Measures for Mass-producing the AC Servo Motor "SANMOTION R" Series

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1.Introduction

Due to the world-wide recession, order intake has dropped drastically, and our business performance was impacted greatly with this change of environment. Even in such an environment, we have completed the integrative relocation of three factories at Midorigaoka, Tsuiji, and Aoki to the new factory in Kangawa, moving forward in the creation of a corporate structure that is not affected by changes in the environment.

Our major measures include building a unified structure by integrating the factories, reducing material costs by starting in-house manufacturing of processes such as electrodeposition coating and material cutting that were performed externally, reducing material costs by changing to steel materials that do not need preliminary tempering due to the installation of shaft heat processing equipment, and reworking the productivity rate by reconstructing the layout to shorten movement from machining to assembly throughout the motor manufacturing process.

Furthermore, in 2010, demand for the AC servo motor increased dramatically, and therefore we developed an urgent need to enhance the manufacturing facilities in addition to the streamlining that we have undertaken. Using this production increase as an opportunity, we moved forward with measures to improve our structure so it will not be affected by changes in environment by restructuring the mass production line with higher productivity.

This document introduces the measures of in-house manufacturing performed on the added production equipment for the small and medium AC servo motor "SANMOTION R" Series (referred to as "R series" hereafter), innovative improvements to the hand-finish and inspection processes, and improvements to the mass production line by adding equipment for increased production.

2.Background of Efforts

After experiencing the effects of the world-wide recession, demand for AC servo motors has increased rapidly, and we developed an urgent need to install additional production equipment and reconst the production line with added production equipment. However, the equipment manufacturers who manufactured the production equipment could not keep up with the sudden rise in demand for equipment after reductions in production last year, and it was almost impossible to manufacture the production equipment in short delivery time. Furthermore, in order to further reduce the time for each process, we required innovative improvements to the processes rather than just adding the same equipment as before. In addition, the theme for the Sanyo Denki 6th Mid-term Management Plan was "Challenging your weakness, and turn it into your strength" , and the division target under the category of "Innovations in manufacturing technology and manufacturing process" was "In-house manufacturing of production equipment."

With this as a background, we worked to increase short-term production through in-house manufacturing of production equipment, low cost equipment manufacturing, and reduction of work hours by improving the process.

3.Overview of Efforts for In-house Equipment Manufacturing

3-1 Purpose

The following targets were set and worked towards for "in-house manufacturing of production equipment."

- Realize the "Innovation of manufacturing technology and manufacturing process" in the 6th Mid-term Management Plan.
- Further enhance production technology utilizing the knowledge and skills earned through in-house manufacturing of the equipment.

Photograph 1: Small-sized simplified molding machine NO.1

Photograph 2: Large-sized simplified molding machine NO.2

- Realize reasonable equipment manufacturing in a short turnaround time.
- Accumulate the gained knowledge and prevent it from being leaked outside the company.
- Accumulate examples of using our products "SANMOTION C Motion Controller" and "AC Servo System" in the manufacturing equipment.
- Make innovative improvements to processes that took time with the conventional manufacturing/inspection equipment.

3-2 Measures towards in-house manufacturing of the stator molding machine

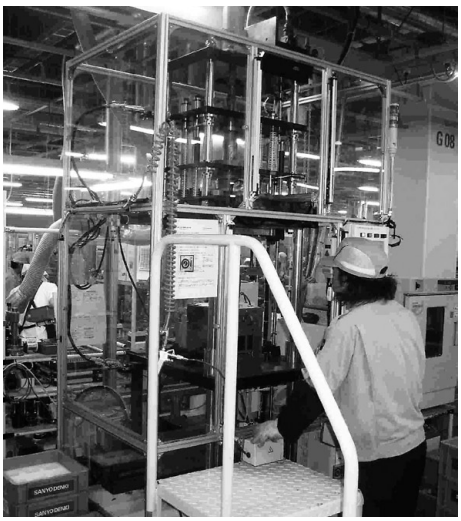
We needed to introduce equipment for stator molding process that has been a bottleneck in increasing AC servo motor "R series" production in a short period. However molding machine manufacturer-proposed delivery schedule did not correspond to the rapid increase in our production.

We challenged ourselves to internally manufacture in-house simplified molding machine in a short period by utilizing knowledge gained from BMC molding technology through P5 motor manufacturing and molding machine manufactured by molding machine manufacturer introduced in advance for the small-sized "R series."

We first manufactured a small-sized simplified molding machine for the models whose stator molds are not shown as their exteriors, such as for 40 mm square, 60 mm square, and 80 mm square motors.

Team having experiences of internally manufacturing mold prototype casting was in charge of machine mechanical part manufacturing from structural design to production, simplifying the structure as much as possible. The control part was structured by using the "SANMOTION C Motion Controller" and "AC Servo System," with the Servo System Division, 3rd Design Department helping with the design. The first machine (Photograph 1) was completed and placed online in June 2010, with an approximately 1.5 month delivery time. We subsequently challenged to internally manufacture a large-sized simplified molding machine (see Photo 2) for 130 mm square medium-sized motor whose stator mold is not shown as its exterior. Then we grew in size and widen the same type machine as the above as the second internally manufactured machine, by incorporating improvements to the first machine for 1.5 months and then placed it online in July 2010 (see Photo 2).

