Productivity and Quality Improvement Solution for Assembly and Machining Workplaces

Use of 4M Data Analysis in Manufacturing to Overcome Customer Challenges

Industrial workplaces are seeing ongoing changes amid the progress of digital transformation in recent years. Hitachi is working toward transitioning to the IoT on the manufacturing floor as well as the digitalization of know-how through a fusion of manufacturing floor data and know-how (OT), big data analysis, AI, and other types of IT. This has included the launch of services that analyze the problem factors and improvement considerations related to customers' production losses, quality, safety by collecting, recording, and utilizing (managing) 4M data regarding production resources on the manufacturing floor in a complex way. One of these is a 4M loss analysis service that models, in terms of 4M data, the insights of production management experts and their loss analysis know-how, providing these methods in the form of analysis and visualization functions and values that help customers resolve the challenges that arise in manufacturing operations.

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1. Introduction

Digital transformation has been progressing across different industries over recent years in tandem with advances in technology and other changing circumstances. Dealing with a challenging environment has become routine for manufacturing in particular, including such issues as the declining number of experienced workers and greater diversity of output. Along with this, expectations are rising for the application of the Internet of Things (IoT) to manufacturing regardless of company size.

Unfortunately, many companies in manufacturing have yet to make much progress in adopting the IoT and their improvement activities continue to rely on analog information management practices such as whiteboards and paper documents. Likewise, expertise in workplace productivity improvement also tends to be held by particular individuals. Continuing to address the major trends represented by a shrinking workforce and shortages of experienced workers by existing production management practices that have yet to embrace the IoT threatens to become a bottleneck. On the other hand, the IoT requires "sensing" infrastructure for the acquisition of workplace data, the installation of which poses a high level of difficulty. Many companies are unable to put such practices in place for themselves, lacking knowledge of how and from which manufacturing processes to acquire data, and of how to manage and analyze it once acquired.

This article describes a 4M loss analysis service that was developed by Hitachi's research and development staff with manufacturing industry knowledge through a process of consultation with industry customers about their current circumstances. The service collects, records, and utilizes (manages) human, machine, material, method (4M) data from the manufacturing floor in a complex manner, and suggests, visualizes, and analyzes the problem factors and improvement conditions related to customers' production losses.

2. 4M Loss Analysis Service

With the help of a customer that manufactures machine tools, Hitachi undertook a trial in 2018 that involved the analysis of "human" (worker actions), "machine" (machine tool operating records), "material" (data on items being produced), and "method" (sequence of steps and tool history) data. While an optional service of the machine tool company handled the collection and visualization of operating records for the equipment used in the trial, its scope did not extend to details of why machine downtime occurred or what was happening in the workplace while operation was halted.

The trial analyzed the acquired 4M data collectively on the basis of plant operating procedures to identify details of losses resulting from human factors that would have been difficult to pick up from single items of data. This showed, for example, that more than 10% of downtime was due to losses associated with restarting machinery that had been out of use due to a shortage of workers. Human-related causes of loss included shortages and absences of workers. The shortages were believed to be a result of inappropriate shift allocation in production planning. Losses due to an absence of workers, on the other hand, involved cases where, although staff were allocated to shifts in appropriate numbers, workers for whatever reason were unable to deal with machine outages and this resulted in a downtime loss.

The trial demonstrated the effectiveness of the analysis, which included being able to uncover the sort of detailed factors involved in losses that are unable to be effectively identified by inquiries held after the event, but that point the way to potential improvements. Hitachi has been working on the development of a 4M loss analysis application since 2019 that draws on experience from this trial and utilizes models that are applicable to numerous machining workplaces for the automatic analysis of 4M data collected from workplaces to identify and present the causes and scale of losses. The following sections describe three functions of this application.

Figure 1 — Production Planning and Performance Screen
This screen analyzes planned versus actual daily production over the course of a month for an entire factory. It also shows the productivity of each machine tool and indicates on which days productivity is low.

