Technical paper

KOM-MICS, a “Tsunagaruka” System for Production Sites

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In recent years, efforts have been made in the industrial world to promote the ideas of “Mieruka” (making things visible) and “Tsunagaruka” (making things connectable), linked with keywords such as Industry 4.0 and IoT. However, there are not many examples of these ideas actually put into practice and utilized. Komatsu has been practically progressing with the improvement of production by “Mieruka” and “Tsunagaruka” under their own plan called KOM-MICS. In this article, we would like to introduce the global image of KOM-MICS, outline our strategy using application software for developing and improving “Tsunagaruka” methods to control machine tools, and show examples of actual applications.

Key Words: *Mieruka, Tsunagaruka, KOM-MICS, Industry 4.0*

1. Introduction

In Komatsu, our construction machines have been progressing in Tsunagaruka (making things connectable) and Mieruka (visualization, visual control, or making things visible) through KOMTRAX, and utilization of obtained data is also progressing, such as services like maintenance proposals.

On the other hand, Tsunagaruka and Mieruka have not been progressed on the facilities of the production sites of these machines, not to mention of the utilization of their data.

Several factors for this are:

(1) It is difficult to acquire data from the facility.
(2) The network infrastructure for sending data has not been well developed.
(3) There are no appropriate applications that can be used for improvement.

Komatsu has been developing technologies to solve these factors, and also working on activities to actually connect the acquired data to the improvement.

2. Overview of KOM-MICS

2.1 Current Development of Exposure Tool and Its Market in the World

Komatsu has various production facilities including heat treatment devices, welding robots, and machine tools in the sites. KOM-MICS collects data from these facilities to the server and makes the data visible (Mieruka) by various applications. The parts of Komatsu products are produced not only internally but also in the subcontractors, and therefore Komatsu makes KOM-MICS available in the subcontractors as well.

This implements Mieruka of the production of whole Komatsu Group so that system functions to help eliminate unreasonableness, waste, and inconsistency.

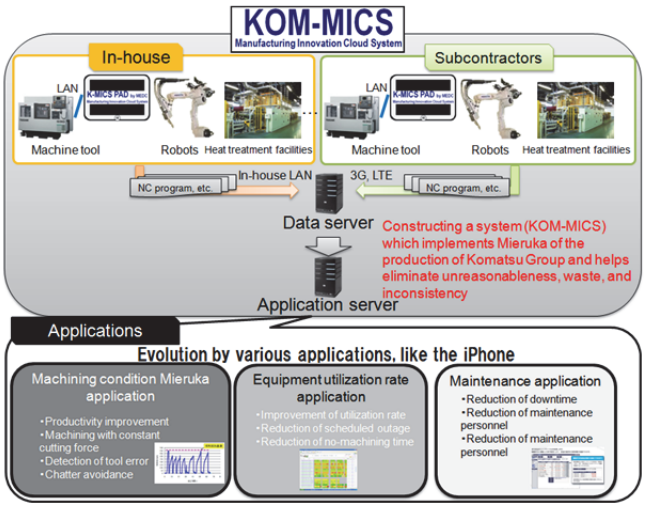


Fig. 1 Global Image of KOM-MICS - Overview

2.2 Tsunagaruka of Machine Tools

For the welding robots, Komatsu manufactures their controllers internally and the operation data has already been standardized. Therefore, Tsunagaruka and Mieruka have been promoted earlier.

Machine tools, however, are procured from various manufacturers in different specifications, so that Tsunagaruka have not been progressed.

2.2.1 Collecting and sending data from machine tools

We have selected and developed devices and software to solve the above-mentioned problems.

For the development of software for collecting data, the data to be acquired, such as NC programs and cutting force, have been standardized and configured as shown in **Fig. 2**. The communication section is separated from the section that converts data for KOM-MICS. This construction makes it easier to develop the communication section for the CNC machines of different companies. The system currently supports the FANUC i series and OSP-P200 and later controllers, and will further support OPC-UA, MT-Connect, etc. successively to increase data acquirable CNCs.

