Virtual Production Line Simulator: GP4

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GP4 (Global Protocol for...) is a tool which helps companies prepare for production by showing them a virtual production line that utilizes 3D data. Recently in various manufacturing industries in Japan, companies have been rebuilding their business strategies in a global market. Developed markets are maturing, emerging markets are expanding and there is increased competitiveness in manufacturing in Asian countries like South Korea and China. Therefore, in recent years, there have been rapid changes in the business environment surrounding the domestic manufacturing industry, and the situation is adverse. One of the major drivers of change in the manufacturing industry is the rapid localization of production bases with the globalization of markets. Furthermore, the strong yen and the Great East Japan Earthquake have added fuel to the fire, and the manufacturing industry has been forced to shift its production bases overseas from Japan at a faster pace. This rapid localization is leading to local personnel who have insufficient experience, and this in turn is causing delays in the start of mass production and higher costs in preparing for production. This major change and issues are concentrating on production preparation work that links design work and mass production. There is a pressing need for reform in this area. This paper describes the method of investigating the optimum production line without actual products, by utilizing GP4, because of the issues with global manufacturing, and the effects of GP4.

1. Introduction

The manufacturing industry has been rebuilding its business strategies in a global market. With the developed markets maturing, emerging markets expanding and competitiveness in manufacturing increasing in Asian countries including South Korea and China, the environment surrounding the Japanese manufacturing industry has undergone rapid changes in the last few years and Japan is in a difficult situation. In the manufacturing industry, in particular, the rapid localization of production bases along with the globalization of markets has caused problems such as delays in the start of mass production and higher costs of production preparation due to insufficient experience of local personnel. This major change and issues are concentrating on production preparation work that links design work and mass production and there is a pressing need for reform in this area.[1)]

This paper describes issues with global manufacturing[2)] and the method of manufacturing and approaches utilizing GP4 (Global Protocol for…), a virtual production line simulator.

2. Issues with global manufacturing

2.1 Issues confronting Japanese manufacturing industry

The hollowing out of Japanese manufacturing has been a significant problem because of the accelerating shift toward overseas relocation of production bases.

In conventional manufacturing with

a production base outside Japan, design, prototyping and mass production trials were conducted in Japan and mass production took place overseas. Mass production trials in Japan make sense because companies can identify various points to improve in advance, and feed them back to design and production design and thus be able to conduct mass production earlier and reduce production preparation costs. It also allows companies to accumulate points for improvement and ideas found in the process as know-how. At present, however, companies are increasingly conducting mass production trials at their production bases overseas for reasons including local production and sourcing along with the overseas shift of core product markets. Mass production trials outside Japan have caused new problems such as an unintended overseas transfer of manufacturing know-how, obsolescence of domestic production design skills and insufficiency resulting from design that is not aware of the production floor.

Because of the expansion of global manufacturing, an increasing number of manufacturers fear their production engineering ability, as represented by *gemba kaizen* (shop floor improvement), will deteriorate. It was one strong advantage of Japanese manufacturing. Plants mainly for domestic production are required to further improve production efficiency and enhance competitiveness by making improvements plus something extra so as to offer better products than those made outside Japan where labor costs are low.

2.2 Issues with utilization of ICT in area of production preparation

In the manufacturing industry, information and communications technology (ICT) is utilized for resource management and supply management including enterprise resource planning (ERP) and supply chain management (SCM) to conduct operations. Meanwhile, the state of ICT utilization in the area of engineering is different. The flow of operations follows a process of design, production preparation and mass production. Upstream engineering systems such as product data management (PDM) are already being introduced in major companies in the manufacturing industry. In the area of production preparation, however, ICT has hardly been applied under the present situation and operations are manually conducted by human systems (**Figure 1**).

As tools for applying ICT to production preparation, products developed by European product lifecycle management (PLM) vendors once attracted attention. However, in many cases they have not been used or companies have decided not to introduce them because of the following issues.

1) Issues with operability

European software generally assumes exclusive operators to be the users. Due to the requirement for high-accuracy results as a simulator, numerous commands and input parameters are necessary and inputting them alone may take a few months. In Japan, manufacturing engineering and manufacturing personnel directly engaged in production preparation are more likely to operate software and the operation is cumbersome to those who are not familiar with PLM software. Menus and manuals in English also raise the hurdle.

