Technology Introduction

Construction of Case Machining Line for Piston Pump

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1 Introduction

PPM [Note 1)] products manufactured in KYB Sagami Plant include piston pumps (Fig. 1). The piston pump is used as a component of hydraulic excavators. One of the components of the piston pump is a pump case (Photo 1) (hereinafter "the case"), which is the core part of the pump.

With the recent rising market demand for environmental measures and energy saving, the demand for piston pumps with a load sensing control [Note 2)] is expected to increase (Fig. 2). We are thus required to manufacture competitive products of this kind. Among the piston pump manufacturing processes, the one involving the highest manufacturing cost ratio is case machining. It is therefore indispensable to reduce the cost. Then, in preparation for the establishment of a new production line, we have successfully established a level of quality, which had been hardly accomplished before, to achieve higher availability and shorter cycle time (hereinafter "CT"). We have finally built a production line that can realize lower manufacturing costs.

Fig. 1 Piston pump

Photo 1 Pump case

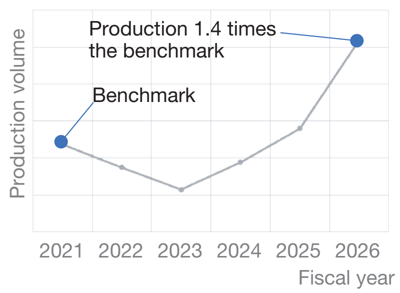


Fig. 2 Estimated production volume of piston pumps

Note 1) An abbreviation for piston pump motor

Note 2) A system that controls the pump discharge to supply the flow as much as needed

2 Line Overview and Challenges

2.1 Case Machining Line

The pump case machining line consists of machining centers (hereinafter "MC"), deburring, rough cleaning, inspection, and jet cleaning (Fig. 3).

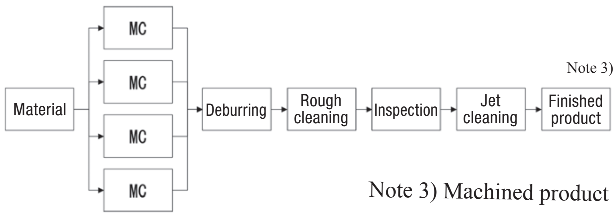


Fig. 3 Manufacturing process

2.2 Problems

The MCs can provide an integrated process [Note 4)]. Each MC can deliver finished products by itself. The problem is that, after products have been machined, they are measured on the same MC, resulting in a long cycle time. Dimensional correction is conducted as the necessity arises, which leads to lower availability. In addition, the pump case is a heavy workpiece (18 kg) to be lifted using a crane. This dangerous work is a factor in the long manual handling operation.

Note 4) A single MC can support all related processes.

3 Purpose

To improve productivity to build a production line for lower manufacturing costs.

4 Objective

Table 1 shows the target values.

Table 1 Target values

Item	Target (from the conventional level)
Production volume	33% up
Availability	6% up
Cycle time	27% down
Personnel	1 person reduced

