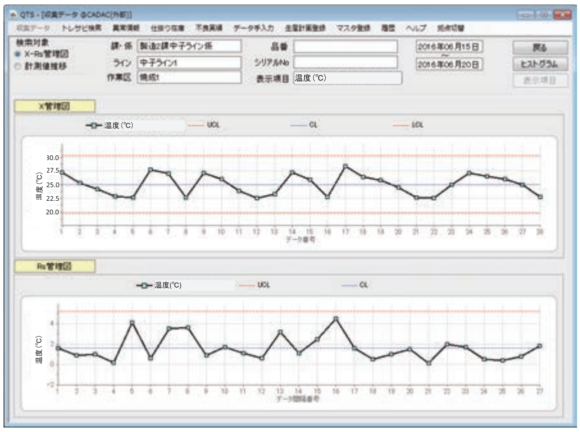

Fig. 12 X-Rs control chart display screen

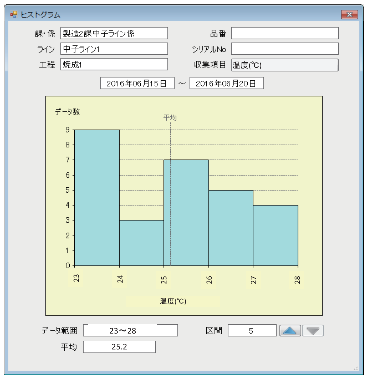

Fig. 13 Histogram display screen

7.2.3 Data tracing feature

Fig. 14 is the screen to trace product/quality data of each relevant line from serial numbers. You can select the search target product, core, molten metal, and mold serial numbers. You can trace (trace back) intermediate products prior to casted products and trace (trace forward) between intermediate products and casted products. Therefore, in case of product failure, the range of the effect can be immediately identified. This enables us to take swift and appropriate measures on products that require such measures.

Fig. 14 Data tracing screen

7.2.4 Production plan registration feature

Fig. 15 is the feature to register production plan data to be forwarded to molding line/fusion line facilities and touch panels. Production plan data is originally prepared as Excel files, but Excel file data is read in this screen, automatically converted to the format to be forwarded to facilities and touch panels, and registered in the DB server. In addition, the screen also shows results against the plan (molding line progress, fusion progress, and mold evaluation result), so we can also understand the current progress status on this screen.

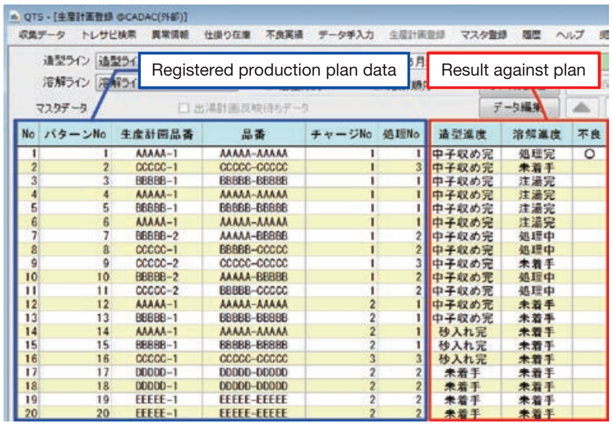

Fig. 15 Production plan registration screen

8 In Closing

The introduction of this system has enabled us to collect quality data of all products covering approximately 300 items, to visualize data, and to trace data in case of failures. In the future, we will utilize the collected data, perform failure analysis/failure prediction, and lead to failure reduction, which is the primary objective.

In addition, since this system collects not only quality data but also other basic manufacturing information, such as production time and number, we will consider applying the system to process control, inventory control, etc., in the future.

Finally, I would like to take this opportunity to express my sincere gratitude to everyone in the relevant divisions who has provided us with great support and cooperation in the course of the development and introduction of this system.

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Technology Explanation

Development of Relief Valve Automatic assembly technology

TAKIGUCHI Masaki

Abstract

Construction machinery is equipped with hydraulic cylinders, hydraulic motors, and other actuators, and these actuators are controlled with control valves (Photo 1). These control valves have built-in relief valves (RV) which restrict oil pressure and flow rate in order to protect each actuator. An RV is comprised of seal parts (O-rings and back-up (BU) rings) and metal parts, and the number of parts is large. Assembly of an RV is done by hand, and developing practical techniques for automatic assembly can reduce the burden on workers, and improve productivity and assembly quality.

This paper describes the development of automation technology for RV assembly work which has achieved improved quality and productivity.

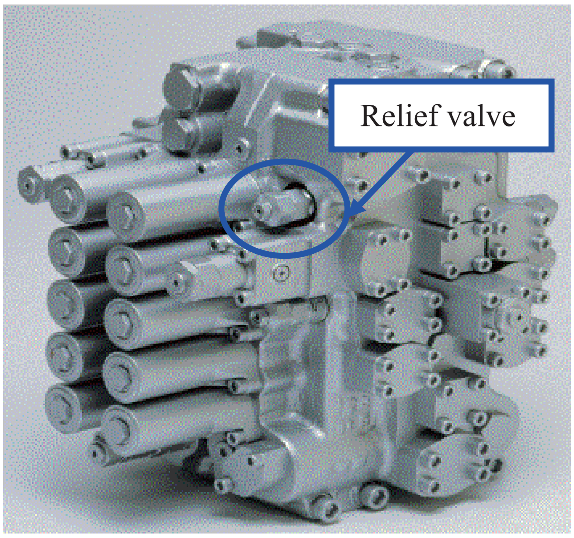

Photo 1 Appearance of control valve

1 Introduction

RVs have been assembled manually. This is because the assembling work requires human skill. For example, RVs need many parts, the parts have to be assembled with small clearance between them, and deformable seal parts need to be assembled. Since the assembled parts have a large influence on the functions of the product, the assembling work has to be carefully conducted with human senses such as visual and tactile senses.

If this work is done automatically, the burden on workers assembling parts can be reduced. However, there are many problems in automating the assembling work. For example, complex technology for assembling the above-mentioned seal parts needs to be developed and measures must be taken to prevent a decrease of the quality assurance level.

In the present work, we developed automatic assembling technology to solve these problems. Not only was the quality ensured but the productivity was also improved by manufacturing and installing mass production facilities.

2 Purpose

Development of automatic RV assembly technology and improvement of productivity by practical applications

3 Challenges

① Machine cycle time: The same as or smaller than the current level
② Productivity of output: 30% increase from the productivity of the existing production line
③ No damage to parts or assembling failure in automatic assembling

4 Requirements

To achieve the targets, we developed automatic assembling technology with the following requirements:

① The order of assembling was determined not based on the order of manual assembling but based on a viewpoint of ease of automating the assembling. The automatic assembling technology should be designed so that the assembling could proceed in this order.
② The technology to be developed should have a quality equivalent to or higher than the quality of manual assembling.
③ The assembling system has to be small enough to fit in the existing space.
④ A mechanism is necessary not to leave defective products for the downstream process.

5 Target products and target processes

Figure 1 shows the appearance of RV components. RVs consist of 20 parts, including 17 kinds of seal parts. RV assembly work consists of a parts assembling process and a parts tightening process. The parts assembling process consists of seal parts assembling and metal parts assembling processes.

The following are the features of the products and assembling process.
① The products have the same parts configuration and the same product number although they have different relief pressure and flow control value.
② Because of the single product number, a set-up change is not necessary in the assembling.
③ The production volume is large since multiple pieces are installed in a major control valve.
④ The product has many soft or compact parts such as an O ring and the assembling work needs the manual skills of workers.

Fig. 1 Appearance of RV

6 Overview of developed facilities

Figure 2 shows the appearance of our developed mass production facilities. The facilities consist of a parts table where operators feed parts to the facilities, an automatic seal-part assembling machine which assembles seal parts to metal parts, and an automatic RV assembling machine which assembles and tightens the metal parts. Each automatic machine has a four-axis joint robot suspended from the top. Therefore, the present system is an integrated system with a robot and various devices.

The major features of the facilities are shown below.
① The facilities have large doors on the front and back sides to ensure maintainability and enhance visibility
② A control panel is installed in the lower part of the facilities to effectively use and save space.
③ For improvement of the workability of logistics staff, a parts feeding area is developed on the back side of the facilities, i.e., the opposite side to the facility operators.

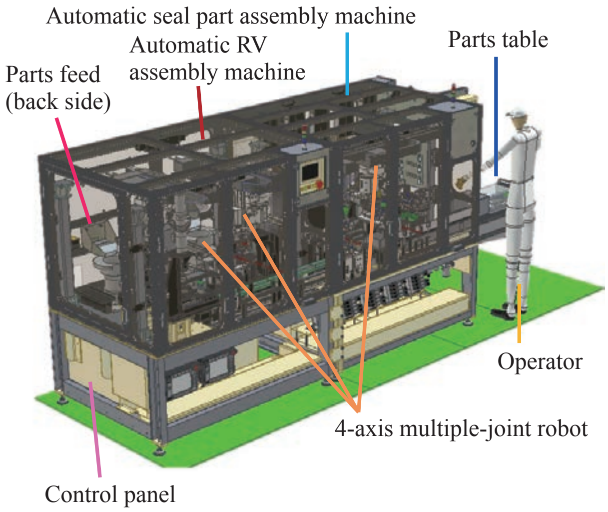

Fig. 2 Appearance of mass production facilities

7 Developed technology

7.1 Development of assembling technology

The work content of workers was analyzed before developing an automatic assembling machine. It was found as a result that they took advantage of human characteristics of smartly using both hands to repeatedly change the orientation of parts. It was easy for human work to change the orientation of parts but a dedicated mechanism and complex facilities would be necessary if a machine was used to do the same work.

However, it was also found that the seal part and the metal part can be assembled from different directions if

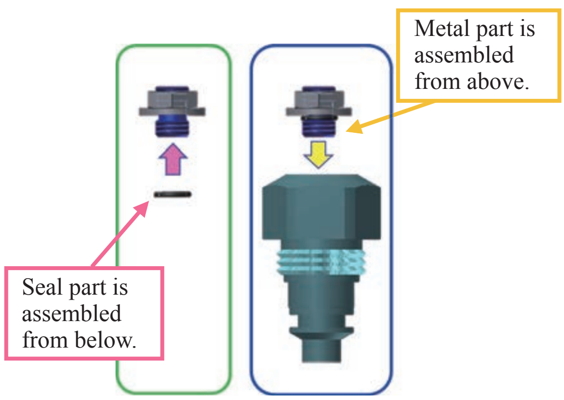

Fig. 3 Difference in assembly direction of parts

the assembling is made on different layers (Fig. 3). So we decided to use a mechanism which first assembles the seal part to the metal part and then assembles the metal part together with the seal part in order to prevent any orientation change of the parts. This realized a simple facility configuration and ensured longer machine time to be used for the assembling work.

7.2 Automatic assembling of seal parts

Here we explain the automatic assembling technology for seal parts. The following need to be taken account of to perform automatic assembling.

① The parts are flexible and hence deformable. (A BU ring has a cut face as it is bias-cut.)
② Since the attachment part has an integrated gutter shape, the seal part diameter needs to be expanded when assembled.
③ There are several points at which the O ring and BU ring are assembled and overlap with each other.

With reference to a support jig for seal parts assembling used in the existing line, we developed a guide jig taking account of the above issues (Fig. 4). The features of the jig are the following.

① The external diameter of the straight part was made larger than the internal diameter of the seal part to hold the seal part by using its strained force.
② The jig has a taper shape with its diameter expanding toward the part attachment point. The seal part expands as it moves along the taper shape.
③ The part position other than the seal-part assembled position is fitted (inserted) to the part attachment hole. So the seal part can be assembled without contacting the assembling position and damage to the parts and seal parts can be prevented.
④ The O ring and BU ring were simultaneously assembled by holding the two seal parts.

