Technology Introduction

Construction of a PPM Pump Flange Machining Line

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1 Introduction

One of the PPM Note 1) products manufactured in KYB Sagami Plant is the “piston pump” (Photo 1). This piston pump is a component used in hydraulic excavators. One of the components for this pump is the “pump flange” (Photo 2), and this pump flange is a core component in the pump. The pump flange contains a semicircular part called the “cradle” Note 2). This is an important part that catches the bearing for the component that controls the pump flow volume.

KYB used to internally manufacture this pump flange, but we loaned the equipment to a supplier for them to manufacture the component in order to respond to the sudden increase in production volume. However, we decided to internally manufacture the pump flange due to the fact that it is a core component, and we have newly established the pump flange machining line.

Note 1) Abbreviation for “piston pump motor”.

Note 2) Refers to the semicircular part that acts as a bearing.

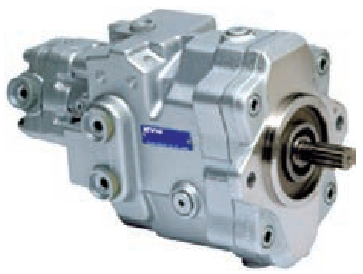


Photo 1 Piston pump

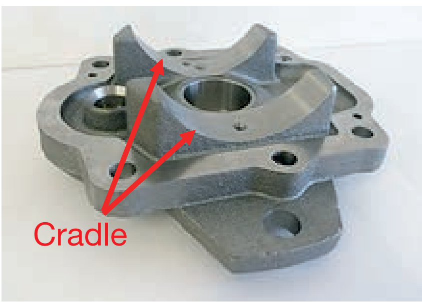


Photo 2 Pump flange
(The semicircular part is called the “cradle”)

2 Overview of Pump Flange Machining

2.1 Characteristics of Pump Flange Machining

① Various kinds and small quantity
(7 casted materials, 16 machined shapes)
② Products with different sizes are produced in one production line.
③ One line has different fluctuations in production volume.
④ It involves the cradle, which is difficult to machine.

2.2 Basic Pump Flange Machining Processes

① Reference level is machined with a lathe.
② Holes are drilled with a machining center.
③ Flash is removed from the machined parts.
④ Unit is washed in a washer.
⑤ Inspection is performed.
⑥ Rust prevention oil is applied.

3 Objective

Establish a pump flange machining line that can respond to “various kinds and small quantity” production.

4 Target

① Operation rate: 85.0% or above
② Line complaint: 0
③ Production start timing: May, 2016

5 Requirements

① Machining line that can respond to production volume fluctuations.
② Establishment of new machining technology that goes beyond the conventional machining method.
③ Line that incorporates a system that does not allow outflow of faulty units to later processes.

6 Implemented Initiatives

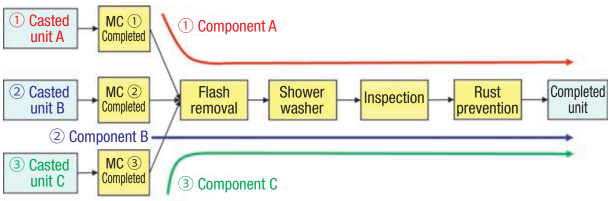
6.1 Responding to Production Ratio Fluctuations

6.1.1 Line Establishment through Process Aggregation

The conventional line was a divided process line in which machining was completed by using a lathe and a machining center. The line machined products with different sizes, and switchover could not be performed often despite the production ratio fluctuations. Due to this, we had a large volume of inventory while promoting the production activities.

We established this line so that it can respond to "various kinds and small quantity" production as a process-aggregated line, in which machining is completed with one machining center unit and in which items with different part numbers were processed at the same time. Fig. 1 shows the flow of mixed-flow production utilizing process aggregation.

Machining of casted unit A in (1) is completed by the machining center (1), and the unit is completed after the flash removal, washing, inspection, and rust prevention processes. By considering this as one flow, the units move through flow (2) and flow (3) to complete the processes for (1), (2), and (3) as one cycle.



* "MC" is short for "machining center".

Fig. 1 Mixed-flow production flow using process aggregation

6.1.2 Responding to Mixed-Flow Production

Since this is a mixed-flow production line in which different part numbers are processed at the same time, we took measures to prevent mistakes in various places.

In order to prevent work piece mistakes in the beginning of the line, we attach an order instruction form to pair with one work piece. This form remains attached to the work piece until the work piece is completed (Photo 3).

Next, before the machining center, the QR code Note 3) (Photo 4) on the production instruction form and the program are checked against each other in order to prevent a program selection mistake. If the check result differs, the alarm goes off to prevent machining. Furthermore, the equipment number and the part number are engraved in the machining center process to prevent mistakes between the work piece and the production instruction form, thus making it obvious for workers at first glance which equipment was used and what the part number is (Photo 5).