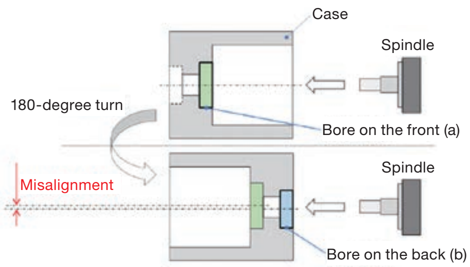


Fig. 4 Overview of front/back machining of case

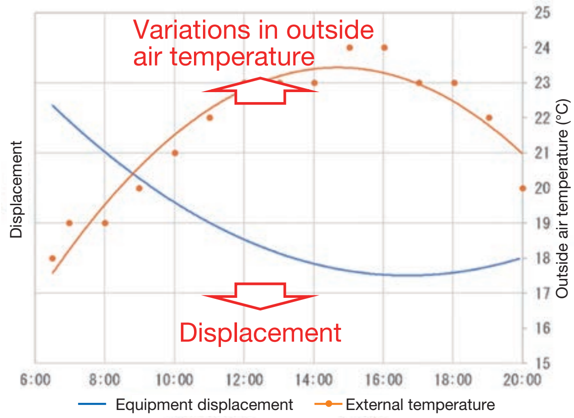


Fig. 5 Equipment displacement due to outside air temperature

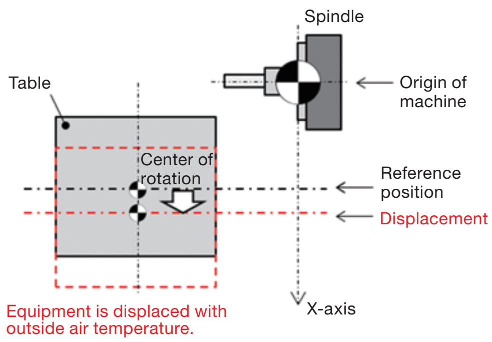


Fig. 6 Conceptual rendering of displacement

5 Requirements

① The machining accuracy shall be improved to ensure the required quality without relying on human operation.
② The machining rate shall be increased to reduce the machining time (hereinafter "MT").
③ Work handling shall be achieved without using a crane to remove dangerous tasks.

6 Achievements

6.1 No more 100% measurement in MCs

6.1.1 Conventional Quality Problems

The case has two holes as its critical parts: one is on the front and the other on the back (Photo 2). In fact, alignment of these holes (coaxiality) was difficult to be obtained (Fig. 4), resulting in 100% manual measurement and dimensional adjustment. These additional tasks degraded the availability and productivity. The case machining was conducted by turning the machining table by 180 degrees to machine the front or the back or vice versa. Naturally, the machining quality was affected by the equipment accuracy. This was found to be attributable to variations in outside air temperature superimposed by the heat generated during continual machining, which displaced the equipment, resulting in unstable machining positions (Figs. 5 and 6). To follow any displacement of the equipment due to temperature variations, temperature sensors and temperature control systems needed to be added, which meant even higher capital investment.

(a) Front

(b) Back

Photo 2 Bore

6.1.2 Internal Measurement using Touch Sensors

High capital investment leads to high manufacturing costs. So, a software program has been developed to measure displacement or deviation from the reference position using the touch sensors already mounted on the equipment and compensate for any displacement to achieve the machining target values (Fig. 7).

① Measure the position of holes provided in the jigs and then establish reference values as initial settings for equipment introduction
② Before mass production, measure the position of the holes in the jigs before machining and add any deviation from the reference value to the machining target value

If the equipment is displaced during mass production, the hole position in the jig changes. That is, the deviation from the initially set reference value will be the displacement of the equipment.

This measurement has made it possible to satisfy the coaxial front and back machining capability. The 100% measurement during mass production is no longer necessary to achieve shorter CT. The dimensional adjustment has been also abolished to eliminate any adjustment loss, thus improving the availability.

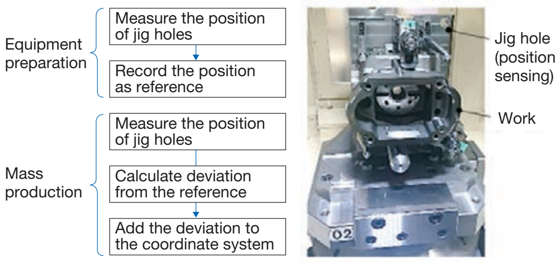


Fig. 7 Program flow and machining jig

6.2 MT Reduction with Optimal Milling Path

Among the case machining processes, milling is the most time-consuming one (Fig. 8). In the conventional milling technique, the milling cutter moves along the shortest path to accomplish the required machining. Since 50% of the perimeter of the cutter was used for milling, the cutter involves mixed operation of up milling and down milling. In fact, this resulted in unstable cutting resistance, which might cause chattering (Fig. 9). The milling machine eventually machined work at a lower speed, resulting in a prolonged MT.

To solve the problem, an optimal milling path has been developed to be suited to the complex geometry of the case (Fig. 10). The cutter has then become able to machine only with down milling being applied with cutting resistance in a fixed direction, successfully suppressing chattering. The machining speed has been doubled to reduce the MT.