2) Issues with main functions

European software has been developed for industries targeting aircraft and automotive body manufacturers facing severe global competition. For that reason, the main functions are focused on mechanical-system production such as off-line teaching verification of robots. Industry sectors facing intensifying global competition at present are automotive parts and electric machinery/precision equipment manufacturers, which mainly adopt human-system production such as cell and shop production. Although European software has functions to support them, inputting data is a lot of trouble and it is difficult

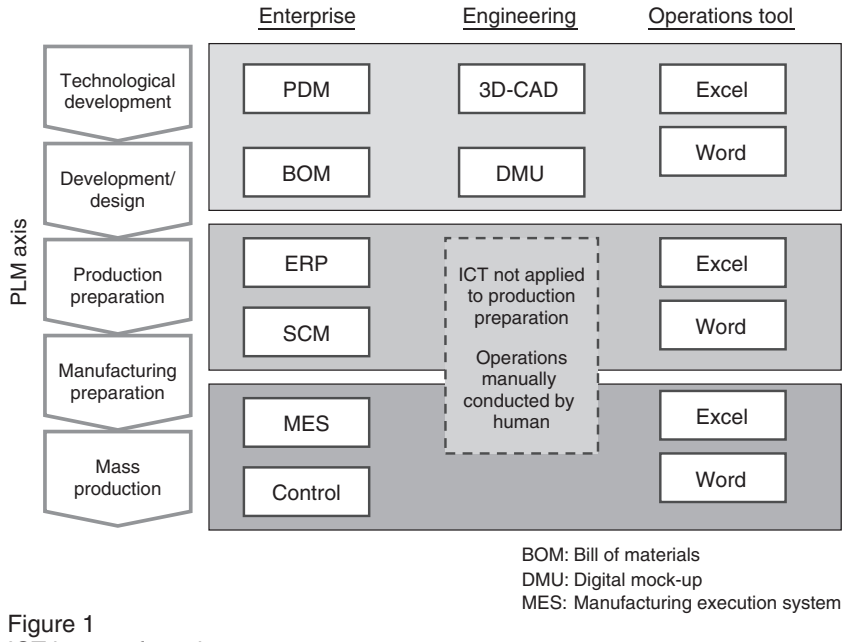


Figure 1
ICT in manufacturing.

to complete preparation before mass production in the automotive parts and electric machinery/ precision equipment sectors.

3. Next-generation manufacturing method using GP4

GP4 is capable of building a production line in a virtual space by using the existing product 3D data, plant layout and assembly sequence as input information to semi-automatically generate the movement of line operators and flow of materials. It quantitatively measures factors such as the production capacity, workability, layout characteristics, material flow characteristics, and production costs and picks the optimum line out of multiple production line proposals (**Figure 2**).

The following are the details of the evaluation method.

1) Production capacity

Simulate in advance whether the production volume required in one day can be achieved by the planned personnel and facilities. Production capacity in excess of or below the production volume leads to wasted inventory or a lost sales opportunity, respectively.

2) Workability

Evaluate ease of manual assembly. The criterion is whether parts are within reach or assembly is possible within that range. Reaching over in an unnatural posture or mounting parts in a squatting position places burdens on operators over time, leading to erroneous work. As a result, the risk of making defective products increases.

3) Layout characteristics

Check in advance to see if the required facilities and parts shelves can be arranged on site without problems. Check the average height of the staff on site to find out the height the workbenches should be in advance. They are both intended to eliminate the need for adjustment after mass production starts.

4) Material flow characteristics

A "buffer" in which materials are held can be checked together with the flow of materials between processes. The operating rate and waiting state of each process in a mixed line handling multiple models, in particular, can be evaluated in advance.

5) Production costs

Calculate the production costs including the labor and facility costs required for the current

