A study on continuous improvement activity support by the IoT technique

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Abstract. Most Information and Communication Technology (ICT) cases of the manufacturing industry converge in the production management department of large enterprises' factories, and production automation by use of ICT increases productivity in the factories.
However, these cases are for mass production, and smaller enterprises which are forced to take multiproduct variable quantity production need to develop an inexpensive operation system of their own to make good use of ICT. It is essential to prepare a tool which can be used exclusively as a digital MONOZUKURI platform. Thereupon we are developing an inexpensive system which makes it possible to exchange, on the Net, information on "things" related to production such as equipment and machines at the manufacturing site. Our aim is to develop a support platform for continuous improvement activities by combining workers' information with the information obtained by use of this system. In this paper is reported the concept model of our platform in the development stage.

Keywords: Kaizen, Smaller manufacturers, IoT, Digital Manufacturing

1. INTRODUCTION

According to a Japanese bank's report on smaller enterprises, many employers think this is not an age of cost differentiation any longer, and that they must give top priority to the strengthening of technical power to survive. Two methods to solve their problems are "Producing highly-added-value products" and "Producing with smaller numbers of workers in the production of many models and shorter delivery." However, the former is difficult for smaller enterprises with no abundant funds, and they cannot defeat large enterprises unless they can develop new products in a short term. Therefore, finding a method for the latter is realistic.

Recently-released-ideas about the Adaptive Digital Factory (Industry 4.0, Industrial Internet, etc.) are booming now. In Japan Manufacturing is called "MONOZUKURI," which emphasizes "Manufacturing with a high level of production and manufacturing techniques," not meaning simple manufacturing. The word MONOZUKURI does not mean just "making", but includes the Japanese spirit. MONOZUKURI, which is Japan's strong point, is weakening, and our country's de-industrialization is advancing. Given this background, Japan Society of Mechanical Engineers etc. have begun to deal with Industry 4.0. The Manufacturing Industries Bureau of the Ministry of Economy, Trade and Industry pointed out Japan's present conditions in MONOZUKURI reform by IoT as follows:

- ✓ Japan is leading the world in the sector of in-plant productivity because of production automation by use of IT, but the IT production automation is for mass production, not good enough to realize "multiproduct variable quantity production."
- ✓ Some enterprises get data from the sensors on products or production lines, and use them for product maintenance

or production line efficiency, but the system is closed within the enterprises. Use of such a system should be spread all over the industry and smaller enterprises.

Although Industry 4.0 is a kind of factory-oriented tackling, use of ICT for manufacturing processes converges in the production management department of large enterprises' factories. For smaller enterprises to make good use of ICT, it is necessary to prepare a tool as a digital MONOZUKURI platform, and also to solve the shortage of technicians for introduction of the tool into the factory.

It is essential to prepare a tool which can be used exclusively as a digital MONOZUKURI platform. Thereupon we are developing an inexpensive system which makes it possible to exchange, on the Net, information on "things" related to production such as equipment and machines at the manufacturing site. Our aim is to develop a support platform for continuous improvement activities by combining workers' information with the information obtained by use of this system. In this paper is reported the concept model of our platform in the development stage.

2. METHOD

Shibuya, et al. research on a work re-design support system for work improvement. We aimed to shorten the development term by incorporating an IoT (Internet of Things) function into the system. The procedure of the research is as follows:

(1) Re-examination of the concept model.
(2) Investigation of a factory with production of many models in small quantities.
  ① Investigation of IoT usage.
  ② Investigation of production plans and output.
(3) Making of a factory model.
(4) Evaluation and re-examination of the model.
(5) Discussion
(6) Modification to the concept model.

3. CONCEPT MODEL DESIGN

3.1 Re-definition of the concept model

Taking the following aspects into account, we re-defined our previous concept model (Figure 1).

