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Study on quality improvement of machine tools

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Abstract

Quality management of machine tools is the key to reducing downtime of customers' machines and the manufacturers' service cost. This paper introduces DMG MORI's systematic workflow from designing, procurement, manufacturing, and acceptance inspections to the delivery of machines, which contributes to improvement of machine quality. Two quality management systems, one for before shipment and the other for after shipment, are described in this paper. Various workflow systems, data analysis, remote monitoring, continuous Kaizen approaches are integrated in the systems. However, defects of machines cannot be completely eliminated, so proactive maintenance and strong service networks are vital for business success. Especially, proactive maintenance is favorably accepted in the industry as a solution to minimize machine downtime and the repairing cost. This paper introduces various sensing technologies to improve the functions of proactive maintenance.

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Keywords: machine tools; smart manufacturing; sensing

1. Introduction

Until recently, machine tools utilizing the state-of-the-art technologies such as 5-axis machines and mill turn centers and the machining methods using those machines were mainly studied in research and development of the machine tool industry. However, new approaches to technical development have been drawing attention lately, e.g. various technologies such as machine tools, peripheral equipment, control units, and applications are combined. To be more specific, systems utilizing the IoT technology and the concept of Industry 4.0 and the latest machining methods such as additive manufacturing are incorporated into new solutions. The authors have been working to employ the above-mentioned technologies to machine tools. However, among customers' demands, having machines that do not break down once they are installed and start operating at their factories are still the most important.

The number of DMG MORI's machine tools installed at customers' factories is approximately 200,000 machines of DMG MORI CO (DMG MORI in Japan) and 130,000 machines of DMG MORI AG (DMG MORI in Germany) are in operation. Moreover, according to the survey, 230,000 companies are potential customers of DMG MORI.

Large-scale manufacturers have installed hundreds of thousands of machine tools at customers' factories worldwide, so they need to provide meticulous services to customers to keep those machines constantly operating. If a machine tool of a customer breaks down, service engineers must visit the customer's factory to repair the machine, and the production at the customer's factory stops until the machine recovers. In most of such cases, customers demand that the manufacturer should recover the machine as promptly as possible. Furthermore, the average life span of machine tools is considered to be as long as 15 years and maintenance services are required during the same period. To provide maintenance services to customers for such a long period, it is necessary to carry spare parts with short life cycles such as electrical parts in stock or modify machines so that the latest spare parts can be used.

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The key to providing customers with machine tools which do not break down is to improve quality during the production processes. This is the common target for most of the divisions in the entire plant including development and manufacturing divisions. The following are the items to be achieved.

1. Common items
   Lean manufacturing
   Education/training
   PDCA cycle
2. Design section
   Design review
   Design verification
   Customer point of view evaluation
3. Manufacturing section
   Before shipment quality management
   Kaizen
   Inspection
4. Procurement section
   Supplier management
   Acceptance inspection
   Cost management
   Delivery management

If these items are rigorously pursued, drastic improvement in the quality can be expected, defects on machine tools cannot be completely eliminated. So efficient and highly-qualified services are important, and the following two solutions are the key to providing such services.

(1) Detect failures before parts broken
    Preventive maintenance with sensing technologies
(2) Repair as soon as possible after failure
    Remote monitoring and maintenance system
    Strong service network
    Parts supply system

This paper introduces approaches to the above-mentioned contents as a machine tool manufacturer.

2. Quality management at the factory

DMG MORI has 13 main factories in seven countries. This global production system, with factories in Europe, the U.S.A., and China, as well as four factories in Japan and three in Germany, reduces risks of volatile currency exchange rates, and enables optimal machine tool delivery for the customers worldwide in terms of transportation costs and lead time. Additionally, high accuracy magnescales and laser scales are produced in Isehara, and Taiyo Koki's grinding machines are produced in Nagaoka. At the factory in Iga, the largest one among the 13 main factories, medium-size and large-size machine tools are manufactured. The quality management divisions in Iga, which consists of two divisions: the before shipment quality management division and after shipment quality management division. The before shipment quality management division is responsible for inspecting machines before shipment to provide customers with high-quality machine tools, whereas the after shipment quality management division is responsible for improving the quality of machine tools after they are installed at customers' factories.

Fig. 1 shows how the processes of the manufacturing management, quality management, and acceptance inspection are combined. These processes and the quality of machines tools are all managed at one central system by computers. Fig. 2 shows the flow of assembly work in a vertical space utilizing the 3D model and BOM system to create standard procedures for assembly work and test procedures.

2.1 Quality management before shipment

Quality inspections are conducted to detect problems including potential problems at the factories before shipment to prevent problems from occurring after machine tools are delivered to the customers' factories. Fig. 3 shows the flow of the product inspections including the positioning accuracy test, cutting test, product inspection, running test, and shipment inspection.

In the quality inspection processes actions for improvement are continuously taken, contributing to the quality improvement of machine tools.

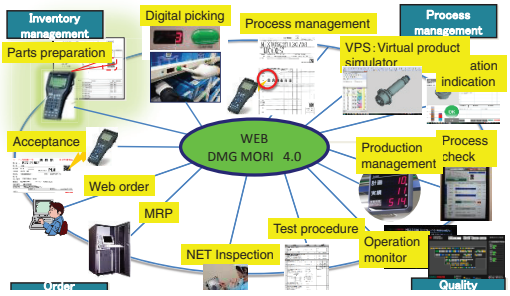

Fig.1 Smart manufacturing at Iga facility of DMGMORI

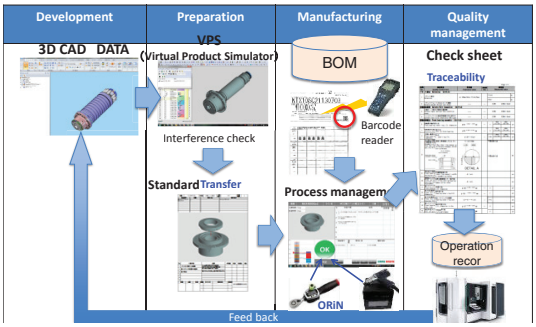

Fig. 2 Utilization of Design data

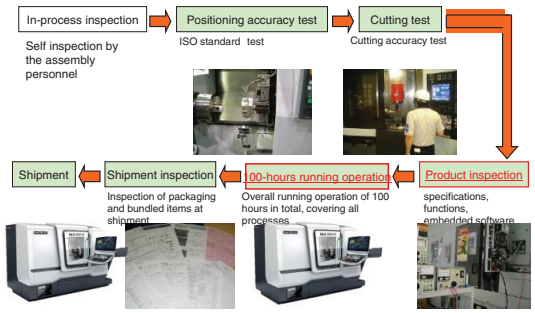

Fig.3 Product inspection