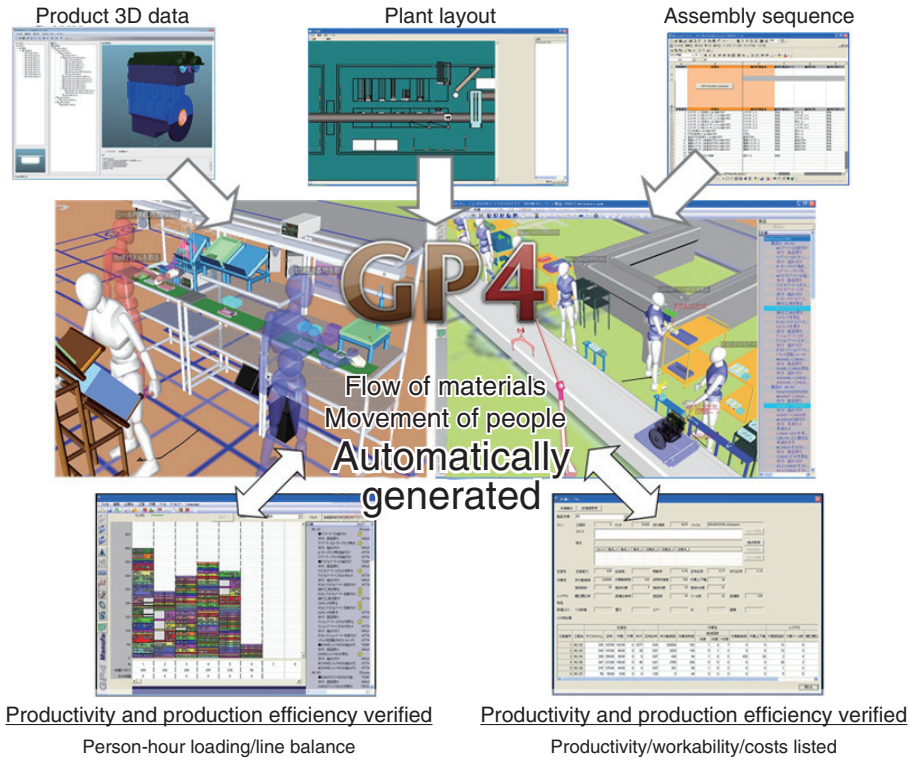


Figure 2
Basic structure of GP4.

production line. An increase in production cost to ensure the production volume may or may not be permitted depending on the product.

The conventional method of production line planning was confined to copying the production line of a past product due to manufacturers' fear of taking risks. As a result, partial productivity increase was achieved by *kaizen*. However, no significant productive increase can be realized and this method is outmoded in global competition.

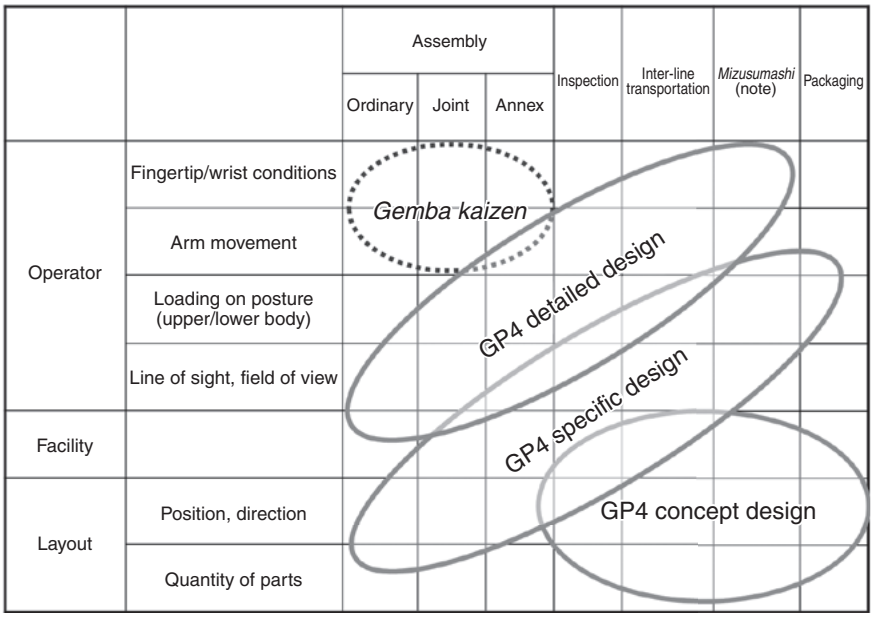
GP4, which has the characteristics described above, is different from a way of replacing *gemba kaizen*. *Kaizen* has enabled the Japanese manufacturing industry to build up its strength and produce high-quality products that are among the best in the world. This method is fundamental as well as rational and we must continue to respect this concept and make the most of it in the future. GP4 applies to the process before implementing *gemba kaizen*, or the process planning phase, and is not a replacement of *kaizen*. GP4 can be effectively used by appropriately applying it to situations different from those for *gemba kaizen* (**Figure 3**).

4. Manufacturing measures in global production

4.1 Measures against hollowing out of manufacturing that utilize GP4

One possible major cause of the hollowing out of manufacturing is that no system is in place to feed back to Japan the process know-how gained during mass production trials in overseas sites. Production preparation work is conducted based on empirical know-how at production sites, and cannot be readily made into logical and standard models, and feeding back is in fact difficult. It is not possible to bring production preparation back to Japan and measures must be discussed from a totally different perspective.

As a measure, GP4 can be utilized during



note) Fixed-course pick-up method. Workers supply the parts between processes moving like whirligig beetles.