The next challenge was to internally manufacture molding machine for the models whose stator mold is shown as its exterior. Since the appearance of molding is visible by customers, inspection criteria in the process, such as glossiness and patterning of plastic on the surface, are stricter from the perspective of product value. Having the



Photograph 3: Small-sized simplified molding machine NO.3

machine pass the criteria by establishing testing and molding condition adjustments was more of a challenge than the ones of the first and second machines. We managed to have the third machine incorporating improvements pass visual inspection and place it online in August 2010 (see Photo 3).

We internally manufactured three types of simplified molding machines at approximately 1/3 of the cost and 1/3 of the delivery time of commercially available machines. We also reviewed the layout of molding machine peripheral tools, achieving to workability within easy reach.

3-3 Electrification of large-sized hydraulic assembling equipment

For the medium-sized "R series" assembling equipment (shown in Photo 4) and magnetizing equipment (shown in Photo 5), we replaced the hydraulic transport unit with the "SANMOTION C Motion Controller" and "AC Servo System," which turned the hydraulic system into an electric one. We had problems with the setup time for the medium-sized "R series" as it was structured for multiple models, but by switching to an electric system, we reduced the setup time, increased the speed of fast transport, and reduced both energy and noise.

Photograph 4: Medium-sized R series assembling equipment

Photograph 5: Medium-sized R series magnetizing equipment

3-4 In-house manufacturing of the inspection equipment

Conventional AC servo motor inspection equipment was manufactured by an inspection equipment manufacturer and purchased by Sanyo Denki. We reviewed the inspection contents and began working towards in-house manufacturing with a focus on reduction of inspection time. By doing so, we not only rationalized the inspection process and sped up measurement and judgment, but we also created a system in which the processing performance could be determined from the data automatically acquired. By continuously cycling through simplifications to the inspection process and reworking based on the process performance, we achieved further improvements in quality and reductions in cost.

Our manufacturing and inspecting guidance teams were in charge of proceeding in-house inspection and adjustment facilities. However, the teams have no experience of building up appropriate inspection system for inspection specifications and establishing highly efficient inspection method, so the development area of their task was challenging. We solved the task, started operation of characteristic inspection equipment for medium-sized "R series" (see Photo 6) from mid-August 2010, and then placed assembling and inspecting facilities for peripheral parts of sensor mounting online. By speeding up measuring and determining all measurement items in motor characteristic inspection, the measurement time was reduced to from 150 seconds to 75 seconds. We subsequently completed and placed inspection and adjustment facilities online, such as sensor adjustment equipment (see Photo 7) and sensor characteristic inspection equipment (see Photo 8) for small-sized "R series." We also reviewed inspection items requiring repeating power-on/off at 40 points, achieving vast inspection time reduction from 240 seconds to 90 seconds. We also made conventional manual selection of amplifier model, brake presence, and brake voltage to auto-selection by only scanning bar code on them, automated amplifier parameter change according to motor specification in inspection, this could reduce the inspection time from 180 seconds to 90 seconds.

Photograph 6: Medium-sized R series characteristic inspection equipment

Photograph 7: Small-sized R series sensor adjustment equipment

Photograph 8: Small-sized R series sensor characteristic inspection equipment

4.Reconstruction of the Assembly Layout

For the small- and medium-sized "R series," we reconstructed the line layout from windings to assembly.

All the assembly and inspection cells added this time are applicable to manufacturing and inspecting guidance system, considering ease of picking up peripheral tools/ assembling parts, hand movements, and the walking spaces. We arranged the overall line with the aim of improving in efficiency of manufacturing flow, product moving distance on the line, and logistics. (see Photo 9, 10, 11, and 12). For machining mating surface of sensor mounting shaft in the assembly process, we modified a miniature lathe to in-house equipment to perform lathe turning with simple manipulation in NC lathe processing for mating surface. This allows a single person to perform three processes, including measurement of deflection. We also introduced three-axis orthogonal servo drive type application equipment in the sealant application process for mounting surface of flange bracket of small-sized "R series" achieving automatic application during assembly.

Photograph 9: Medium-sized R series assembling line

Photograph 10: Medium-sized R series sensor adjusting and inspecting line

Photograph 11: Small-sized R series assembling and inspecting line

Photograph 12: Small-sized R series
Workflow from sensor characteristic inspection to label printing/issue

5.Conclusion

This document introduced “R series” mass production line as a technology which overcame the recession through “in-house manufacturing and inspecting facility and effort for improving work efficiency” and “improvement and reconstruction of assembly line by adding facility to increase production.”

We introduced “facilities to increase production including in-house facility” and launched improved assembly line based on our plan, and these our efforts have lead to considerable achievement. We deepened the understanding of our products through the introduction of in-house manufacturing and inspecting facilities, and this built up new improvements achieving significant reduction in working hours for some processes.

To achieve “the number one motor works in the industry” aiming to attain a high level of customer satisfaction measurement, we continue to improve each assembling process and line, review inspection processes, and proceed reduction in measuring time.

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