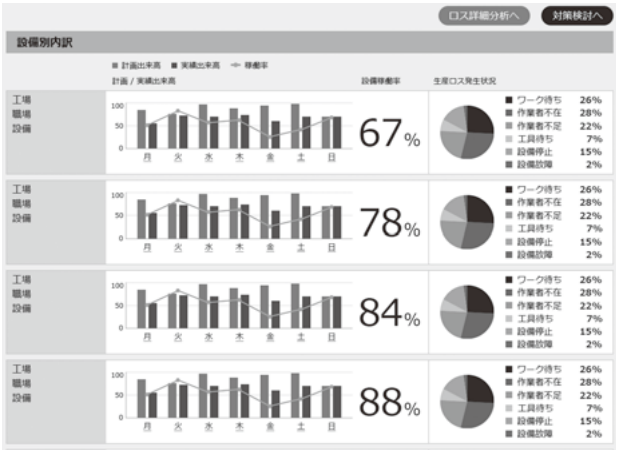


Figure 2 — Detailed Loss Analysis Screen
In response to the user selecting a day on which production losses occurred, this screen presents a timeline showing what sort of losses occurred and at what times of the day. The loss information is generated by an algorithm that uses 4M data as a basis for automatic loss assessment. The screen also presents graphs of machine operation and shows the relative proportions of the different loss causes during the day.

2. 1 Production Planning and Performance Screen

To show productivity across the entire factory, the 4M loss analysis application provides a production planning and performance screen that can be used to analyze planned versus actual daily production over the course of a month (see **Figure 1**). It also shows the productivity of each machine tool and indicates on which days of the week productivity is low. This indicator provides users with the date information they need to gain an overview of production and to conduct detailed analyses of the causes of loss.

2. 2 Visualization of Causes of Loss

Another function of the 4M loss analysis application provides information about loss causes for particular machines on particular days (see **Figure 2**). This function displays the

Figure 3 — Video Review Screen

This screen is used to view video of the plant during loss incidents and is invoked by selecting one of the losses listed in the detailed loss analysis screen. This allows the causes of loss to be determined in greater detail by showing what was actually happening in the workplace, information that is not captured by numeric data.

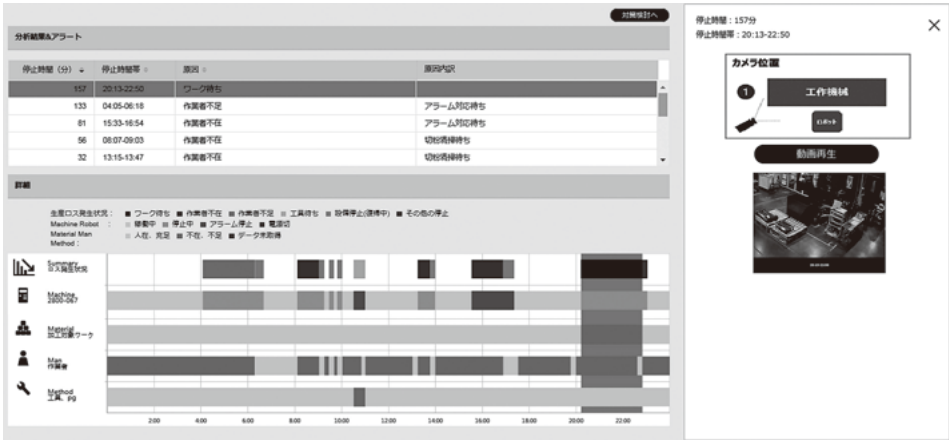
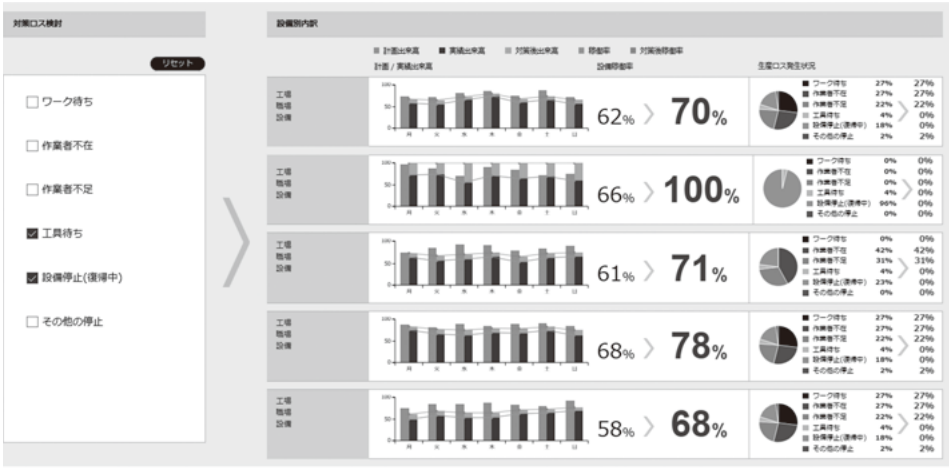


Figure 4 — Loss Countermeasure Simulation Screen

This screen is used to simulate the level of benefits that can be expected from taking action to prevent frequently occurring loss incidents. It can be used in plant improvement activities to identify which production losses have the highest priority.



causes of lost time, such as staff unavailability or waiting on materials, that occur on the machine during the specified 24-hour day together with the incident duration and time of day, ranked by the length of the downtime. This helps customers find countermeasures by providing an automatic and detailed assessment and presentation of the scope and duration of incidents along with loss cause information that would normally only be available in the form of impressions gained while the incident was taking place.