Figure 5 shows the way of assembling seal parts by using the guide jig shown in Fig. 4. The seal part put to the guide jig is moved up by the seal part push-up claw along the guide jig. The seal part is then fitted to the designated position.

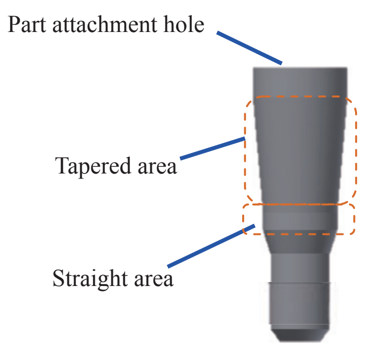

Fig. 4 Guide jig

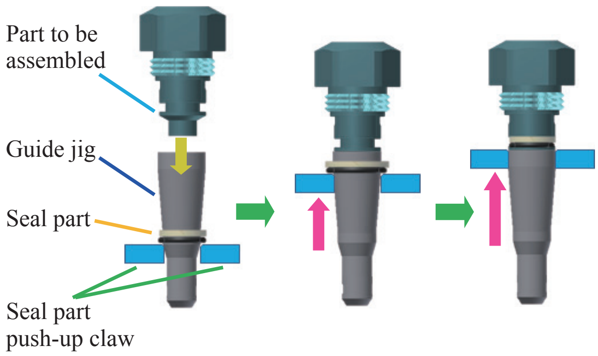

Fig. 5 Seal part assembling method

7.3 Automatic assembling of parts with small clearance

For the present automated assembling work, we introduced a robot which could repeatedly make the same motion and have high precision for the repeated positioning. However, clearance between the main poppet and the piston is smaller than the accuracy of the repeated positioning of the robot (Fig. 6). It would therefore be difficult to realize stable assembling by simple positioning control. In general, the position and force are monitored and corrected by using an image processing device and force sensor. However, additional inspection devices need to be installed for this purpose.

In the present development, we improved the robot software to make the facility configuration as simple as possible. We combined the speed optimization and compliance control Note 1) during the assembling process to assemble the parts with small clearance. Also, galling of the parts during assembling is detected by monitoring the electric current load rate of each robot axis to prevent shipment of defective assembly products (Fig. 7).

Note 1) Compliance control means assembly control by monitoring and regulating the electric current of each motor to realize soft motion of a target object.

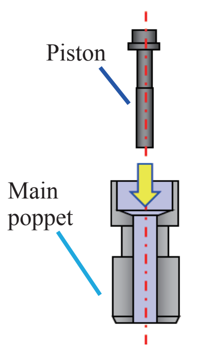

Fig. 6 Assembly with small clearance

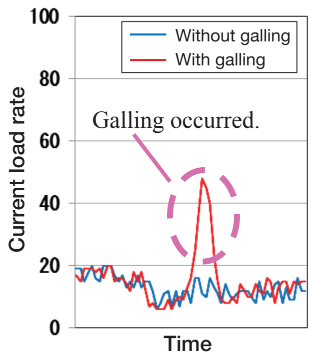

Fig. 7 Change of current load rate

7.4 Automatic tightening of adjuster

Here we explain the tentative tightening way of an adjuster to the plug. The tightening is made only tentatively because final tightening is made in the relief pressure adjustment process Note 2). So the tentative tightening lasts until the O ring assembled on the adjuster comes to the plug.

Note 2) Process of setting the relief pressure of RV

The screw pitch of the adjuster is small and galling could occur when it is tightened. When an operator does this work, he/she has to adjust the pushing force and rotating force to tighten the screw. If galling occurs, he/she can feel it, loosen the screw, and tighten it again.

In the present development, we designed a mechanism of tightening the screw, using a commercial motor of moderate price to detect galling, based on the observation of the operator's work.

The selected motor was a low torque type suitable for tentative tightening. It also has a function of restricting output torque of the motor and can keep the tightening torque almost constant for all products. Also, a mechanism of detecting galling by checking abnormal torque output during tightening was introduced.

An overview of tentative tightening of the adjuster is shown in Fig. 8. The adjuster has a hexagonal hole for the tightening but the phase of the hole could randomly change. To fit in the hole whose phase is changing, a ball-type hexagonal wrench was employed in consideration of availability and ease of insertion. A floating mechanism was used to fit the tool center to the unfixed adjuster.

Then the tool can enter the hexagonal holes of the adjuster even without matching of their phases.

The above tightening system realized stable tightening quality with no failure of tentative tightening.

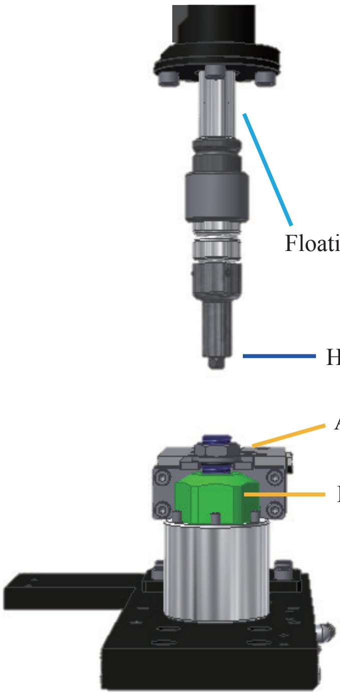

Fig. 8 Overview of tentative tightening of adjuster

7.5 Automatic assembling of small spring

Here we explain the small spring assembling technology. One of the features of the small spring is low rigidity and it being deformable due to thin wire and large ratio of L (length) to D (diameter), which could cause an unstable posture after being assembled.

When an operator assembles the spring by hand, he/she can prevent deformation or falling of the spring and visually check the posture of the spring after assembling it. To do this automatically, it is necessary to introduce a mechanism of preventing assembly abnormality (for occurrence prevention) and a mechanism of detecting the abnormality (for abnormal product shipment prevention).

In the present development, we focused on occurrence prevention and developed an assembly technology for preventing deformation and falling of the small spring. A centering shaft was introduced to the robot hand to bring the small spring, which could easily fall down when assembled, to the target position to enhance the accuracy of the assembling work (Fig. 9). In addition, a bracket is mounted on the device to prevent the small spring from falling after it is assembled and synchronized with the robot's motion of assembling the spring to stabilize the posture of the spring (Fig. 10).

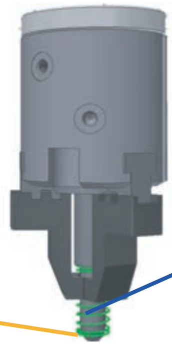

Fig. 9 Hand for small spring

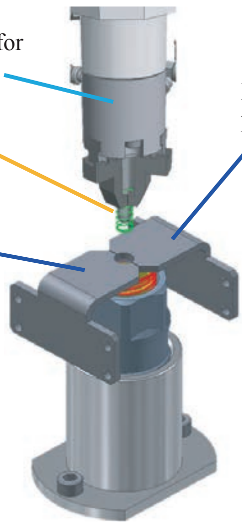

Fig. 10 How to assemble small spring

7.6 Automatic application of grease

RV components make a sliding motion when the pressure is released from the control valve. The component to which the seal part is assembled with the BU ring also slides. To prevent reduction of sliding performance, grease is applied to the seal part. Otherwise the pressure release function is influenced.

When observing the side face of the areas to which the grease was applied, one can find that the BU ring's side face is plane and the O ring's side face is curved (Fig. 11). To realize an automatic mechanism of uniform grease application, the grease application needs to be adjustable for various shapes of the surface.

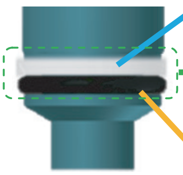

Fig. 11 Magnified view of grease application surface

A transfer-type grease application method (Fig. 12) using an extendable roller was developed. Grease fed from a grease feeder is transferred to the roller and then to the parts.

Here is how to apply grease. A roller applies grease to the exterior of the part fixed in front of the roller while moving back and forth. The roller arm has an extendable mechanism to make the roller follow the exterior surface of the part for uniform application of grease. It is difficult for workers to deliver a stable application of grease. The present method can apply a constant amount of grease, realizing stabilization of the grease application quality.

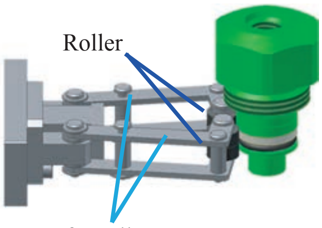

Fig. 12 Overview of grease applying device

7.7 Making facilities compact

The automatic assembling facilities explained in Sec. 7.6 and preceding sections are expected to be installed in an existing space which has been used for manual assembling work. Namely the facilities have to be made compact.

The following measures were taken to make the facilities compact.

① Use of a multi-joint robot suspended from the top allowed effective use of the space under the robot.

② The facilities were made compact by not using a general parts feeder for parts supply but developing our original picking machine.

When deciding to use the suspended robot, we were concerned about the influence of insufficient rigidity of the facility frame on the assembly performance (Mount area deviation due to robot motion: 0.3 mm or smaller as recommended by the manufacturer). So we undertook structure analysis of the frame (Fig. 13) and determined the frame size and beam structure based on the analysis result. As a result, assembling performance degradation due to insufficient rigidity after the installation of the facilities could be prevented.

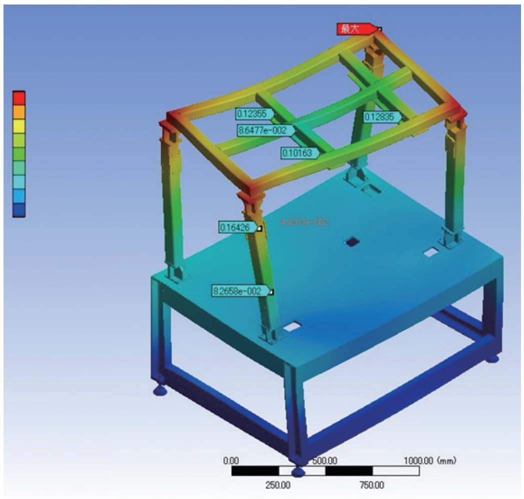

Fig. 13 Result of structure analysis of facility frame

7.8 Countermeasure against shipment of defective products

Introduction of the automatic assembling technology must not result in shipment of defective products having assembly abnormalities. The following functions were introduced to prevent such inappropriate shipment.

① Check on presence/absence of large and small assembled springs

It was difficult to detect the large and small springs assembled concentrically because both springs were made with thin wires and the spring phase randomly changed. To solve the problem, we focused on the difference in the number of turns of the springs and used a belt-shape laser sensor. The presence of each of the large and small springs was detected based on the difference of the shielding quantity (Fig. 14). The thin-wire springs can be detected as the light from the laser sensor goes straight. With the sensor array, the springs can be detected even if their phases randomly change.

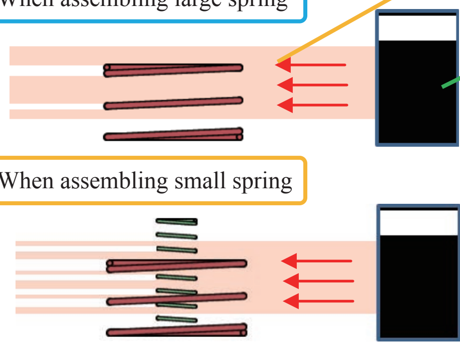

Fig. 14 Sensor to find assembled large and small springs

② Check on good/defective condition of assembled seal part and check on presence/absence of applied grease

The O ring and BU ring are assembled in a specific order. The sealing performance would decrease in case of a lack of parts or wrong order of assembling and it is necessary to check the assembling condition of the facilities. Previously, operators visually checked the assembling condition when they assembled parts. Instead, we installed an image processing device in the facilities to inspect all products for the prevention of automation-caused quality degradation.