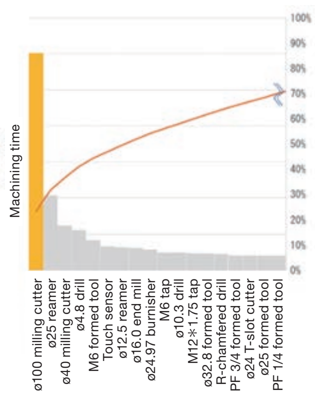
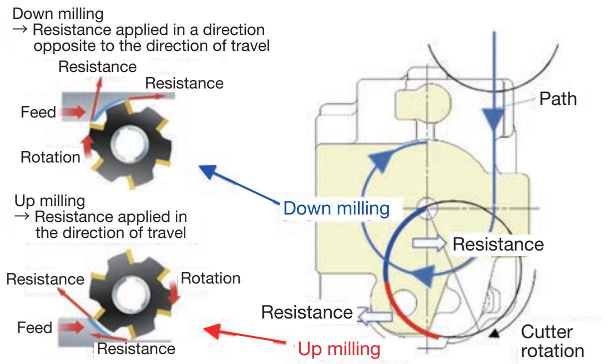
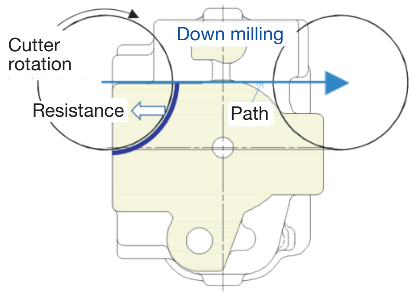


Fig. 8 Machining time of individual processes



Resistance occurs in two directions, which is likely to cause chattering

Fig. 9 Milling (before change)



Constant resistance to suppress chattering

Fig. 10 Milling (after change)

6.3 Reduction of Manual Handling Time by Improving Jig Installability

The horizontal MC uses cross jigs for machining the case. Work must be set in position horizontally (Fig. 11). Lifting the heavy work involves danger tasks. The use of a crane makes it difficult to accurately position work, taking more time to complete attaching or detaching. As a result, the target manual handling time cannot be met.

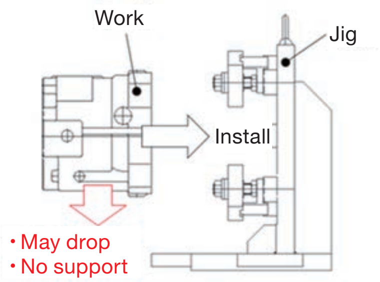


Fig. 11 Conventional way of setting work

To solve the problem, a jig that can allow the operator to set heavy work without lifting using a crane has been developed (Photo 3).

When loading, the work is slid into the jig from the carrier cart and guided by the jig for temporary positioning. The operator can just push the work to the end to accomplish final positioning with the aid of tapered pins

(Photo 4). With improved operability of jig setting, the work attach/detach time has been reduced by 50% and the manual handling time in the total production line has been reduced by 20%.

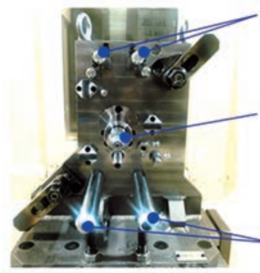


Photo 3 Jig overview

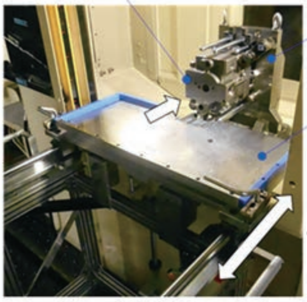


Photo 4 Work in position

7 Results

The target values have been achieved. The results are shown in Table 2.

Table 2 Results

Item	Achievements (from the conventional level)
Production volume	36% up
Availability	14.7% up
Cycle time	27% down
Personnel	1 person reduced

8 Conclusions

A new measurement method has been developed to achieve the process capability for the machining accuracy that was difficult to be achieved before. A new production line has been built to no longer involve dangerous tasks or no longer put a load on operators.

We will deploy this technique to realize new products at lower costs in future.

9 In Closing

I would like to take this opportunity to thank all those concerned from related functions who extended cooperation to the building of this production line as well as all those who gave guidance and support to us.

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Joined the company in 2017.
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Mainly in charge of design of pump manufacturing process for PPM products