2. 3
Workplace Loss Video Display

The 4M loss analysis service uses cameras with a body detection function to capture data on worker actions. Along with quantifying worker actions, by linking this information to on-screen loss records, these cameras also provide customers with the ability to view a video of what was happening in the workplace at the time of the incident under review (see **Figure 3**). While the manufacturing industry has in recent years made a start on installing cameras in the workplace, the problem is that reviewing workplace footage to identify the causes of loss incidents can be very time-consuming. Use of this function helps to shorten the amount of time customers spend on investigating countermeasures.

2. 4
Estimation of Benefits of Loss Countermeasures

This function is used to estimate the benefits of resolving the issues identified for a particular machine once they have been highlighted (see **Figure 4**). Whereas past practice in manufacturing has been to rely on intuitive assessments of the nature and scope of losses, this function quantifies their extent to help customers prioritize countermeasures.

3. Benefits of 4M Data Analysis

Through the automatic identification of loss causes, the 4M loss analysis service helps customers reduce machine tool downtime and make frequent improvements. This leads to higher productivity, shorter delivery times, and higher sales.

Loss cause analysis by means of 4M data can also be used to identify quality issues in manufacturing workplaces (losses that take the form of quality defects). A quality review of a tire production process conducted for a customer in 2019 facilitated the rapid and effective implementation of countermeasures. This involved collecting and analyzing 4M data relating to the four steps of compounding, component preparation, tire building, and curing and then

presenting the factors involved in quality defects at each step and in order of severity. Artificial intelligence (AI) was used to analyze 4M data on the highest ranked factors and identify workplace measures that, when implemented, helped to reduce the defect rate. By providing a real-time view of what is happening so that countermeasures can be put in place more quickly, and by using AI to analyze 4M data, Hitachi intends to acquire new knowledge that could not be obtained using existing production practices(1).

With regard to its quality analysis service using 4M data, Hitachi is also looking at undertaking work on storing and processing data on people, materials, machines, tools, robots, and other resources that has been collected for the purpose of production loss analysis and then correlating it against product quality. As it rolls out production loss analysis, Hitachi also plans to expand its scope to encompass this quality analysis also.

4. Future Outlook

With a view to serving a greater number of customers, Hitachi is currently looking at adding a cloud option and at extending the scope of the solution to encompass multi-purpose analyses that include data on robot operation as well as 4M data. Along with the primary machine tool, the "machine" elements of machining cells also include auxiliary robots that automate the transportation, insertion, and removal of parts to be machined. Accordingly, Hitachi will develop analytical techniques that help customers further improve productivity by identifying the causes of the minor stoppages in robot operation that reduce machine utilization. At sites with leading-edge equipment, fully automatic configurations are achieved through the use of auxiliary devices such as materials handling robots. One of the concerns when using this sort of equipment is that, along with machine tools and machinists, minor stoppages in robot operation can also be a cause of lower utilization. As it can be difficult to ascertain in detail what proportion of downtime is due to such minor stoppages, in many instances no such objective assessment takes place. This is because it is not possible to acquire such a detailed understanding when relying on data from robot control panels that only covers alarms and whether the robot is operating or idle. On the other hand, when 4M data is also available, it should be possible to make detailed assessments that include the causes of losses, whether they relate to materials or processes or are associated with robot attachments such as hands or chucks, for example. Research and development work is currently underway using actual data and Hitachi plans to move on to trials and deployment in the future.

5. Conclusions

This article has described a solution for resolving the challenges facing customers by using 4M data from the manufacturing floor, and Hitachi's plans for the future. Hitachi intends to leverage its solutions that use 4M data to bring the IoT to the manufacturing operations of a greater number of customers and to pursue digital transformation.

Reference

1) MONOist, "Sumitomo Rubber Industries Makes Tire Production Smarter with Hitachi 'Lumada' and PTC 'ThingWorx'" (Oct. 2019) in Japanese, https://monoist.atmarkit.co.jp/mn/articles/1910/04/news052.html

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