Note 3) "QR code" is a registered trademark of DENSO WAVE.

Photo 3 Production appearance

Photo 4 Production instruction form with a QR code

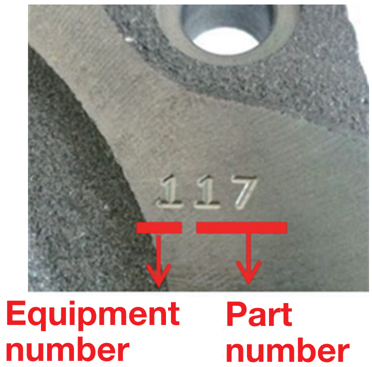


Photo 5 Engraving

6.1.3 Production Method That Can Respond to Production Ratio Fluctuations

Since there is a wide scope of pump flanges, they can simultaneously have different production ratio fluctuations. Since different part numbers can be machined by each machining center, we can freely select production methods, such as lot preparation Note 4) and pattern production Note 5). By promoting lot preparation for products with larger production volume and pattern production for products with less production volume, we can respond to production ratio changes by switching them (Fig. 2).

Note 4) Production method in which the machining timing is determined for each model.

Note 5) Production method with standardized production sequence.

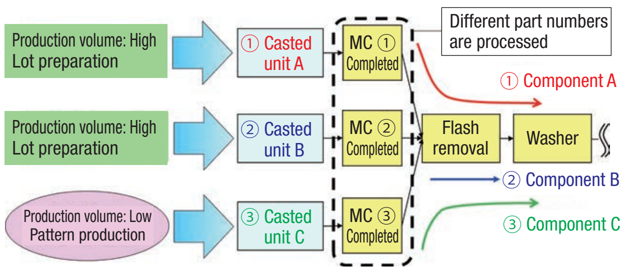


Fig. 2 Production method

6.1.4 Measures to Improve the Switchover Capabilities

In the conventional method, a jig was used for each casted unit. Due to this, manual clamp jigs had to be switched for different work piece thicknesses. Since manual tools were used in this switching process, it took time.

In this initiative, we utilized the toggle mechanism using a hydraulic clamp for the clamp jig. Due to this, the clamp stroke expanded, enabling us to respond to various unit types by using one clamp jig (Fig. 3). Furthermore, now that the clamp jigs can be switched in one step without using tools, jig switchovers can be minimized, reducing the time.

Moreover, we considered standardizing sub-jigs by using work piece overlays in order to reduce the number of switchovers and reduced the number of jigs to reduce the number of switchovers (Photo 6).

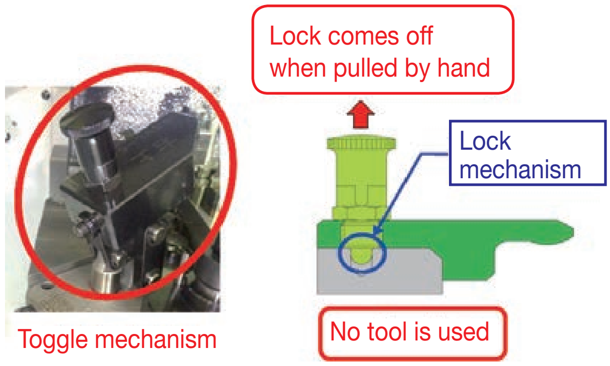


Fig. 3 Hydraulic clamp

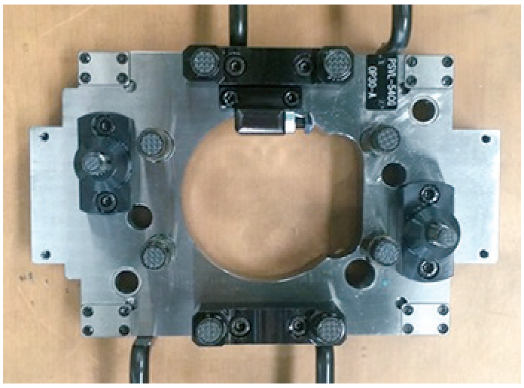


Photo 6 Standardized sub-jig

6.2 New Machining Technology for Cradles

6.2.1 Establishment of High-speed/High-precision Machining Technology

In the conventional machining method, 2 work pieces facing each other were set as a pair on the lathe to turn-machine the semicircular shape of the cradle part (Fig. 4). Since 2 work pieces were attached to the jig in this method, the weight was heavy. This caused the chuck clamping force to be reduced, making it easy for the work pieces to come off. Due to this, we could not improve the machining conditions.

Since this new line is a self-completion line using one machining center, machining technology at the machining center was required. The common method to machine cradle-like semicircular shapes one by one is to perform contouring machine Note 6) that moves in a circular manner. However, this requires machining time. Therefore, we used boring machining Note 7) that moves in a linear manner in order to achieve high-speed machining (Fig. 5).