In addition, with regard to infrastructure for data transmission, by supporting Wi-Fi and LTE, the system can also be used at the sites without sufficient infrastructure.

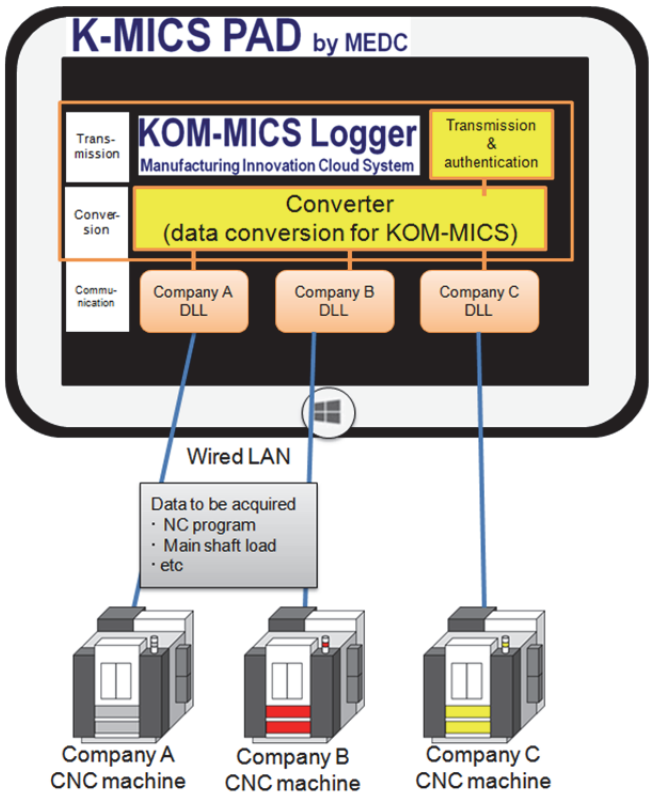


Fig. 2 Configuration of data collection software

With regard to data collecting hardware, a commercially available tablet PC is used so that it can be retrofitted easily to an existing machine tool (**Fig. 3**). The required specifications are shown below, and the hardware does not depend on any specific tablet.

- Dustproof and drip-proof
- Power On AC (function to automatically start the application with energization of PC)
- Windows (x86, x64) operating system
- Wi-Fi
- Wired LAN port
- LTE

Fig. 3 Installation of tablet for measurement

2.2.2 System configuration

The overall system configuration is as shown in **Fig. 4**. Data is sent from the tablet terminal to the server and viewed on the PC in which the dedicated viewer is installed. The server contains a database which retains the current status of machines and has a file server function that stores the coordinates, NC programs etc. used for the past machining. After copying necessary data to the local PC, viewer processes it for Mieruka.

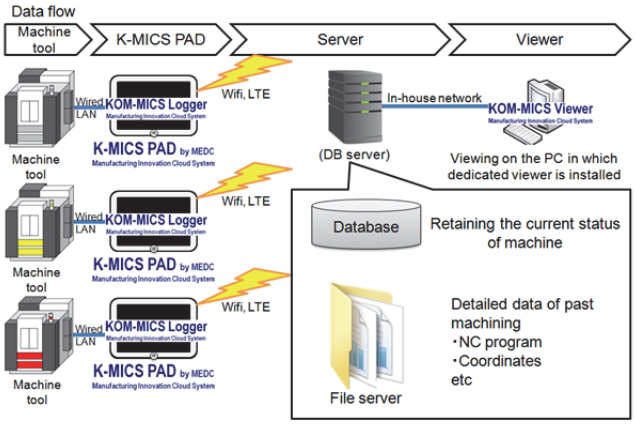


Fig. 4 Overview of overall system configuration

2.2.3 Mieruka application

Mieruka (visualization) of the data collected as described previously has been realized by various applications.