- ✓ In many cases, smaller enterprises take "production of many models in small quantities" for received orders, and make production plans so that they can keep a certain amount of stocks. We should consider a production method to shorten changeover time and improve production efficiency by keeping some stocks.
- ✓ We should make a system so that the supervisor can put many hours in improvement in the worksite by reducing his routine work such as keeping accounts.
- ✓ One characteristic of "Japanese MONOZUKURI" is repetition of small improvements depending on talent and workers' experience. At the factory where we conducted an investigation, workers taxed their ingenuity in changeover and so on, which contributed to the shortening of manufacturing time. We should introduce "Wisdom of MONOZUKURI worksites and a strong insistence on skills" into the model.

In designing an operative system, we classified the problems into four groups for solution.

I. Examination of a production planning support method by use of the O2O technique.
II. Examination of IoT usage and a tool for production operation.
III. Examination of the usage of digital manufacturing techniques in production operation.
IV. Examination of the usage of digital manufacturing techniques in work improvement.

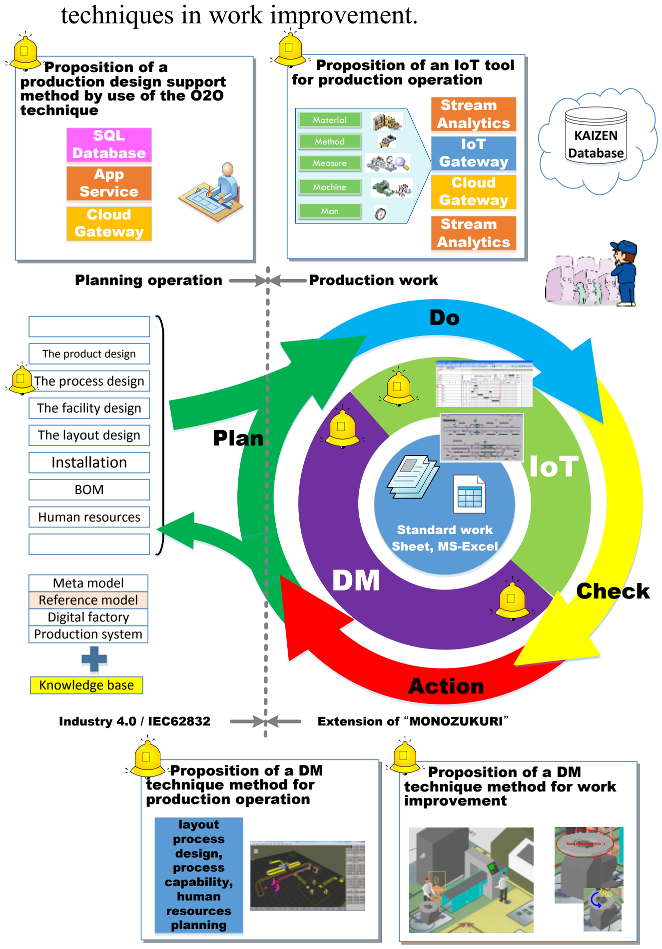


Figure 1: The outline of the work improvement support system by use of IoT.

3.2 IoT

IoT is a technique to actualize yield improvement and a higher level of maintenance by correlating and accumulating data on both products and their production process. What is important to make effective use of IoT is the linking of design, preparation of production and mass production by SIM (Simulation Integrated Manufacturing).

The data usage of IoT is divided into four phases, that is, Collection -> Accumulation -> Analysis -> Use. The phases "Collection" and "Use" are easy to realize at a relatively small cost, but the others are not. The digital MONOZUKURI platforms for them are not secure yet. And also there are neither big data analysis methods nor common methods for addition of other values such as a predication model. Designing a system by M2M (Machine to Machine) with no use of IoT is more effective, but we designed a system by use of cloud computing.

3.3 Digital manufacturing (DM)

DM is a method which makes it possible to conduct effective development by using the virtual simulation of design and production for the real production line. The DM tools are classified into "Assembly work simulation" and "Production line simulation."