Tool rigidity is also important to realize high-precision machining. We responded to this issue by enlarging the tool diameter to enhance the rigidity by considering the tool deflection so that chattering is not caused by the interrupted turning of the semicircular shape and also by considering the interference with the jig. This enabled us to achieve the high-speed/high-precision machining.

Note 6) Outline machining that uses NC table control.

Note 7) Precision hole machining method.

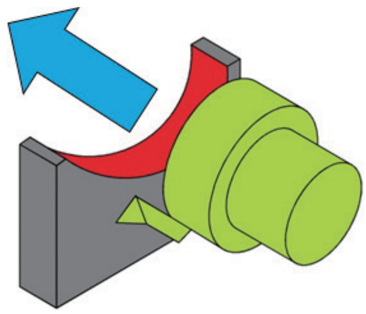


Fig. 5 Boring process

6.2.2 Establishment of Measuring Technology

In the conventional measuring method of the cradle part, we were only able to take measurements when 2 work pieces were chucked within the unit immediately after lathe machining. We used to take measurements by using a cylinder gauge (as shown in Fig. 6) and managing the measurements, but measurement of large-diameter units was difficult, requiring expertise.

In this initiative, we developed a semicircular measuring instrument to measure the cradle part (Photo 7). In this

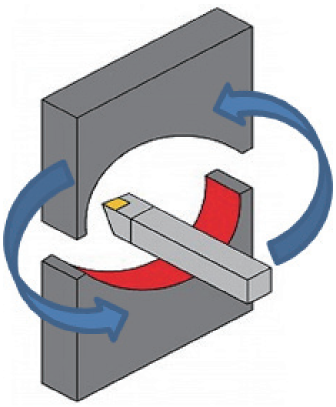


Fig. 4 Conventional processing method

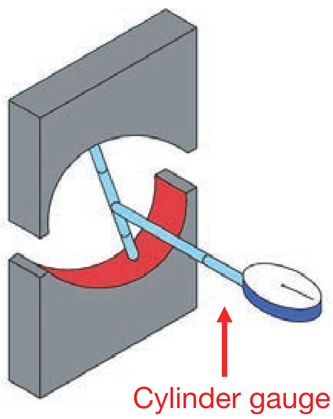


Fig. 6 Conventional measuring method

method, the master ring gauge is used as the standard to compare and measure the work piece and the master. Since the machined diameter can be calculated based on the obtained radius of curvature, this method has enabled us to measure each work piece.

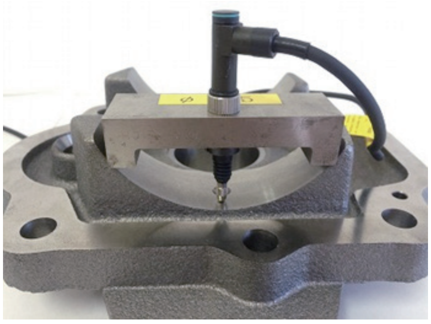


Photo 7 Developed measuring instrument

6.3 Measure against Faulty Unit Outflow

In the conventional method, a worker would look at the standard, search for the location to be measured, and manually write the measurement result in the measurement form. Since the order of measurement could change depending on the worker, we were unable to establish a standard work piece procedure for measurement.

In this initiative, we introduced the inspection support system (Photo 8), which was developed by KYB's Production Technology R&D Center, in order to be able to measure work pieces that are randomly manufactured in mixed-flow production and to establish a standard work piece procedure for measurement. With this line, each work piece is produced with the production instruction form attached to it. This production instruction form has a QR code printed on it. When the part number information is read from the QR code, the screen is switched for each part number, initiating the measurement.

This work pieces with all 16 models, enabling 3 machining centers to simultaneously respond to the production of 3 different models.

In order to remove the work time variations and to establish the standard work procedure, each measurement location is displayed one after another, helping the workers understand where to measure. In addition, by standardizing the measuring method, we can now control work variations. Furthermore, we matched the measuring instrument number on the screen and the actual goods number to prevent workers from being confused. In this system, the measurement results from the measuring instrument are communicated wirelessly, allowing the worker to measure the next part only if the result is within the tolerance.

Photo 8 Inspection support system

7 Result

All of the targets were achieved.
① Operation rate: 86.0%
② Line complaint: 0 (As of December, 2016)
③ Production start timing: May, 2016

8 Summary and Future Tasks

By establishing this line, we were able to establish high-speed/high-precision technology for cradle machining by machining centers. We were able to establish a process-aggregated line that can respond to the "various kinds and small quantity" production.

In the future, we will deploy and develop the initiatives to other lines by using this technology as the base.

9 In Closing

We would like to express our appreciation to relevant divisions who have provided us with cooperation in the establishment of this pump flange machining line as well as everyone who has provided us with guidance and support.

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