- Real-time operation status

The real-time operation status is visualized (Mieruka) (**Fig. 5**). It is designed to be able to determine not only moving or stopping of machines but also fast forwarding or machining. Komatsu can know the operating status of machines not only in Komatsu but also in subcontractors by KOM-MICS.

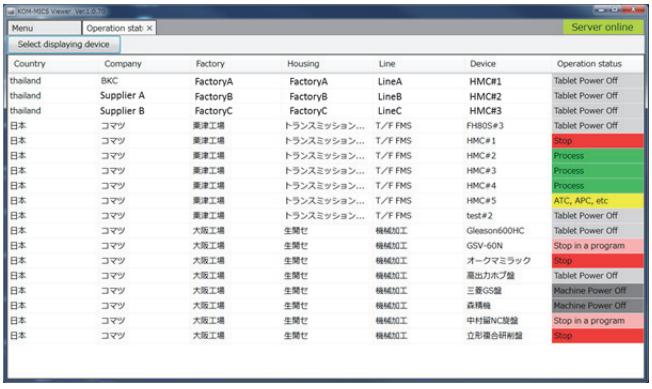


Fig. 5 Real-time operation status

- Operating ratio

By aggregating the real-time operation status, the operating ratio is also become visible. The operating ratio is normally led from whether the machine is operating or not, but KOM-MICS can grasp the operation more in detail by checking whether the machine is creating added value or not (whether it is machining or not).

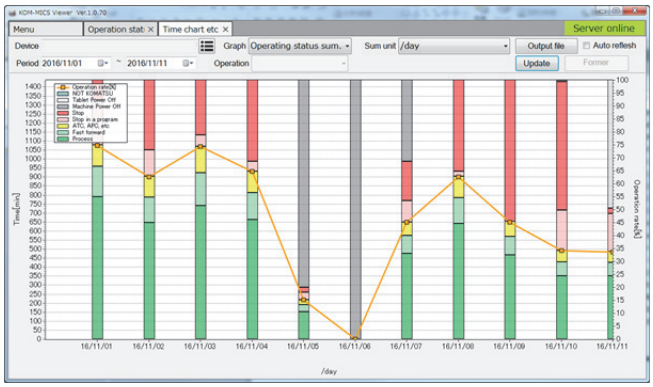


Fig. 6 Daily operating ratio

- Time chart

The time chart can be displayed with time on the horizontal axis and date on the vertical axis. It tells when which process of which parts were executed.

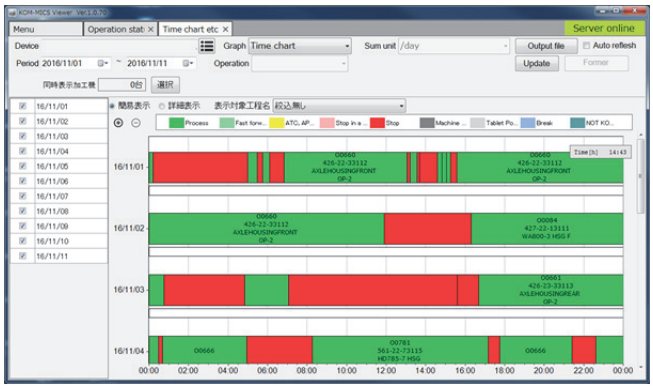


Fig. 7 Time chart function

• Volume of production

The system is also designed to be able to grasp the volume of production. It is possible to easily grasp how many parts of which process have been completed in which processing machine.