The exterior color of the seal part is used to detect the part, and the presence and assembling condition of the seal part are judged based on the ratio of the area occupied by the designated color to the designated area (Fig. 15). Also, the presence of grease is checked based on the color of applied grease on the exterior of the part, which is done by the above-mentioned image processing device used to check the assembling condition.

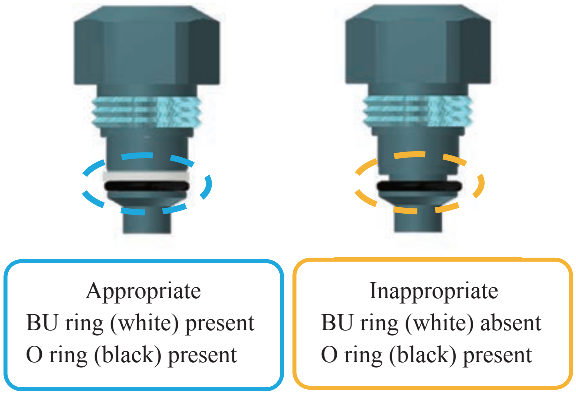

Fig. 15 Check for presence of seal part

8 Achievement of the work

① Machine cycle time: The same as or smaller than the current level
② Output productivity: 23% increase from the productivity of the existing production line
③ No damage on parts or assembling failure in automatic assembling

The target of the output productivity could not be reached. Improvement activities will continue to reach the target.

9 Concluding Remarks

New technology necessary for automating RV assembly work was developed and facilities with the new technology in place were introduced. The facilities could improve productivity.

Automatic assembly of seal parts, which had been considered difficult, was successfully developed. This technology can be used as the basis for future automated systems.

Our developed technology can be applied to work processes whose automation has not been realized because of difficulties. We would like to use the technology when a highly competitive production line is constructed.

Lastly, I would like to thank the company staff who supported me during the development and installation.

Author

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Launch of Takako Vietnam MMP Production Line

KAMIYA Hotaka, KAMENO Shota

1 Introduction

The mini motion package (hereinafter referred to as MMP) made at KYB Gifu East Plant is a compact electric hydraulic linear actuator in which an electric motor, hydraulic pump, oil tank, and cylinder are integrated (Photo 1).

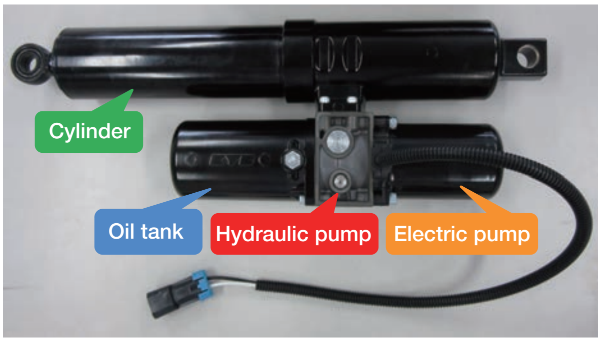

Photo 1 Mini Motion Package (MMP)

MMP is mostly used as an actuator mounted on agriculture vehicles such as combines and pesticide spraying machines, and its major markets are Japan and North America.

To reduce MMP production costs and promote overseas expansion, KYB planned to launch a new line at an overseas production site.

According to the plan, an MMP production line was launched at Takako Vietnam Co. Ltd. (hereinafter referred to as TVC), a 100% subsidiary of Takako Industries, INC, (hereinafter referred to as Takako), which is a group company of KYB.

In this report, we introduce the MMP production line at TVC's second plant (Photo 2) launched in September 2014 as the second MMP production base site following the one in KYB Gifu area.

2 Overview of plant

TVC is a local subsidiary in Vietnam established in 2003 and more than 800 employees work there.

The plant is located in an industrial park near the large city of Ho Chi Minh in southern Vietnam, about 24 km from Tansonnhat International Airport (Fig. 1).

Photo 2 Exterior view of Second Plant of TVC

Fig. 1 Location of TVC (Google Map)

The industrial park was constructed by the governments of Vietnam and Singapore and has a complete infrastructure such as electricity, water supply, and sewage. TVC has two factories in the park, each of which has two buildings: A and B.

The newest building was the second plant's building B constructed in 2013, and it was planned to install the production line of MMP as the first line in building B.

3 Schedule of launching the line

Mass production was planned to start in August 2014 and the following schedule was made.

① Trial operation and training in Japan: Middle of April, 2014
② Delivery and installation of facilities: End of May 2014
③ Launch of TVC local line: Middle of July, 2014
④ Start of mass production: August 2014 or later

4 Concept of MMP production line

Based on the following concept for the production line, the production process and layout were discussed with local staff of TVC in TV meetings and through emails.

① Process that prevents defective products from being discharged even when unskilled operators are working (More mechanisms to prevent failure and avoidance of operations that rely on operator's intuition or short-cuts)
② Facility specifications with safety mechanisms to prevent disasters
③ Installation of the assembly line inside partitioned area with air conditioner to prevent contamination
④ Line layout that allows increase/decrease of operators depending on a change of production quantity
⑤ Making parts supply system for reduction of in-process inventory with physical distribution flow taken into account (Fig. 2)

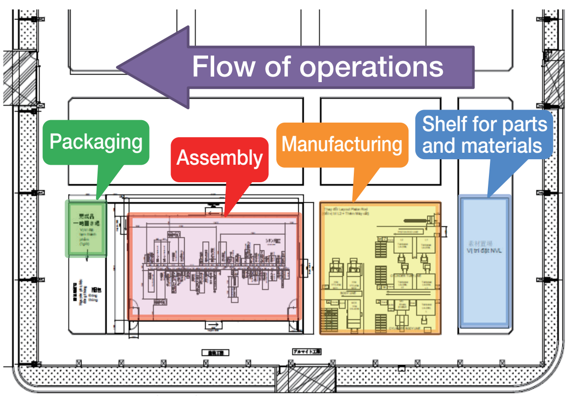

Fig. 2 Factory layout

In particular, as for ①, hammering work for mounting by skilled workers was discontinued in Japan and a new mounting machine was developed and introduced.

5 Problems of launching the line

There were problems, shown below, in launching the MMP production line of TVC.

① Launching of the production line in a short period of time
② Operation training for local workers
③ Education of local engineers about products and facilities
④ Construction of logistics system

Mass production began one month behind schedule due to a delay in the tentative launching in Japan. However, since thorough checks and improvements could be made in advance, the launch at TVC went relatively well.

6 Launching of the line

6.1 Preparatory work in Japan

We only had about two months for the production line launching work from delivery of the facilities to start of mass production, and the deadline would be missed if a check of the processing ability of the facilities, preparation of necessary jigs, preparation of documents, and other work were conducted after the delivery of the facilities to Vietnam.

So, we launched the line and made an in-company audit of the production process in Japan before the shipment (Photo 3).

Photo 3 Launching of assembly line in Japan

For the process audit in Japan, the same requirements used for actual line launching were used. Evaluations of the following items was made.

① Does the production process secure the quality of products?
② Is there any problem in the quality of assembled prototypes?
③ Are the specifications required by TVC satisfied?
④ Are the facilities and production process safe?
⑤ Are a condition table and instruction manual available?
⑥ Are a parts-feed lane and tote box prepared?
⑦ Can the facilities be operated as designated in the instruction manual?

In the evaluation, performed together with staff from related divisions, prototype products were actually assembled in the developed line to find any problems in

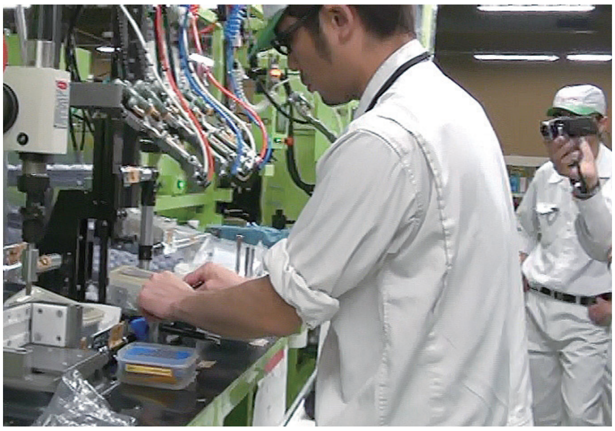

Photo 4 Check of line work

each of the assembled products (Photo 4).

As a result, problems were identified from various viewpoints and the production process could be improved before the shipment of the facilities.

6.2 Specifications of facilities for overseas sites

The following points were taken into account in the specifications as the facilities were the first MMP facilities for overseas.

① Conformance with local electricity conditions
② Countermeasures against high temperature and humidity
③ Display descriptions written in both Japanese and English or switchable between Japanese and English.
④ Work place height suitable for average height of local workers

The power supply frequency is 60 Hz in the KYB Gifu area and 50 Hz in Vietnam. The machine was designed to use either frequency or to have inverter control. Also, a protection circuit against power failure was introduced.

Southern Vietnam where the factory is located is a tropical area. In particular, it is very humid in the rainy season. So, the facilities could have rust and the control equipment could break down. Regarding this point, we collected information from local staff and people from the company in Japan to determine the specifications of the rust processing and control panel.

Another unavoidable problem in overseas business expansion is language. It would be better if descriptions in the production line could be written in Vietnamese, but the KYB staff could not write Vietnamese. Therefore, English was used to write the descriptions. Since there were many product-specific terms and there were no translation standards for the terms, they needed to be translated one by one.

We tried to use easy English because the local workers could not understand difficult English words.

6.3 Installation of facilities at TVC

The local staff of TVC installed the facilities and partitions for air conditioning and connected the power supply and pneumatic source.

Directions given from Japan were only for the specifications, installation position, and installation height of the facilities and the local engineers were allowed to

Photo 5 Installation of assembly line

determine the details. The installation was completed successfully and the engineers seemed to get used to the installation of the facilities (Photo 5).

6.4 Trial operation adjustment and production trial

After installation of the facilities, bolts, wires, and pipes were further tightened and the facilities were inspected to make sure there was no machine damage that could be caused in the delivery.

In the trial operation, air pressure, oil pressure, oil amount, and sensor positions were adjusted and automatic cycle operation was performed to check each process quality.

As mentioned above, the power frequency is different between the Gifu area, Japan and in Vietnam. This causes a change in the motor rotation speed and reduces the flow volume of the hydraulic pump. However, the designated flow could be achieved by anticipated valve operations.

6.5 Operation training for local workers

The MMP assembling line requires a lot of manual operations and hence the performance of the line directly depends on the skill level of operators.

Therefore, skilled Japanese workers conducted training and guidance (Photo 6).

Photo 6 Training of workers

In the training, handling of quality issues and infrequent operations were explained to improve the on-site capabilities of the workers.

6.6 Education for local engineers

For the launching of the production line, it is necessary for local engineers to maintain the facilities and deal with problems.

So, we issued a manual for facilities inspection and calibration steps and educated the TVC engineers (Photo 7).

Photo 7 Training for facility inspection procedure

Also understanding the structure of MMP is necessary to grasp its production process. For example, when a non-standard MMP product is found in the performance test, one can identify the cause if he/she knows the product structure.

So, we taught the engineers about the mechanism of MMP using drawings and hydraulic circuit diagrams and explained to them about how the products were used by end users, to let them realize the importance of the management items (Photo 8).

Photo 8 Explanation on MMP structure

TVC engineers were studious and had a strong sense of responsibility. They asked a variety of questions.

I had a hard time to logically answer them and strongly realized my lack of knowledge, although I was motivated by their enthusiasm.

6.7 In-company examination and customers' approval

After the line construction, training, and production trials, an in-company examination was conducted by the quality assurance groups from Takako, TVC, and KYB (Photo 9).