The former is for evaluating workability in the assembly process, and the latter is for finding the progress of a process by inputting a process, equipment, workers and so on. Both of the tools are necessary for practicing improvement activities effectively in "Japanese MONOZUKURI."

4. FACTORY INVESTIGATION AND MAKING OF A FACTORY MODEL

4.1 Factory investigation

The enterprise was a small-scale food manufacturer with 28 employees, manufacturing ice cream for convenience stores. The manufacture of ice cream is made up of about 12 processes, and we investigated 11 processes excluding the process "Storage." The manufacturing processes from the process "Material blending" to the "Filling process" to put frozen ice cream in ice-cream containers were in a liquid condition. We had to tax our ingenuity in "counting" for DM.

The enterprise's factory was a small three-story building. On the 3rd floor "Material blending" was conducted, on the 2nd the processes "Sterilization" and "Refrigeration", and on the 1st floor "Filling" and "Inspection." Because the structure of the building disabled us from observing all the floors at the same time, we conducted our investigation by practicing video-recording with time indication for process analysis, and checking daily production reports for liquid analysis.

4.2 Making of a factory model

The first half of ice cream manufacturing is the same as the process industry like chemical plants where substance runs through pipe or tank apparatuses. In these processes the operator in charge of monitoring work recorded the liquid condition, so we used his data for reproducing the first part. For the second half we reproduced a filling machine by use of CAD, analyzed the speed of the conveyor for ice-cream-filled containers and the packing work, and made a factory model so that the work of three workers could be truly reproduced.

To actualize the above, we decided to make a reproduction by use of the concept "Connective factories" of Industry 4.0, considering the 1st floor, the 2nd and the 3rd to be different factories. So, with reference to the digital factory standard (IEC62832), we arranged various mechanisms of the factory by use of the concept "Layer". In the existing method you need to define models such as an object model for an object and an activity model for an activity, one by one. Defining processing machines and work ways inside the factory will amount to vast work. In IEC62832, the rules for making reference models and conducting management, etc. are defined in the upper layer, instead of defining each reference model, which we thought to help to handle the task "changeover" frequently occurring in factories with "production of many models in small quantities. We used V5 by DELMIA and Quest for the making.

4.3 Contrivance for the use of the IoT technique

For continuous improvement activities, we decided to use three kinds of standardized work tables as an interface. We made a program which made it possible to see Excel data through the factory model by storing data on in-plant measurement in the three standardized work tables. Moreover, in this factory 40 kinds of ice cream was manufactured, but its refrigeration storehouse was too small for extra storage, and the amount of shipping request fluctuated. So the production plan was changed each week. For that, we contrived so that inputting production elements such as the number of articles to be manufactured, the amount of each material and the tank to be used in Excel would lead to direct simulation.

Figure 2 shows the relation between the IoT technique and DM. DM1 in the figure represents the loading of Excel for the production planning. In the factory the ice cream in containers was dumped instead of being sent to the quick freezer until the ice cream reached the quality standards. This was because it took five to ten minutes for the quick freezer to become stable. As a result, the number of the production estimate obtained by simulation was much different from that of finished products. So we decided to re-calculate the gap between the simulation value and the actual one by re-inputting stirring information about materials, the number of finished products and so on in the simulator. DM2 in Figure 2 shows the re-inputting. Figure 3 shows the waste table and a gap value on the simulator screen.

DM3 in Figure 2 graphically, with tables or graphs, shows the VM board, which is advocated by Central Japan Industries Association (ChuSanRen), of the simulation results and the actual production results by use of necessary parameters.