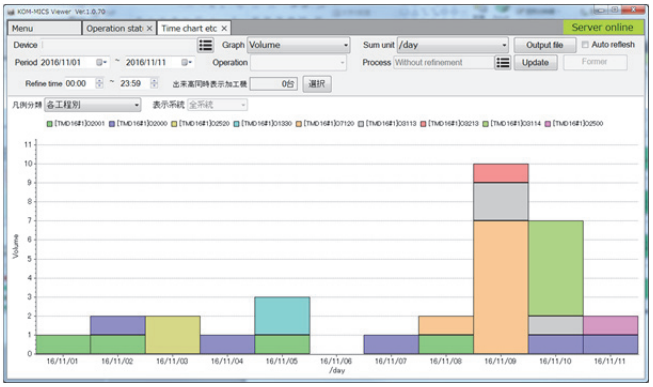


Fig. 8 Production quantity graph

• Mieruka of cutting force

Further detailed information in the process can also be viewed. In the machining process of a machine tool, the system is designed to be able to know what force was applied and in which cutting path the machine moved when it was operated by which NC program. This enables easy determination of the location to be improved.

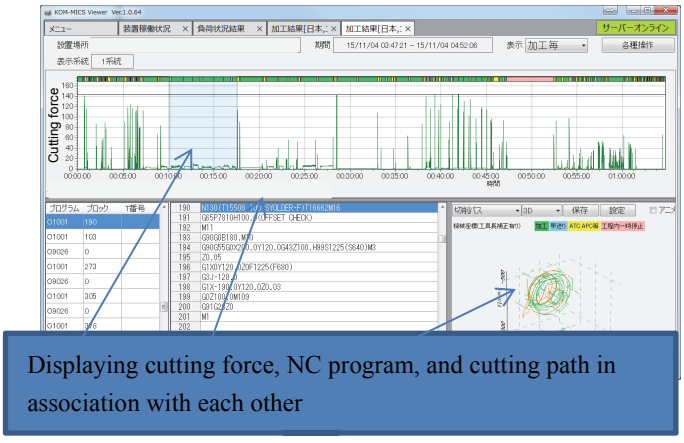


Fig. 9 Mieruka of cutting force

2.3 Application for Improvement

We have thus practiced Mieruka, but Mieruka is a means and is not our goal. Based on the data, Komatsu creates applications for improvement.

2.3.1 Making cutting force constant and reducing air cut

Making cutting force visible (Mieruka) causes various things to come to light. For example, even when using the same tool, the cutting force greatly varies depending on the machining location. This kind of problem has been improved.

Specifically, first, a cutting force is measured for each tool. Then it is known that to which cutting force the tool can be used. At the same time, it also indicates the portions where the cutting force is low and the portions where no cutting force is applied (**Fig. 10-(1)**). Next, fast-forwarding is applied to the portion where no cutting force is applied, and the feed speed is increased for the portion with low cutting force (**Fig. 10-(2)**). Doing so enables improvement by modifying the mass production machining program.

However, doing this manually takes time and is not realistic, and therefore Komatsu created an application which automatically performs this modification on the machining program (**Fig. 11**). By specifying the target cutting force and the NC program lines to be improved, the application automatically improves the NC program accordingly. At this time, the cutting time and cutting force by the improved NC program are also simulated and displayed. By using the application, NC programs can now be easily improved.