Photo 9 TVC's in-company check of the line

The process audit had already been made in advance in Japan but the production line improvement was performed based on some comments from TVC and Takako. These comments were made because of incomplete prior agreement on the line specifications. This problem should be fixed in future.

There were also some comments on the processing ability of the parts and the worker education level. Because of the comments, the facilities failed to pass the examination. After countermeasures were taken, they finally passed the examination a week later.

After passing the in-company examination, we had a customers' examination at the end of August 2014, received approval for acceptance of products, and began mass production.

6.8 Start of mass production and first shipment

The MMPs produced at TVC are all exported to foreign countries. They are packed in a dedicated cardboard box and shipped from the board pallet (Photo 10).

Photo 10 Packaging and shipping of MMP

Everyone was pleased when the first MMP produced at TVC was packaged for shipment.

7 Example of problems in on-site launching

7.1 Dew condensation and rust

Although expected in advance, the problem of dew condensation and rust arose immediately after the launching of the production line.

The air conditioner kept the temperature constant inside the partitions. However, workpieces and facilities in a place where cool air directly came from the air conditioner had dew condensation and parts with little rust resistance quickly became rusty (Photo 11).

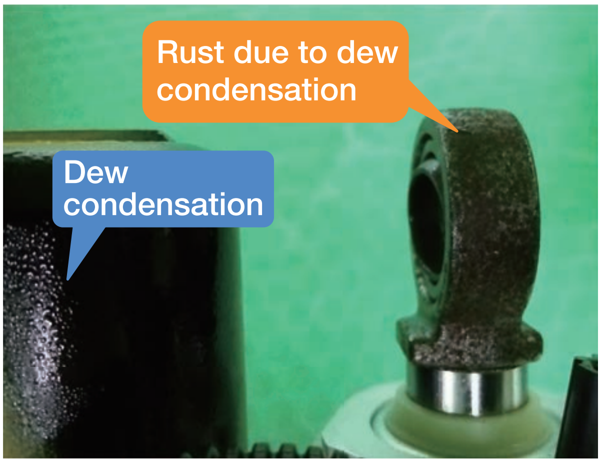

Photo 11 Dew condensation and rust of workpiece

In particular, the temperature-controlled hydraulic oil pipes had significant dew condensation and even had water dripping from them (Photo 12).

Photo 12 Dew condensation of hydraulic pipe

We therefore adjusted the temperature and wind direction of the air conditioner to prevent the workpieces from being cooled excessively. We also used heat insulating materials to cover the pipes.

These countermeasures prevented dew condensation and rust.

7.2 Parts precision problem

Machining and procurement of parts on-site are a major problem in overseas production.

For the MMP production line, a cutting process of major parts was constructed at TVC and local procurement of small parts was promoted. The precision of the parts was high enough but problems related to assembling failure occurred frequently. This was because the precision of the products processed in Japan was much higher than the standards given in the drawings or because burnishing or small deburring, not specified in the drawings, occurs on actual products, which results in differences from the drawings. These problems could affect the failure incident ratio of the assembly process.

For future promotion of part procurement on the spot, the exact designation of drawings needs to be made in collaboration with associated departments

If products are machined and assembled in the same factory and the assembled products have no particular performance problem, the machining precision of the parts would not be a big issue. However, if the parts are exported from KYB to overseas, they could be judged as defective in the acceptance inspection. This is due to a difference between the parts machining performance and the design specifications. The difference is not allowed for overseas expansion of business.

8 Change of paint in cylinder painting process

8.1 Elimination of hexavalent chromium

After being assembled, the MMP cylinders are painted in the existing painting line at TVC.

In general, the adhesive strength of paint is weak on aluminum materials and etching primer is used for primer coating to ensure the adhesive strength of black paint.

However, the etching primer contains hexavalent chromium, an environmentally hazardous substance, so we decided to change the paint material to one not containing hexavalent chromium to meet customers' requests.

We therefore discontinued the use of the etching primer and changed the coating to a single coat with highly adhesive black paint for the improvement of the pretreatment cleaning.

8.2 Introduction of pretreatment cleaner

Previous pretreatment cleaning processes were manually conducted by using white gasoline.

To maintain the paint quality after the discontinuance of the etching primer, a new cleaner was introduced for automatic pretreatment cleaning using an iron phosphate chemical conversion coating agent (hereinafter referred to as pretreatment agent). In order to maintain the painting quality even after the elimination of etching primer, a new cleaner was introduced to realize automatic pretreatment cleaning.

A pretreatment agent was chosen for future application to iron products such as HST[Note 1)].

Note 1) Abbreviation of Hydro-Static Transmission, which is a hydraulic change gear mounted on agriculture machines.

The cleaner was manufactured in Japan and installed at TVC after a paint test was made to check the quality (Photo 13).

Photo 13 Preprocessing cleaner (Right: Preprocessing, Left: Cleaning)

8.3 Appearance change due to change of paint

The surface texture of the cylinder changed due to a change of paint. We therefore needed to make the appearance acceptance criteria again and take the following measures.

① Replacement of photos used for appearance acceptance criteria
② Re-training of examiners to judge appearance
③ Re-production of a sample of a defective product

These measures are necessary for appearance quality control at overseas sites. The measures were taken mostly by the TVC Quality Assurance Department and mass production could be started by using the new painting.

9 Future development

MMP production began at TVC, but the production line can realize higher productivity.

The production quantity needs to be increased by switching MMP production in Japan to production at TVC. Also, quality improvement and cost reduction need to be aimed at to expand the demand for MMP.

At present, the rate of procurement of MMP parts on the spot is low and the cost could be reduced by increasing the rate.

Procurement of parts on the spot is also essential for reduction of part inventory and will be promoted collaboratively with associated departments.

10 In Closing

I had a valuable experience in various aspects including technology in the launching of the first overseas site line.

Some problems, which were only potential problems in Japan, actually occurred. I think I developed a new viewpoint through this experience to handle domestic business.

I was also anxious about life and work in Vietnam during my stay. However, the people in TVC helped me a lot with private and business matters, so I could have a fruitful life in Vietnam (Photo 14).

Photo 14 Dinner with TVC staff

I hope for further friendships between and the future development of KYB Japan and TVC Vietnam, and would like to thank the staff there.

Authors

KAMIYA Hotaka

Joined the company in 2011. Second Production Engineering Sect., Gifu South Plant, Hydraulic Components Operations. Mostly engaged in construction and improvement of machining and assembling lines of industrial hydraulic machines.

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Introduction

Development of Nakanojo Factory

MIYAZAWA Koichi

1 Introduction

After a business tie-up with Kayaba Kogyo Co. Ltd. (currently KYB Co. Ltd., hereinafter referred to as KYB) in 1972, KYB-YS Co. Ltd. (hereinafter referred to as YS) began production of hydraulic cylinders in 1973. Since then, the company has been manufacturing self-distributed products. In 2009, the company shifted its main cylinder products to KCM (KYB-Cylinder-Medium pressure) products, and the current sales of the hydraulic cylinders count for about 35% of total sales of the company. So the hydraulic cylinders are now the company's core product.

The hydraulic cylinders manufactured by YS are mostly for mini shovel machines and small shovel machines and are delivered to domestic and overseas construction machinery manufacturers. The current situation of the cylinders for small construction machines is as follows:

① The company has been losing its advantage because of the improvement of the basic quality of foreign products.

② A considerable productivity increase is necessary to survive in the global market because domestic construction machinery manufacturers have begun to employ more foreign products due to the strong yen.

A new factory construction project was launched in FY2011. In FY2012, the project changed to a hydraulic cylinder CHC (Challenge to Half Cost) project. This project aimed not only to improve production processes but also to construct the world's best cylinder production factory with attention paid to the entire process from receiving materials to shipping products. In February 2016, the existing line was re-organized and a new production line was launched (Photo 1).

Photo 1 Exterior of plant building

2 Overview of factory

The land for the new factory was bought in September 2008. The capital investment plan was suspended and re-examined after the Lehman Shock. Since March 2011, the old buildings have been dismantled, the land has been developed, and the production lines have been constructed (Table 1).

The land area is 45,576 m^2 and total floor area including product storage and material storage is 11,432 m^2 (Photo 2).

The withstanding load of the floor is 2 ton/m^2 and there are about 150 production machines in operation.

For the air conditioning of the factory, EHP (Electric Heat Pump) is used. The temperature is controlled to be 20°C in winter and 28°C in summer.

Table 1 Timeline

Item	Month/Year
Start of construction	11/2012
End of construction	7/2013
Start of A line	3/2014
Start of C line	9/2015
Start of B line	2/2016

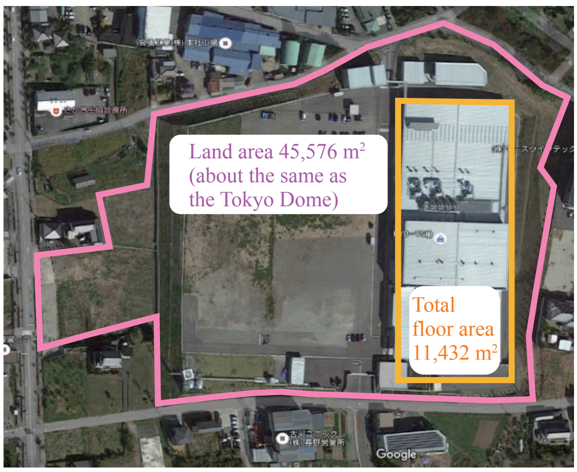

Photo 2 Complete view of plant (Google Map)

3 Concept of Nakanojo Factory

Under the concept of aiming to be the world's best hydraulic cylinder factory, the following four items were focused on.

① Organizing logistics in the factory
② Shortening production lead time and reducing intermediate products in progress
③ Energy saving at the factory
④ Making the factory environment clean

3.1 Organizing logistics in the factory

For organizing the logistics in the factory, the factory layout was determined so that materials are delivered from the south of the factory and products are shipped from the north (Fig. 1).

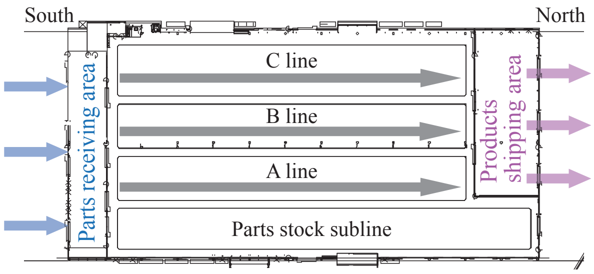

Fig. 1 Logistics line in plant

The rule of the logistics is determined as follows:

① Fixing the time of receiving and shipping items
② Setting the timing of line feed of each part
③ Bare parts transfer Note 1)
④ Parts supply from the corridor using the feed lane (Photo 3)

With the rule, we could reduce the transfer loss and decrease the number of handling steps.

Note 1) A method of feeding parts without using a tote box to avoid unnecessary empty box management (Photo 3).

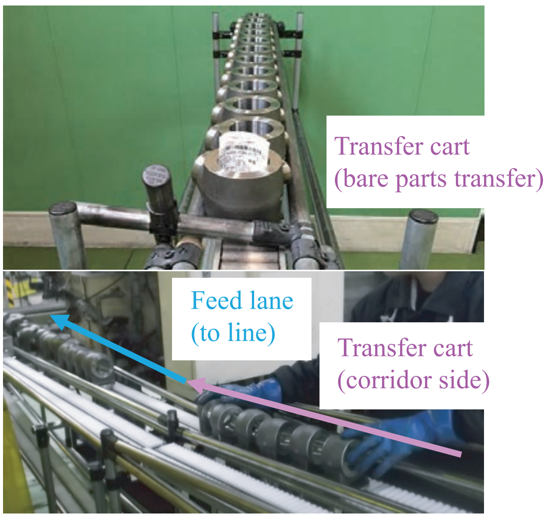

Photo 3 Bare parts transfer cart and feed lane

3.2 Shortening production lead time and reducing intermediate products in progress

The conventional type of factories have separate tube processing lines, piston rod processing lines, assembly lines, and painting lines and there are branches and confluences that could cause a lot of intermediate in-process inventory.