Figure 3
Difference between situations for *gemba kaizen* and GP4 application.

the production preparation work to conduct the work in a virtual space domestically in Japan for preventing the outflow of process know-how. Process know-how is mostly generated during touch & try in mass production trials—something that is localized in the present circumstances. This touch & try can be implemented domestically by using GP4 to accumulate process know-how, and then applied to overseas production bases. Mass production trials at overseas production bases changes from the traditional problem elimination (process know-how accumulation) phase to a verification level. In addition, feeding the process know-how accumulated in GP4 back to design provides new engineering management and leads to consistently high manufacturing quality (**Figure 4**).

4.2 Measures for applying ICT to production preparation by using GP4 based on Japanese-style manufacturing

GP4 is not simply a simulator. It is a process planning tool capable of assisting the reconciliation technique, at which Japanese manufacturing excels, to sophisticate production. From that perspective, GP4 has two features:

1) Simple operation allowing use by those unfamiliar with CAD

GP4 assumes that users who have process know-how run PCDA themselves by planning, verifying and changing based on the results. It means that users are those who usually never touch 3D CAD such as manufacturing engineering personnel. GP4 features operation icons suggesting work procedures and functions to allow the user to create simplified shapes of products without 3D CAD. In addition, a standard library of about 450 types of resizable parts shelves and tools is offered because plant facilities are often not 3D modeled. Process planning using GP4 is possible on the spot and most of the actual users are those engaged in manufacturing engineering or manufacturing.

2) Functions focused on person-system production

For mechanical-system production using robotic or automated machine systems, products are already provided mainly by European

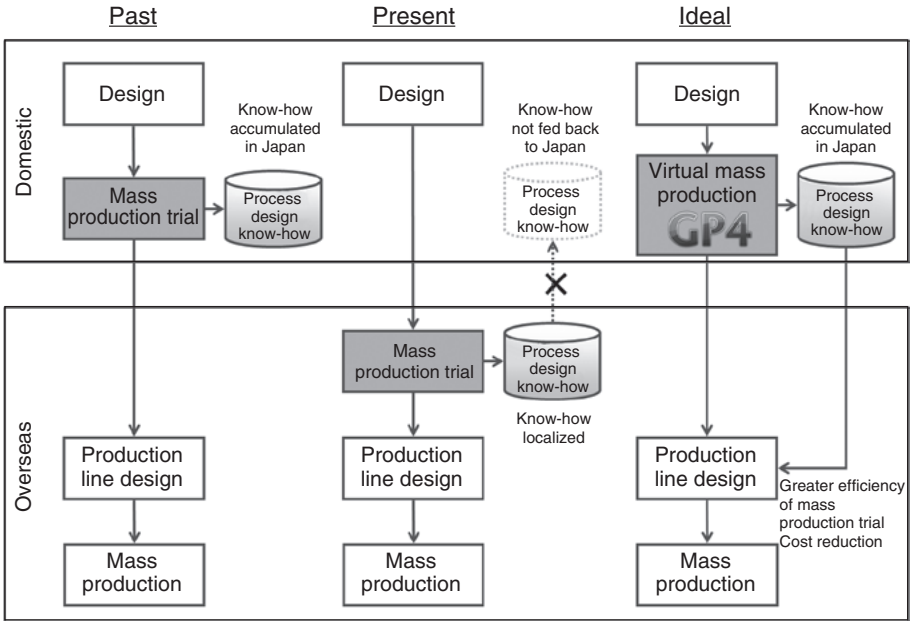


Figure 4
Issues with and measures for manufacturing in global production.

vendors. However, they are not adequate or require cumbersome inputting data for dealing with manual assembly or mechanical processes, inspection and parts picking involving manual procedures. GP4 excels in work involving manual procedures, which are difficult to handle with the existing technologies, and minimizes the time required for inputting data into the system by incorporating semi-automated functions such as automatic generation of walking work. It also has a function of outputting standard work combination tables and human-machine charts generally used for *gemba kaizen*, thereby allowing ICT to be gradually applied to production preparation without making significant changes to the existing work.

5. Effects of application of GP4

In addition to productivity improvement, the effects of applying GP4 include those that can be classified into the following three types.

1) Reduction of production preparation period (minimization of opportunity loss)

Making production behavior visible improves mutual understanding between sections, leading to a reduction of the production preparation period by half or more.

2) Start of mass production with problems solved earlier (minimization of variable costs)

Mass production can be started with high production capacity.

3) Reduction of rework costs by decreased mass production trials and design reviews (DRs) (minimization of fixed costs)

Reduction of rework can reduce the facility prototyping and change costs to one-third or less.