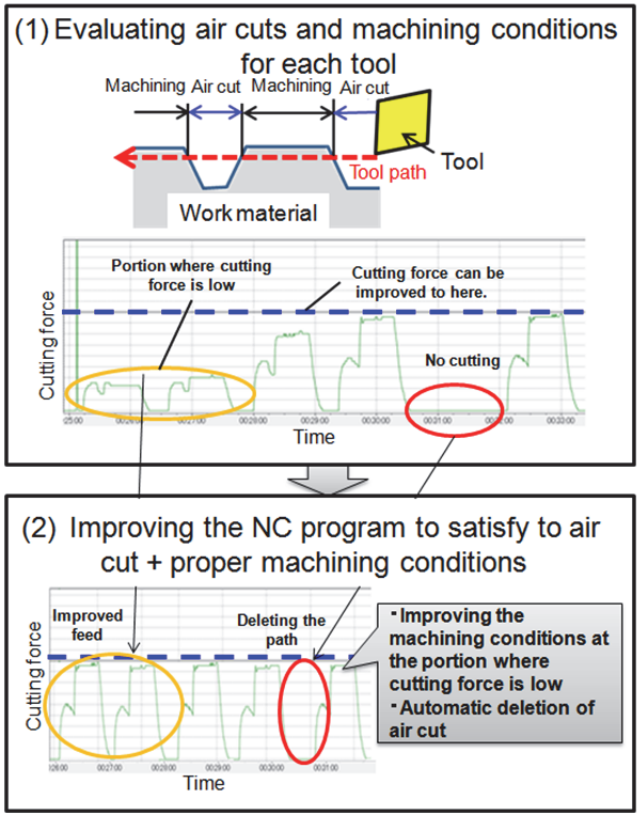


Fig.10 Concept of improvement

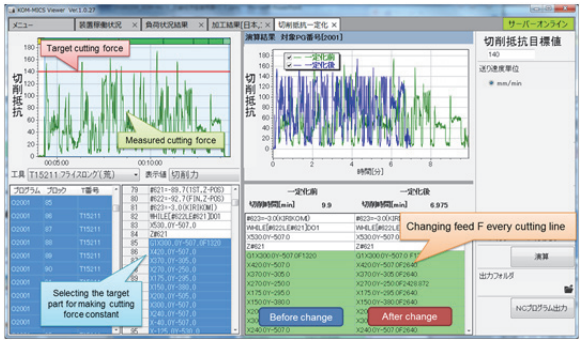


Fig. 11 Example of constant cutting force of NC program

2.3.2 Adaptive control

In Komatsu, there are also cases where the improvements described in previous sections are not applicable. For example, the cases in which the variation per workpiece or lot is large, or the positions with low cutting force (air cut) are not constant.

To respond to these cases, we have also developed the technology called adaptive control which controls feeding by detecting the cutting force in real time. It feeds at high speed at the air cut portions where no cutting force is applied and, at portions with low cutting force, it automatically controls the feed according to the feed at the portions with high cutting force.

An image of this operation is as shown in **Fig. 12**. It differs from the content in the previous section in the point that the feedback control is done in real time.

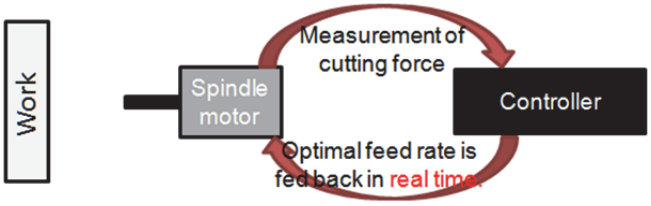


Fig. 12 Image of adaptive control

Applying this control makes the cutting force constant and can reduce the machining time. An experimental example shows that the machining time has been almost halved (**Fig. 13**).

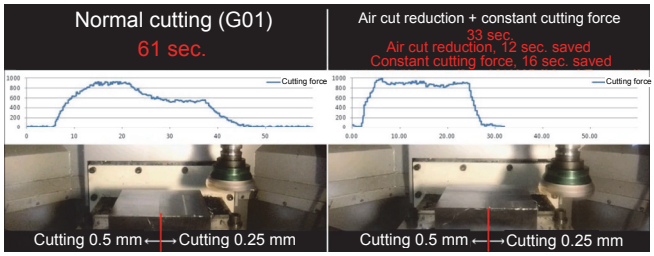


Fig. 13 Experimental example of adaptive control

3. Improvement Examples

Using these technologies, Komatsu as well as subcontractors have practically made improvements.

3.1 Improvement by constant cutting force and air cut reduction

We made cutting force constant and reduced air cut for the turning process of flange.