To solve this problem, the development of a "straight line" with the tube, rod, assembly, and painting processes being integrated was aimed at (Fig. 2).

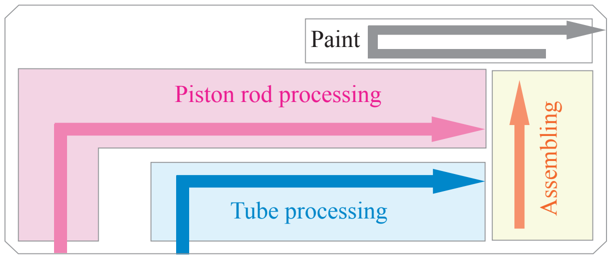

Fig. 2 Straight line layout

The following are necessary to develop a straight line.

① Leveling of facility MT
② Reduction of handling time
③ Reduction of setup time
④ Optimization of production direction (on the number of lots and timing)

A balance sheet was created for each of the products and improvement points were identified in advance. Then the existing facilities were remade to meet the specifications of new facilities.

Collaboration of the associated departments realized improvement of handling and setup processes and achievement of the target of the production line.

The tube processing line and the rod processing line were placed face-to-face to check the status of the production at any time.

As a result, the straight line (Photo 4) could be constructed. With the line we could considerably reduce the production lead time (by 85%) and intermediate in-process workpieces, which resulted in the decrease of the transport carts by more than 90%.

Photo 4 View of straight line

3.3 Energy saving at the factory

① Installation of solar power generation panels on the roof (Photo 5)
② Use of LED for factory lighting (Photo 6)
③ Installation of a compressor room on the second floor of the central factory to reduce loss of factory air pressure

The factory energy is thus saved.

Current solar power generation is up to 10 kW/h and more panels can be installed to achieve 50 kW/h.

Photo 5 Solar power generation panels on the building roof

Photo 6 LED light in plant

3.4 Making the factory environment clean

As a countermeasure against contamination, air supply and exhaust balance was taken for plating and painting and a system of keeping the room pressure positive (Photo 7) was installed to prevent dust from entering the room when the doors or shutters were opened.

A top plate was installed above the assembly line to prevent foreign objects from falling. Internal seal assembling was made in the integrated line (inside partitions) to prevent contamination.

Photo 7 Air supply system outside and inside the plant

4 Newly employed Technology Introduction

Here we introduce a technology we employed for the first time for YS hydraulic cylinders in the new production line at Nakanojo Factory.

4.1 Friction welding after plating of piston rod

Friction welding of the piston rod and rod head needs to be made after the plating to develop a straight line (Fig. 3). So the following two measures were taken.

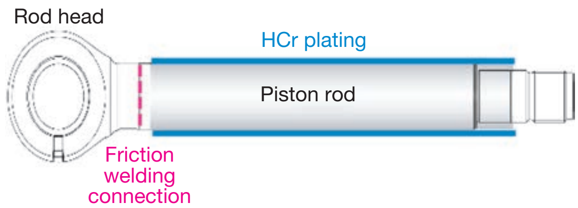

Fig. 3 Illustration of piston rod

(1) Establishment of power feed method for piston rod plating

In conventional plating, the connected width across the flat area of a rod head is used as the power feeder.

A power supply method for plating in a single item state at the new factory was studied by designing the power supply unit and power supply jig and masking shapes. After trial and error, a single-item power supply method shown in Fig. 4 was developed.

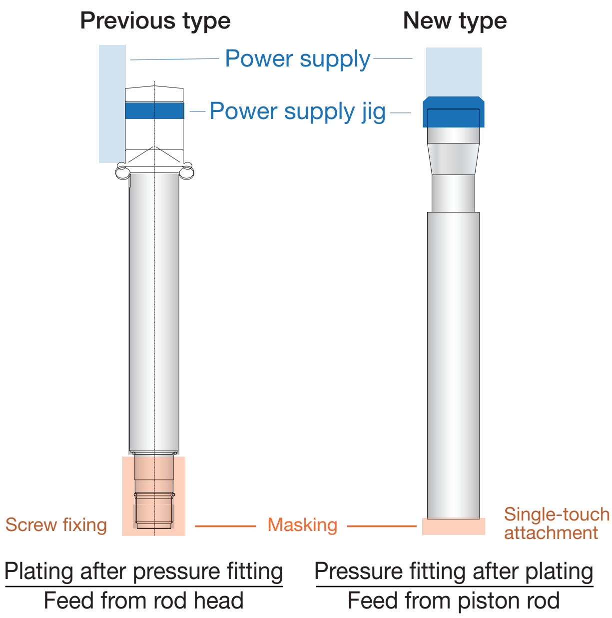

Fig. 4 Plating feeder

(2) Prevention of indentation of plated sliding part

We were concerned about the occurrence of indentation on the sliding part in the friction welding after plating.

However, indentation was prevented by changing various conditions and the material and shape of the jig.

4.2 In-house processes of induction hardening and tempering

In-house processes were developed to reduce variable expense.

Setting of the facility specifications and conditions and quality check could be done in collaboration with staff from associated departments in the KYB group and the system was launched immediately with the quality target, MCT target, and schedule target being satisfied (Photo 8).

Photo 8 High-frequency hardening and tempering

4.3 In-house manufacturing of major components of hydraulic cylinders

In-house processing of four kinds of components, namely, rod heads, pistons, cylinder heads, and cylinder bottoms was developed (Fig. 5).

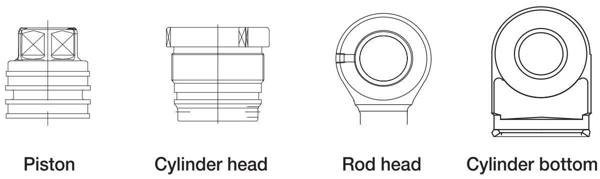

Fig. 5 Four major components

The specifications of the facilities were determined for mold turning in the mass production process by referring to the case of KYB Gifu Higashi Factory, and the group members collaboratively worked on the development of the facilities.

We followed a trial-and-error process for the way and mechanism of giving production direction so that we could establish a production system paying attention to the entire process from receiving materials to parts supply to each line (Fig. 6).

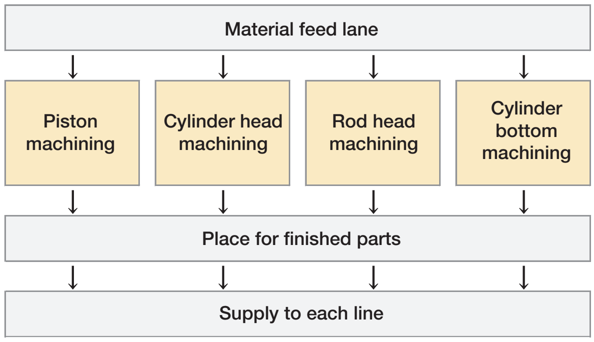

Fig. 6 Layout of component machining processes

5 In Closing

The factory construction of YS was the first one since the construction of the valve factory in 2006. However, there were no preceding cases of factory construction involving land development, line development, and line transfer. The construction project was so large and took about eight years from purchasing the land to starting mass production in all the production lines.

The entire production of hydraulic cylinders had to be maintained during the construction and launching of the factory. So, the production department manufactured the cylinders for stock and many staff members collaboratively worked on the transfer of the existing facilities in a short period of time.

In the factory construction, various laws including the building act could be complied with thanks to the support of many departments. I would like to thank NIPPO Corporation and department staff of the KYB group for their considerable support.

Author

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Introduction

Aim for Gold Medal in 2018 Pyeongchang Paralympics

OGURA Hideaki, ISHIHARA Wataru, SUZUKI Takeshi

1 Introduction

KYB began providing shock absorbers for Alpen ski sit ski competitions at the Nagano Paralympics in March 1998. It provided shock absorbers and technical support for sit skiing of the national team at the Salt Lake, Torino, and Vancouver Paralympics, contributing to their winning medals.

After the Vancouver Paralympics, KYB's project associated with sit skiing became less active when the national team organization changed, resulting in lack of connection and communication with the national team. Also, a Japan agency of a shock absorber manufacturer in Europe, which had significantly increased its share among the top European athletes, proposed technical support for Japanese athletes. A test was made to check the performance, indicating that these shock absorbers were better than those of KYB. Therefore, the Japanese athletes employed the European shock absorbers, as did the top European athletes, in the Sochi Paralympics.

In this report, we explain our activities to help the national team athletes win gold medals at the Pyeongchang Paralympics in March 2018.

2 Take up the challenge again!

We, as a KYB group member, reviewed past activities and decided to undertake a sit ski project again not only for social contribution reasons but also to improve our technology for developing shock absorbers for sit skis, develop human resources, and establish KYB's brand image.

The design, development, and technical support of sit ski shock absorbers were all entrusted to the Technology Department of KMS (KYB Motorcycle Suspension Co., Ltd., which separated from KYB on October 1, 2013), a department for designing motorcycle shock absorbers that had a long experience history stretching back to the Nagano Paralympics.

The development staff of the KMS Technology Department joined the training camp of the national team in February 2015. A newly designed shock absorber was delivered to the camp and comments and product evaluations were collected from the athletes (Photo 1).

The national team athletes had extremely high physical ability levels and we almost forget about their disabilities. From their experience as top athletes, they required higher level of specifications than expected for the shock absorbers, which worked as their legs. We found from their behavior and speech that the athletes were "real professionals." So we thought that we could gain their trust only when we put our entire heart and spirit as engineers into the development project.

Photo 1 Test at training camp

3 System improvement for continuous support

KYB became an official sponsor and official supplier of the Alpen Ski National Team of the Japan Para-ski Federation in August 2015.

As official sponsor and supplier, KYB could further strengthen product supply and technical support for athletes of the national team. KYB could also use its logo on the uniforms the athletes and staff wore (Photo 2).

Photo 2 Athletes in kits with KYB logo

4 Product overview

The sit ski shock absorber was developed based on a gas-charged shock absorber for motorcycles. Its cylinder size, gas tank shape, total length, and stroke were all developed for sit skis. Seals and working oil developed for snowmobiles were also used to maintain the performance in extremely cold weather. The gas tank was designed to have a separate tank structure to secure the gas volume as much as possible. The sliding performance was improved by using a **DLC** (Diamond-Like Carbon: See "DLC" on page 58 of the Glossary) piston rod. The operability of the damping force control was improved by employing an integral adjuster [Note 1)] used in a motocross shock absorber. The state-of-the-art mechanisms of sport shock absorbers were thus used.

In the development, we aimed to make the spring and damping force properties fine-tunable for each national team athlete to extract maximum ski performance (Photo 3).

Note 1) Integrated mechanism of adjustment function of the elongation side damping force and the compression side damping force, which are often positioned separately in conventional shock absorbers, for immediate adjustment on a ski course.

Photo 3 KYB's new type shock absorber

5 Start of development and use in actual events

The development of a new-type sit ski shock absorber began in autumn 2014. At that time, European commercial shock absorbers were ranked highest to use for sit skis and most Japanese athletes used them. For the second challenge, KYB aimed to completely surpass the performance of the European shock absorbers. In the prototype development, we examined the damping force, weight, and other specifications of the competitive products as far as we could.

We had a chance to provide our first prototype to the athletes at the training camp of the national team in Sugadaira Ski Resort in February 2015 and let them try to use the new KYB shock absorber. When the prototype was attached to the frame, the attachment bracket had to be additionally machined. Also, interference between the bracket and the frame, which had not been noticed in a static position, occurred due to insufficient dynamic analysis. However, the shock absorber could be successfully attached with help of the athletes and the test result was highly satisfactory.