The following are comments from users who introduced GP4 regarding the effects of the introduction.

1) Auto manufacturer

Reduction of production preparation rework and concept design of a new line for new product launch were achieved.

2) Automotive parts manufacturer

Production preparation person-hours and indirect costs for new product launch were reduced to one-half and one-third respectively.

3) Major consumer electronics manufacturer

Start of mass production was brought forward by two months and the line planning person-hours reduced by half.

4) Major printer manufacturer

Production lines at an overseas plant were virtualized, which led to close coordination with the overseas subsidiaries.

5) Heavy electric equipment manufacturer

Productivity by cell production was improved by 40% and independence and invigoration of the production site achieved.

6) Plant facility manufacturer

Operating rate and throughput of a plant were improved by linking the layout plan to production plan.

6. Construction of global production infrastructure and future developments

6.1 Construction of global production infrastructure by making use of GP4 and cloud[3)]

To maintain manufacturing know-how in Japan and implement actual manufacturing overseas, utilization of cloud is important. A global production infrastructure can be constructed by Remote Virtual Environment Computing (RVEC), a high-speed image compression technology developed by Fujitsu Laboratories, which allows high-speed compression of 3D CAD data run on a cloud so as to display such data on a client PC, and the Engineering Cloud service combined with GP4.

For example, one possible method of building a global virtual mother line in Japan in a secure environment includes the following procedure (**Figure 5**).

1) GP4 is utilized in Japan to build a virtual mother line.
2) Overseas plants view GP4 data through the cloud environment.
3) Information about overseas localization is updated each time via the cloud and the information is stored in Japan.
4) The information stored at respective overseas bases is made into a new and standardized DB as required and made use of in the subsequent production.

6.2 For construction of real global production infrastructure

GP4 transforms the pattern "overseas transfer of production = hollowing out of manufacturing" and makes it possible to construct a global production infrastructure

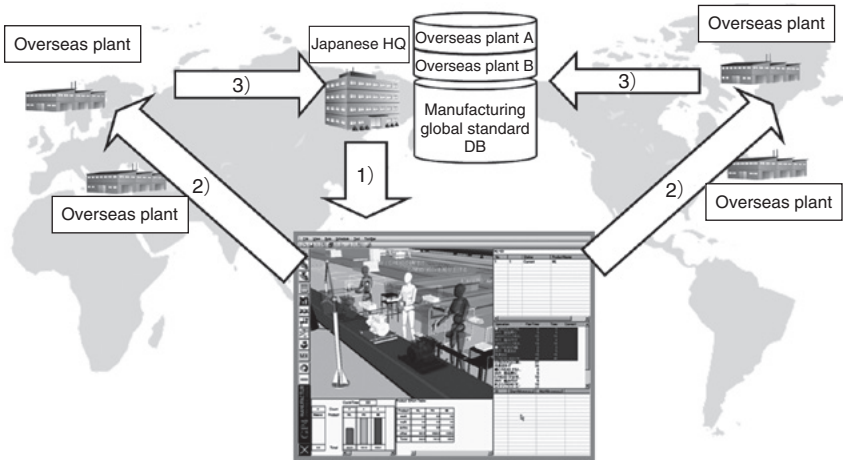


Figure 5
Global virtual mother line by making use of cloud.

capable of swiftly and flexibly responding to natural disasters such as earthquakes and rapid changes in the business environment. For the "construction of a real global production infrastructure," we are moving ahead with solution development including further strengthening of the linkage with the PLM and SCM axes as in PDM linkage and production control linkage respectively.

7. Conclusion

This paper has presented issues with manufacturing in global production and a method of investigating the optimum production line without actual products by making use of GP4 together with its effects.

The White Paper on Monozukuri 2010[4),5)] says that the number of Japanese overseas subsidiaries increased by 1800 in the last seven years and the number of those in China, in particular, doubled. The overseas production percentage is steadily increasing and has reached more than 33% of all production. The Great East Japan Earthquake and strong yen have further accelerated the trend, and globalization of production is unprecedentedly advanced. Based on this situation, applying ICT to production preparation will undoubtedly be an important strategy for the manufacturing industry in the future.

Fujitsu has practiced Japanese-style manufacturing from the perspective of the manufacturing industry for information and communications devices and other products. We intend to make use of this empirical know-how to further enhance GP4 and continue to offer "manufacturing ICT of Japan" that is inimitable by European PLM vendors and takes advantage of the Japanese strengths in manufacturing.

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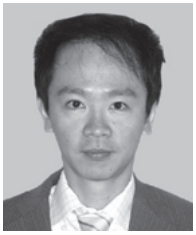

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