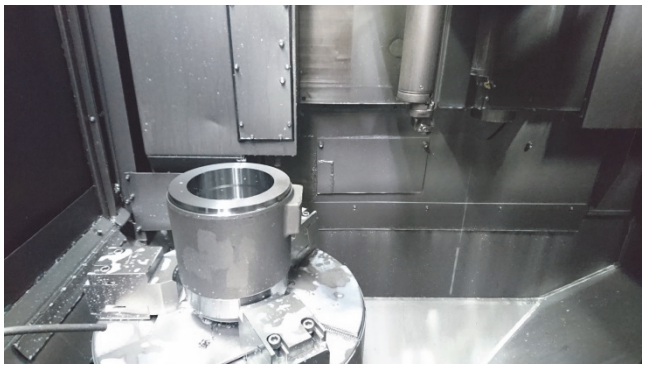


Fig. 14 Example of flange machining

Cutting force before improvement was as shown below. There were a part where no cutting force was applied or another part where the cutting force was increasing gradually, so we improved the related part of the NC program. This resulted in about 25% reduction of cutting time.

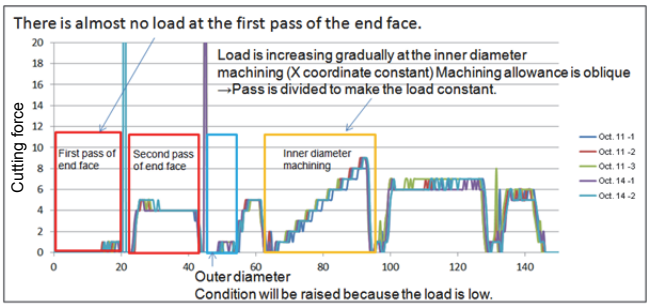


Fig. 15 Example of cutting force measurement

3.2 Improvement by Adaptive Control

The rough machining of a cylinder block by the milling machine was improved using the adaptive control. The cylinder block was a large type as shown in **Fig. 16**.

Fig. 16 Photo of cylinder block

The result was as shown in **Fig. 17**. It was verified that the machining time of the applicable tool was reduced by 35% and that the portion where the cutting force had been low was improved to higher cutting force.

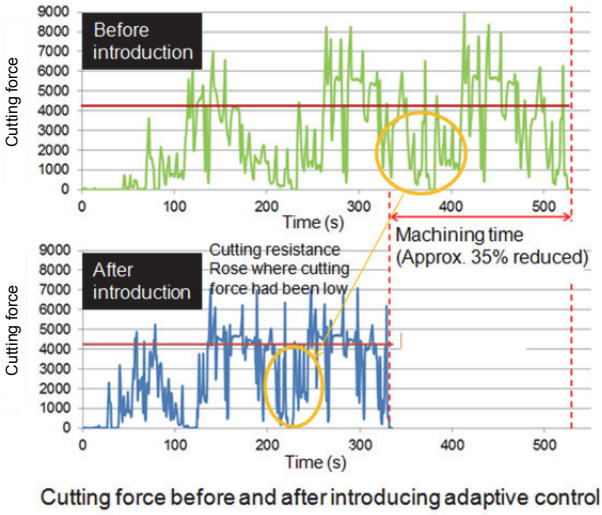


Fig. 17 Waveform comparison before and after introducing adaptive control

4. Conclusion

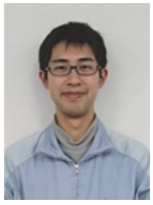
The results we obtained from our research and development of "KOM-MICS, a "Tsunagaruka" System for Production Sites" are described below.

(1) We made it possible to collect information from machine tools relatively easier than before by developing applications for collecting data from machine tools and selecting hardware for that purpose.

(2) We developed applications for "Mieruka" and practiced "making information visible" including information on the real-time operating condition, operating ratio, time chart, production quantity, cutting force, etc.

(3) We also developed applications for improvement to enable automatic coding of NC programs which make cutting force constant and also real-time control of cutting force by adaptive control.

Introduction of the writers



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[A comment from the author]

We expect that IoT will be utilized at production sites in the future and will help improvement activities. For that purpose, we want to continue researching and developing a system that can be used on site with "inexpensive, fast, and easy" as a keyword.