After the training camp, the athletes told us that they wanted to use the KYB shock absorber in the next World Championships. So we provided the prototypes of the original form to two athletes including Takeshi Suzuki, a slalom race gold medalist in the Sochi Paralympics. The athletes participated in the World Championships in March 2015 without sufficient training using the KYB shock absorber; however, Suzuki won a gold medal in the slalom race using the new shock absorber.

6 Support for tour abroad

In our re-challenge, we realized success in the first year although we found through the international races some problems with the shock absorber. Intensive tests had been conducted by the end of the 2014/2015 season. Additional tests in a foreign country were necessary because it was difficult to adjust the shock absorber for actual races due to condition problems related to snow and courses.

The new team's first overseas training camp was in New Zealand (Photo 4).

Since we had enough time for the test in the New Zealand training camp, we could communicate with the athletes. Therefore, we could reconsider the national team's reasoning about the shock absorber setting (skiing with the deep stroke position of the suspension kept at a turn). We proposed to realize full performance of the shock absorber by increasing the damping force. The athletes at first felt uneasy but gradually got use to the setting as they skied. As a result, they understood the potential of the product and the possibility of future performance improvement.

Around that time, the relationship of mutual trust between the athletes and the development staff deepened and both parties could share the direction to pursue. Under this relationship, specification improvements accelerated. As a result, the technological level of the shock absorber became high enough to win a gold medal in technical athletic events such as the slalom.

On the other hand, performance in high-speed events such as the downhill was found to be insufficient in major competitions. At first, we tested the shock absorber with focus on technical events such as the slalom and giant slalom. For these races, the stroke of the suspension should be fully used to absorb ragged snow courses, as in motocross races. However, it was found that the setting concept of the shock absorber employed by the development staff and the Japan national team for the high-speed events was different from that used by overseas high-ranking athletes. In summer 2016, we joined a high-speed race training camp in Chile, South America for specification development and technical support dedicated to high-speed events.

Photo 4 Expedition in New Zealand. Adjustment of shock absorber on ski course

7 Challenge of Takeshi Suzuki

This chapter was written by the Sochi Paralympics gold medalist, Takeshi Suzuki, who entered KYB on August 1, 2015.

The following is the history of Takeshi Suzuki.

1997: Began sit skiing when he was a 3rd grade elementary student.

2003: First participation in Alpen Ski World Championships when he was a 3rd grade junior high school student.

2006: Participated in the Torino Paralympics when he was a 3rd grade high school student.

2010: Participated in the Vancouver Paralympics when he was a college senior. Won a bronze medal in the giant slalom.

2013: Secured overall World Cup title.

2014: Won a gold medal in the slalom at the Sochi Paralympics and a bronze medal in the downhill.

2015: Secured overall World Cup title for the second time.

7.1 Victory with KYB

When I heard that KYB would restart support of the sit ski national team from the second half of the 2014/2015 season, I was half pleased and half uneasy.

I won a gold medal at the Sochi Paralympics using the European shock absorber and so I initially thought that I wanted to choose the most suitable products for races or courses. However, I also thought that I would not grow as an athlete if I pursued stability.

When I was struggling with this conflict, I saw the development staff working at the training camp and actually used the KYB shock absorber. Then I realized that, with these development staff and the company, we together would be able to develop a new product to win a medal by the next Paralympics. Only a month was left to the World Championships, the most important competition in the season, but we decided to use the KYB shock absorber and removed (cut out!) a part of the sit ski frame and attached the shock absorber to the frame.

Usually, a new type of shock absorber the athletes were not used to would not be used in such an important competition. However, we were not anxious but rather excited.

The result was not very good in the high-speed races, but a gold medal was won in the slalom, which Japan was good at (Photo 5), verifying the high performance of the KYB shock absorber.

Photo 5 Won a gold medal in Alpen Ski Slalom in 2014/2015 season.

7.2 Challenge as KYB employees

After the Sochi Paralympics, I strongly wanted to change my environment. At that time, I was introduced to KYB. However, I had already witnessed the work of the development staff at the training camp in Sugadaira and had thought, “I want to work for a company with these people.” Since I liked cars and wanted to work for a car component company, I decided to work for KYB. I thought that this was desitiny.

After entering the Public Relations Dept., Corporate Planning Headquarters, I have tried to advertise KYB through lectures or sit ski race reports. Since I think that KYB’s technology could be used for not only sit skis but also welfare, I would like to be involved in this direction of the business.

7.3 Bonds with development staff

In the 2015/2016 season, we could communicate more with the development staff than in the 2014/2015 season.

Two development staff joined the New Zealand sit ski training camp for the first time and didn’t seem used to the atmosphere. However, after experiencing some camps, they gained the trust of all the national team members especially in the training camps in Canada and Korea. That time we could talk about many things with them. No other teams had shock absorber technical support staff in the training camps. The athletes of overseas teams were surprised, saying “This is a real racing team!”

7.4 Toward Pyeongchang Paralympics 2018

In the Pyeongchang Paralympics in 2018, we would like to win gold medals in individual events but also see Japanese athletes sweep the podium, which could not be achieved in the Sochi Paralympics.

For this challenge, technologies for not only the slalom and giant slalom, which Japanese athletes are good at, but also high-speed downhill races and the super giant slalom need to be improved.

There are only two years left until the Pyeongchang Paralympics. We would like to do our best to get gold medals and all the other medals with the KYB shock absorber.

Authors

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Joined the company in 1986. General Manager, Design Sect. No.2, Engineering Dept., KYB Motorcycle Suspension Co., Ltd. Mainly engaged in design and development of motorcycle suspension for racing. Leader of sit ski shock absorber design and development.

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Glossary

“DLC (Diamond-Like Carbon)”

Used in “Aim for Gold Medal in 2018 Pyeongchang Paralympics” (page 54)

TAMURA Tetsuya, Materials engineering Sect., Basic Technology R&D Center

1 What is DLC?

DLC (Diamond-Like Carbon) is a general term for hard amorphous carbon film. It is an extremely thin black film with a thickness usually about 1 μm. As the name indicates, the film has a mixing structure of extremely hard diamond and graphite used for pencil lead (Fig. 1). The properties of the film change depending on the mixing ratio and there are many variations of DLC with a different content of hydrogen or metal.

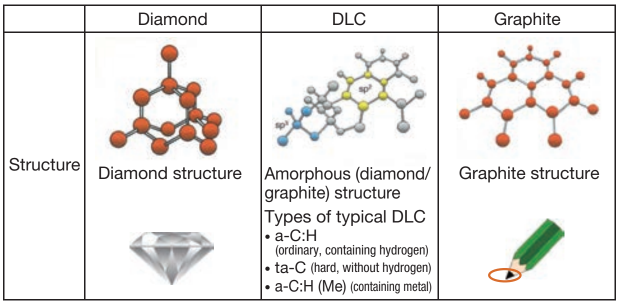

Fig. 1 Structure of DLC

2 Features of DLC

DLC is a low-friction film. If it slides against steel, the friction coefficient is about half of that of nitrocarburizing or Cr plating (Fig. 2). The wear amount of DLC is less than one fiftieth of that of nitrocarburizing (Fig. 3) and the seizure load of DLC is more than twice that of nitrocarburizing (Fig. 4). Thus, DLC has a great advantage in sliding property. There is no other surface treatment that has this distinguished property.

3 Application examples at KYB

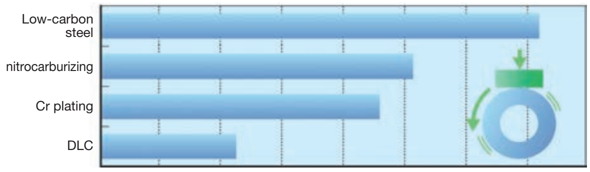

Fig. 2 Friction coefficient of various surface treatments

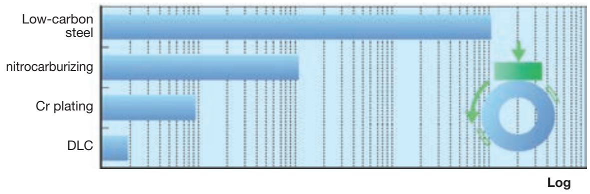

Fig. 3 Wear volume of various surface treatments

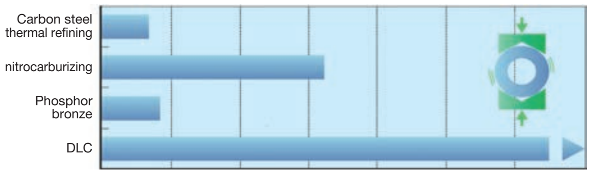

Fig. 4 Seizure load of various surface treatments

Taking advantage of the low friction property, DLC is used for the inner tubes of motorcycles and piston rods of passenger cars. Taking advantage of the high wear-resistance property, DLC is used for swash plate control pins for piston pumps (Fig. 5).

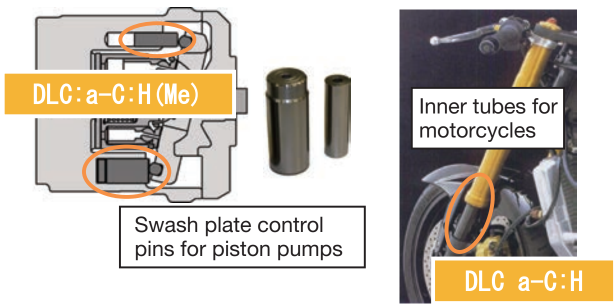

Fig. 5 Applications of DLC at KYB

Essay

Report on visit to Bauma 2016

HASEBE Atsutoshi, NIIJIMA Takeshi

1. Introduction

Bauma is a combination of the German words Bau (construction) and Maschinerie (machinery), and is one of the three largest construction machinery exhibitions in the world, along with Intermat (France) and Conexpo (USA). It is held in Munich every three years. The exhibition is switched every year among Bauma, Intermat, and Conexpo.

Development of automatic driving technology and various sensing technologies for construction machinery has progressed in recent years to save on man power. In particular, the technology called Information-Oriented Construction has been making construction work more effective and automated using GPS (global positioning system) and drones (unmanned aircraft). This technology is also studied by the automobile industry. So different industries share the technology. Also, we can see in Bauma numerous concrete mixer vehicles and related technologies of large companies throughout the world. We are from two departments: the Basic Technology R&D Center and the Special Purpose Vehicles Div. One of us from the former visited the site for three days and the other from the latter visited the site for two days. In this report, we introduce some trends in sensing technologies, concrete mixer vehicles, and related technologies in the global construction industry.

2. Exhibition site and overview of exhibition

Bauma is held in Messe Munich. About 40 international exhibitions are held every year in this site. More than 30,000 companies from more than 100 countries attend the exhibitions and more than two million people from more than 200 countries visit the site every year. The site was established in 1998, before which it was Riem International Airport. As we noticed afterwards, the airport was the one where a chartered plane used by England soccer team Manchester United crashed on February 6, 1958. This famous accident was called the “Munich air disaster” and 23 people including eight players died.

Although we have visited exhibitions held at Pacifico Yokohama and Tokyo Big Sight, Messe Munich was unbelievably large; larger than the ones we have seen in Japan. The site size was almost equivalent to the distance between two subway stations.

It was much bigger than Tokyo Big Sight, one of the largest exhibitions sites in Japan (Table 1).

The outdoor exhibition space is about 47 times larger than Tokyo Big Sight and there were many large heavy machines and cranes exhibited. Since there were no tall buildings around the site, the outdoor exhibition space attracted our attention from a train approaching the site (Photo 1). It was more like a festival than a business site.