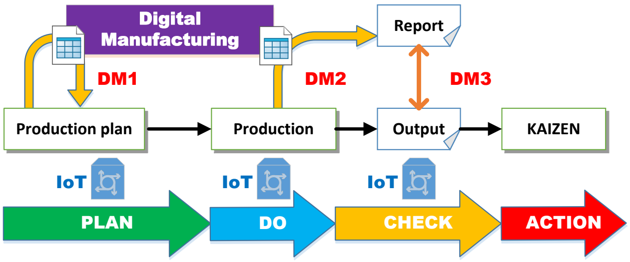
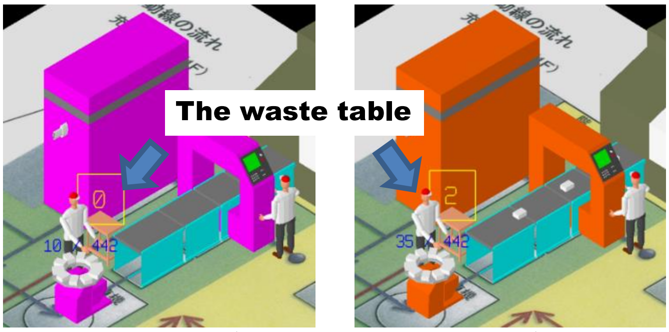


Figure 2: The relation between IoT and DM.



In preparation In operation

Figure 3: A scene of representation of a gap value.

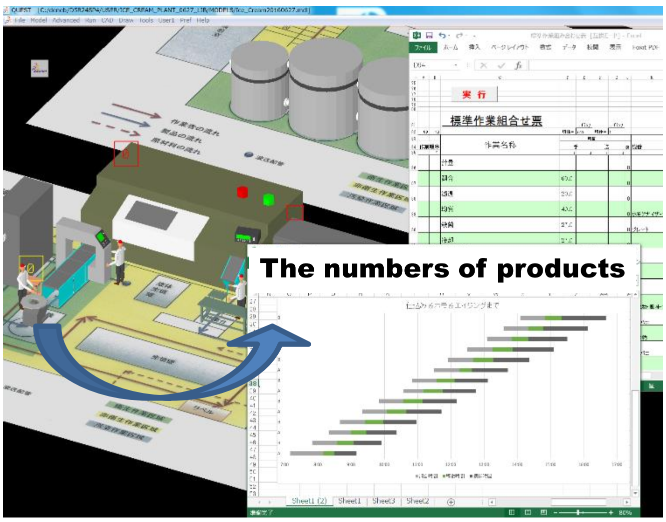


Figure 4: A example of representation of a tank condition and the numbers of products on the screen.

4.4 Verification of the concept model

We created a concept model of the factory in operation to check whether the DM technique was useful in production operation improvement, and examined its usefulness for the verification of the model, with the result that it was found that some functions added to the DM would lead to its effective use.

And also, to improve the worksite, it was necessary to incorporate a mechanism which would enable the capture of various matters inside the worksite, by use of the IoT technique. It was also necessary to examine where in the factory various sensors on the market could gather information properly. It was found that the minimum information could be obtained inexpensively, using the cloud database such as sensor computers “Raspberry Pi2” and “Microsoft Azure,” which revealed that the concept model needed no big change.

5. CONCLUSION

This research showed that visualization of things related to equipment, machines, etc. in the worksite could contribute to productivity and quality improvement by use of the IoT technique. The DM technique is software used at the stage of production planning, that is, planning operation. Manufacturers with “production of many models in small quantities” cannot conduct production as planned, and adjust their production by product each day. It was found that the use of the IoT technique for observing daily production activities with fewer workers and that of the DM technique for continuous improvement activities will lead to effective improvement operation. That is to say, the combination of techniques in popular use or the change of usage or places can be a powerful weapon.

REFERENCES

O2O: Kenji Muramatsu (2009) Requisites for Global Optimization in Production and Operations Management. *Production Management*, **Vol. 15, No.3**, 55-60.

IEC62832 (2015).*http://www.vde.com/de/technik/industrie40/documents/2015-02-19_bmwi_d%C3%B6brich%20industrie%204.0.pdf*

Masahiro Shibuya, Kenichi Iida and Koki Mikami (2015) A study for standardized work suitable for smaller enterprises. *The 23rd International Conference on Production Research, Manila, Philippines.*

ChuSanRen (2006). *http://www.chusanren.or.jp/english/h_vm.html*