Table 1 Comparison of exhibition sites

	Tokyo Big Sight	Messe Munich	Area ratio
Total area	243,419 m^2	605,000 m^2	2.5
Indoor exhibition area	80,660 m^2	180,000 m^2	2.25
Number of exhibition halls	10 halls (total of west and east areas)	17 halls	—
Area of each hall	4,680–8,880 m^2	3,500–11,000 m^2	—
Outdoor exhibition area	About 9,000 m^2	425,000 m^2	47

Photo 1 Bauma view from train

Bauma was held on April 11 (Mon) to 17 (Sun) in 2016. A total of 3,423 companies from 58 countries participated in Bauma and about 0.58 million people from 200 countries visited it. One of the authors (Hasebe) visited the exhibition from April 11 to 13 and the other (Niijima) from April 14 to 15. Since visiting a large exhibition like Bauma was our first experience, we were not sure if we could see everything in two or three days. In fact, it took a whole day to look around the entire exhibition area and we needed to visit target booths in an efficient manner. In particular, there were many heavy vehicles in the outdoor exhibition area (Photo 2) and demonstrations of the vehicles were performed, which we often stopped at.

Photo 2 Large cranes and other heavy machines

There were large and small booths in the exhibition hall. We could see many parts including large parts such as excavators' buckets, cylinders, and crawlers, and small parts such as bolts, valves, and connectors. A construction machine manufacturer even used a whole hall for their exhibition. We could see their extraordinary interest in Bauma.

3. Trend of construction machinery sensing technology

There are many kinds of sensors such as an ordinary pressure sensor or a sensing system using a stroke sensor or camera. The sensing technologies that attracted our attention are introduced here.

3.1 Stroke sensing technology

The stroke of a cylinder is measured and the bucket position is estimated. There were various sensing methods such as a magnetic one and an optical one (Photo 3) (Table 2).

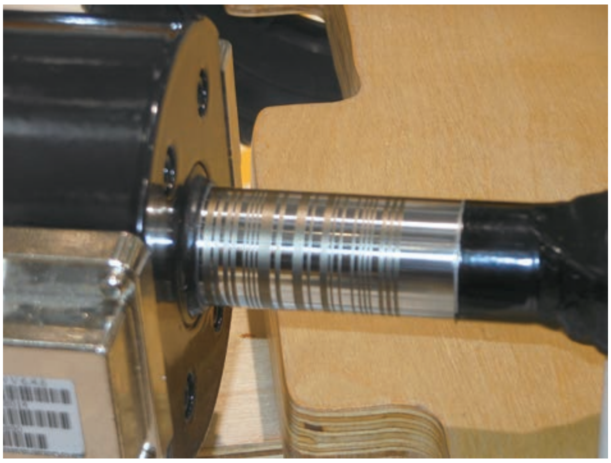

Photo 3 Optical stroke sensor

Table 2 Comparison of stroke sensor types

Type	Features
Magnetic pattern type	A magnetic sensor reads a pattern engraved on the rod to detect the position of a cylinder.
Magnetostriction type	Strain arises through the application of a magnetic field. This magnetostriction curve is used to detect the position of a cylinder.
Hall device type	A Hall device detects an electromotive force generated when a magnetic field is applied to an electric current. The Hall device and a magnet are used to detect the position of a cylinder.
Optical type (Photo 3)	The position of a cylinder is detected by applying a laser to the rod with a pattern engraved.
Wire type	A wire is attached at the tip of the cylinder head and the position of the cylinder is detected based on the extracted wire length.
Radio wave type	A radio wave is applied to the piston. The position of a cylinder is detected by measuring the time from when the radio wave is emitted to when the reflected wave is received.

3.2 Circumference recognition technology

In addition to safe driving support functions of automobiles, many safety check devices using a millimeter wave radar or camera were displayed. In particular, there were many circumference monitoring camera systems, including a surroundings-view system with multiple cameras and object detection systems with monocular or stereo cameras. Currently, these technologies have been actively developed in the automobile industry but are expected to also develop in the construction machine industry in future.

3.3 Surveying technology

We found some systems for measuring a work site using a camera-mounted drone (unmanned aircraft), which was getting very popular. One of them was a unique one that did not use a dedicated camera but a commercially available digital single-lens reflex camera (Photo 4).

Photo 4 Drone for measurement

Photo 5 Pump mixer vehicle

4. Trend of concrete mixer vehicles

On the visiting days of April 15 and 16, the weather changed repeatedly between being cold with heavy rain and being warm with a clear sky. Since Niijima had only two days, he decided to spend most of the time observing concrete mixer vehicles and related technologies.

In the outdoor exhibition booths, there were concrete mixer vehicles displayed by automobile companies and several large-sized world-leading manufacturers not only from Europe but also from other areas. Every company displayed vehicles that integrated a concrete mixer vehicle and a concrete pump vehicle [Note 1)] (hereinafter referred to as a pump mixer vehicle: Photo 5). In Japan, a concrete mixer vehicle delivers fresh concrete to a concrete pump vehicle then a concrete pump vehicle places concrete throughout a construction site. So we do not find pump mixer vehicles in Japan. In addition to the pump mixer vehicles, there were many concrete mixer vehicles with belt conveyors (hereinafter referred to as conveyor mixer vehicles). According to staff from a manufacturer, there was a certain demand in Europe to save on manpower in narrow areas in cities or mountainous areas, and the market for pump mixer vehicles and conveyor mixer vehicles occupied about 10% of the entire concrete mixer vehicle market.

Actually, the urban area in Munich had many buildings of similar design, which was probably due to landscape control, and the roads were narrow and not always straight. The area was so complicated that we happened to walk into the backyard of a neighboring house of our hotel when we left the hotel (Photo 6). We have the same situation in cities in Japan, but those vehicles are not popular because of the severe vehicle weight standard. If the vehicles can meet the Japanese standard, there should be a high demand for the pump mixer vehicles and conveyor mixer vehicles against the background of a labor shortage in the construction industry.

In addition to the pump mixer vehicles and conveyor mixer vehicles, we also found electronically controlled concrete mixer vehicles displayed by various manufacturers. The operation of the vehicles was simplified and the engine speed and drum rpm and direction could be controlled gradually by operating a lever on the backside of the vehicles. The conventional mechanical lever operation is being replaced with an electronic one.

Photo 6 Near hotel (in Munich)

On the other hand, the electronically controlled concrete mixer vehicle (hereinafter referred to as an e-mixer) that KYB began selling in October 2004 has a dial-type controller on the driver's compartment and the backside of the vehicle to continuously vary the rpm of the engine and drum. Also, the e-mixer's control is optimized to eliminate unnecessary energy loss by using a two-speed-step hydraulic motor to suppress the engine speed by half. Although we should not forget that the region dependence of the operation form is an important factor in the development, I honestly think that KYB leads the other companies in concrete mixer vehicle control technology.

Note 1) Vehicle that deposits fresh concrete delivered by a concrete mixer vehicle into a concrete formwork.

5. Trend of concrete mixer vehicle-related technology

In the exhibition site, we found not only the concrete mixer vehicles that we often saw in cities but also other vehicles. For example, there were integrated vehicles of a concrete mixer vehicle with a small wheel loader (hereinafter referred to as self-placement mixer vehicle). Also, there were vehicles with large material tanks that allowed production of the appropriate amount of concrete at construction sites (hereinafter referred to as mobile batcher plants).

Self-placement mixer vehicles have a wheel-loader-like bucket and driving system and can measure and deposit, using the bucket, concrete materials into the mixer to make concrete. Ordinary concrete mixer vehicles mix an appropriate amount of concrete made at batcher plants (hereinafter referred to as plants) and transport it to construction sites. However, it is difficult to construct a plant or deliver concrete with a concrete mixer vehicle in a remote island or in a country with poor road conditions. Self-placement mixer vehicles would be useful in such areas. In Bauma, two Italian companies exhibited self-placement mixer vehicles. Their vehicles were almost the same size but used different methods to measure materials with a bucket. One of them attached a pressure sensor on a hydraulic cylinder that moved the bucket up and down and the weight of materials scooped by the bucket was displayed on an LCD in the driver's compartment. On the other hand, the other company did not use a pressure sensor but extended a hydraulic pipe to the driver's compartment and used a pressure gauge that had conversion tick marks between pressure and weight for analog display of the pressure. According to the company staff, analog-type operation was preferable from a viewpoint of after-sales service or training because the self-placement mixer vehicles were mostly for developing countries.

KYB manufactures mobile batcher plants, but the ones in the exhibition were of a different type. The mobile batcher plants of KYB are the so-called batch type where measurement, mixing, and discharging of materials are made in a single process. On the other hand, the exhibited vehicles are of a continuous type where the measurement, mixing, and discharging of materials are conducted in parallel. An advantage of the batch type is that the processing time can be controlled in each process step to maintain output at a constant level. A disadvantage of the batch type is the small output. The continuous type can produce large amounts as all the processes run in parallel, but process control to respond to a change of material properties is difficult. Since the concept and way of using the vehicles change depending on regions, it would be very important to understand customers in future overseas development.

6. In Closing

My visit to Bauma was a precious experience, as I could understand the state-of-the-art construction machines that we could not have otherwise seen. I am an employee of a hydraulic products company, but I have no opportunity to directly see construction machines or hydraulic products in my everyday work. Therefore, I was inspired by seeing a variety of small product parts, including bolts, seals, and other small parts and extraordinarily large heavy machines. I had to use English to communicate with exhibitors. Sometimes I could get information without any problems and sometimes I had a hard time understanding when I asked a question. I thought that I would need to improve my English ability for the next visit as I would like to participate in exhibitions like Bauma. (Basic Technology R&D Center: Hasebe)

In the two-day visit to Bauma, I could see products from various manufacturers and have a profitable time. I was overwhelmed by the large scale of the exhibition and the excitement of the exhibitors. As I looked at various exhibition booths, I felt that every company had a clear target. I thought that we would need more effort to understand customers' thoughts and culture and clarify targets in future overseas development. (Special Purpose Vehicles Div: NIIJIMA)

Lastly, the authors would like to thank those who provided us with the opportunity for this precious experience.

Authors

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Joined the company in 2009.
Electronics engineering Sect., Basic Technology R&D Center, Engineering Div. Mostly engaged in development of sensing systems for automobiles.

NIIJIMA Takeshi

Joined the company in 2014.
Engineering Dept., Kumagaya Plant, Special Purpose Vehicles Div. Engaged in the development and design of new products.

Announcement

Acquisition of iNARTE-EMC, Radio Wave Test Engineer's Qualification

ISHIZAKI Yukio

1 What Is the Radio Wave Test Engineer's Qualification "iNARTE-EMC"?

"iNARTE-EMC" is an international engineer's qualification that certifies electromagnetic compatibility (hereinafter referred to as "EMC" [Note 1)]) engineers' skills regarding electronic and electric products.

This was launched when a U.S. non-profit organization "iNARTE [Note 2)] established an engineer's qualification system in the field of EMC in 1998 upon request of a government agency. In Japan, the "iNARTE JAPAN Committee" was organized in 1998 within the KEC Electronic Industry Development Center, and the iNARTE-EMC qualification test was introduced.

As of April, 2015, there are 2,289 iNARTE-EMC holders in 26 countries worldwide, and 1,081 of them are Japanese, covering approximately half of iNARTE-EMC holders worldwide.

Effects of iNARTE-EMC are internationally recognized in the field of EMC. Below are some examples:

① EMC tests sometimes require that the person who obtained the measurement data is an iNARTE-EMC holder.

② The American Association for Laboratory Accreditation A2LA recommends that iNARTE-EMC is used as a qualification for judges.

③ An automobile manufacturer requires that EMC evaluation examiners are iNARTE-EMC holders.

As you can see, iNARTE-EMC is a qualification that certifies that the person is an EMC technology specialist and can be considered as a qualification that is suitably regarded especially in the practical field. Therefore, iNARTE-EMC holders are required to understand the principles/fundamental rules of EMC and to have the skills to extract EMC evaluation results that are socially reliable based on this understanding.

Note 1) Abbreviation for "Electro Magnetic Compatibility"

Note 2) Abbreviation for "The International Association for Radio, Telecommunications and Electromagnetics"

2 Extremely Difficult Test!

First of all, iNARTE-EMC is not a qualification test that anyone can take. It requires that your profession involves EMC work and experience in terms of a number of years. For example, the iNARTE-EMC engineer qualification test requires that the person has at least three years of experience with practical work in the case of a bachelor's degree holder. The person also has to have references who can prove the above facts. Unless the person satisfies these prerequisites, he/she cannot take the test.

The major characteristic of the iNARTE-EMC qualification test is that it does not test memory like many Japanese qualification systems. This test focuses on solving presented questions, meaning that this qualification test specializes in practical work.

Below are detailed contents of the actual test.

① The test involves four hours each in the morning and afternoon. There are 48 questions, each in the morning and afternoon, with eight questions you can eliminate. Among the 80 answers, 70% must be correct to pass the exam.

② The test is an open book test, allowing you to bring materials, such as scientific calculators, reference materials, your own notebooks, and PC/tablet (no Internet connection available). There is no limit to the number of books or electronic data you can bring. In this test, you utilize the materials, which you brought, to solve the questions.

You would think you can easily pass this qualification test since you are allowed to bring so many materials. However, the reality is otherwise. The passing rates for iNARTE-EMC in recent years have been on the decline. After the peak in 2014 (26%), it has declined to 20% in 2015 and 17% in 2016. Despite the fact that materials are allowed, the passing rate is this low, indicating the difficulty of the iNARTE-EMC test.

Even if you pass this qualification test, you are still not qualified with iNARTE-EMC. Those who passed the qualification test are required to submit assignments to be qualified, and you are not certified as an iNARTE-EMC holder until you pass this assignment review.

In addition, the iNARTE-EMC qualification must be updated every year, and qualification holders must submit an annual activity report in English upon update.

At our Development/Experiment Sect., Electronics Technology Center, members have been taking the iNARTE-EMC Engineer test since 2015. Four members took the test and two of them passed in 2015. Two members took the test and one of them passed in 2016. As of now, there are a total of three members holding the iNARTE-EMC qualification. We can say that this pass rate is extremely high, compared to the aforementioned pass rate.

Some of the factors that have enabled us to achieve this high pass rate, despite the low overall pass rate of approximately 20% in the past few years, are:

① We possess our own radio wave testing facility, enabling us to internally perform the entire process from consideration of testing plans, interpretation of radio wave testing standards, determination of results, and summary. Particularly notable is that radio wave test examiners were able to thoroughly perform trouble-shooting in case of abnormal data as well as surveys during the tests by themselves without restrictions in terms of time, which allowed them to come to the correct solutions.

② To prepare for the introduction and internalization of the radio wave testing facility, the entire radio wave test group simultaneously started studying to acquire the qualification. The group members supported and encouraged each other through joint voluntary study sessions, following up on those who were behind, etc.

Photo 1 shows the iNARTE-EMC certification.

Photo 1 iNARTE-EMC Engineer certification

3 Test Contents

EMC evaluation is not simply about “arranging and measuring”. We must provide “a sense of security” to customers based on the measured data. Therefore, examiners are required to not only correctly understand the target product but also understand the rules and principles of EMC and extract evaluation results that are socially reliable.

In order to certify such technical capabilities, the iNARTE-EMC qualification test requires knowledge in the following fields:

① Magnetics
Maxwell's Equations, radio wave propagation

② Antenna properties
Structures, principles, basic properties

③ Countermeasure technology
Countermeasure components, shielding effect, materials

④ Electric circuits
Various laws, distributed constant circuits, coupled lines

⑤ Electronic circuits
Digital circuits, amplifiers, noise factors

⑥ Electric math
Complex numbers, approximation, waveform analysis

⑦ Communication methods
Modulators and demodulators, noise theory

⑧ Measurement technology
Fundamentals of receivers, reliability

⑨ Practical work management
Website management, antenna calibration

⑩ EMC design
Printed circuit boards

⑪ Standards
CISPR, IEC, ISO

⑫ Biological effects
Surrounding electromagnetic fields, ICNIRP

The scope of questions cover extremely broad fields. Therefore, the test requires judgment/application, rather than memory.

4 Thoughts of a Successful Examinee

I would like to introduce the thoughts of a successful examinee below:

iNARTE-EMC is a very difficult qualification test due to the low passing rate as well as expertise and vast scope of required knowledge, so examinees have great concerns about the test. On the other hand, hearing about the efforts toward the test by other companies and external testing sites also made me realize that this qualification holds a high status for engineers in the field of EMC and feel that it would be rewarding to take on the challenge.

I am very happy to know that the fact that I have been certified indicates that my skills and knowledge from high-functioning EPS-ECU EMC evaluations, introduction of KYB’s first anechoic chamber, actual tests, and work that I have managed and promoted have been highly received in an objective manner.

We expect that promotion of electronic control and wireless communication will accelerate further, as we can see in the examples of electronic cars becoming more popular and automatic driving. EMC test standards are also being updated and established along changes of EMC environment. We are making concerted efforts to respond to changes in terms of facilities and testing skills and perform optimal tests.

Photo 2 shows the 3 iNARTE holders of the Development/Experiment Sect., Electronics Technology Center.

Photo 2 iNARTE holders of the Development/Experiment Sect. (From left: Mr. Honda, Mr. Yamada, and Mr. Mizuno)

5 Evaluation/System of Electronic Products in the KYB Group

The Electronics Technology Center, Engineering Div., was established in October 2012. The Development/Experiment Sect. was positioned in Gifu North Plant as a sector in charge of performing reliability evaluation.

The Electronics Technology Center develops not only products for various businesses of KYB but also product hardware/software in response to the needs of the KYB Group. Reliability evaluations in the Development/Experiment Sect. cover a broad scope throughout the KYB Group, so they require a number of testing facilities and great skills of experimental technicians. The below items introduce the evaluations/systems of electronic products.

5.1 Electronic Experiment Building

The operation of the Electronic Experiment Building began in April 2012 as a designated facility to evaluate the reliability of electronic/electric products, which are used in products of various companies in the KYB Group.

Photo 3 shows the appearance, and Table 1 shows the major overview.

Table 1 Overview of Electronic Experiment Building

Overview of the construction		2-floor steel construction Total floor area: 1,560m^2
Operation start		April, 2012
Major facilities	Radio wave-related	4 anechoic chambers (Including 2 shield rooms)
	Physical environment-related	16 units
	Power/surge-related	4 units
	Property tester	1 unit

Photo 3 Appearance of Electronic Experiment Building

5.2 Anechoic chamber and testing facility

We have newly introduced an anechoic chamber, which was the first to be introduced to the KYB Group, and a radio wave testing facility when the Electronic Experiment Building was built. The minimum requirement for the anechoic chamber was that it would enable us to guarantee the reliability of KYB products. We also gave consideration so that it would enable us to evaluate customer products, which use KYB products, as much as possible. With automobile-related products, which are ultimately used with higher frequency, we formulated the anechoic chamber specifications so that we could perform tests with actual vehicles.

Photo 4 shows the inside of the biggest 3m-method anechoic chamber, and Photo 5 shows a scene from an actual radio wave test.

Photo 4 3m-method anechoic chamber

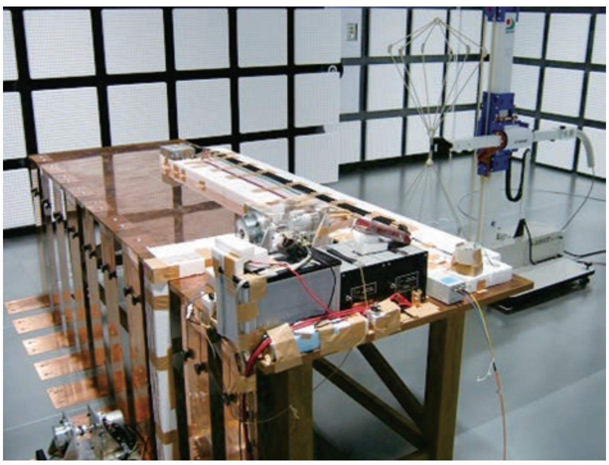

Photo 5 Example of a radio wave test

5.3 Physical environment-related facilities

KYB products, which are used in the fields of land, sea, and air, are exposed to a number of environments, such as temperature, humidity, vibrations, static electricity, and lightning. We must prove that our products possess the durability as required by customers in such environments.

The Electronic Experiment Building has 16 physical environment-related facilities and 4 power/surge-related facilities, and we conduct thorough reliability evaluations in various stages of product development.

Photo 6 shows an environment testing room, and Photo 7 shows a scene from an ECU operation confirmation test under low temperatures.

Photo 6 Environment testing room

Photo 7 ECU operation confirmation test in low temperatures

5.4 Field test with actual vehicles

In addition to thorough bench tests in the Electronic Experiment Building, we have also been proactively participating in field tests using actual vehicles. Photos 8 and 9 are from our ECU operation reliability test with actual vehicles in extremely low temperatures in North America.

Photo 8 Operation reliability test with actual vehicles in extreme low temperatures

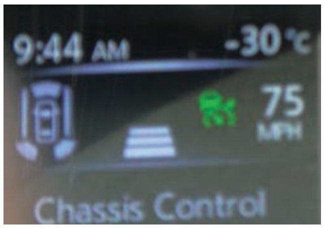

Photo 9 Recorded -30 degrees Celsius at 9:44 am during the test

6 In Closing

As represented by automatic driving of automobiles, promotion of electronics/control has been drastically accelerating in society. Improvement of the technical level in the Electronics Technology Center is urgently required, so we must not only establish the evaluation system but also improve skills and the number of qualification holders among members.

I would like to express my gratitude for relevant internal and external people who have provided great support for us to obtain the Radio Wave Test Engineer's Qualification "iNARTE-EMC". I would especially like to thank the members who have passed the extremely difficult test as a result of their diligent efforts.

Author

ISHIZAKI Yukio

Joined the company in 1983. General Manager, Developmental Experiment Sect., Electronics Technology Center, Engineering Div. Assumed present post after working in the Motorcycle Engineering Dept., in Germany/Italy, and in the Development/Experiment Dept.

Editors' Script

I edited the Essay for this issue. I enjoyed the editing work because I could imagine the scene reading the article. I would like to thank the authors.

All the employees of KYB group companies are working every day on various developments and improvements. KYB Technical Review contains articles covering a wide range of issues, from development to production.

Although you may think that the Technical Review is only read by those involved in technology and development, I would appreciate it if all the employees have an interest in the articles. I would like to edit the Technical Review, hoping to hear views such as "I found a new idea from the article." (MIYAJIMA)

As I belong to the Intellectual Property Dept., I have many opportunities to see new technologies undergoing research and development for which patents are applied. I thought that I already knew many KYB products through such opportunities. However, being an editor of the KYB Technical Review, I encounter many unknown products and am astonished by the wide range of KYB products. I am looking forward to the next editors' meeting to find new products in the next issue. (OGURA)

A predecessor suddenly passed the editing work of the KYB Technical Review on to me, and this is the third issue I have edited. I had submitted an article to the Technical Review but I did not imagine then that I would become an editor. I work with fascination while editing articles in different fields to my job (preparation for shock absorber production). Since the KYB Technical Review provides an opportunity to introduce the achievements of our work inside and outside of the company, I want the achievements of my department to be published in the Technical Review while I am engaged in editorial work. (SHITA)

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