



HIPARMS
Highly Productive and Reconfigurable Manufacturing System

Final Report

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1. Introduction

HIPARMS, Highly Productive And Reconfigurable Manufacturing Systems, Project was endorsed for international project in July, 1999. In this project, 17 companies and institutes, which are belong in 3 region (EU, Switzerland, Japan), have been participated. This project is consisted of 13 WP, and each WP activities started in April 1999. Current Partners of HIPARMS project were as followings;

Japan Region: Yamazaki Mazak Corp.(RCP) Sumitomo Electric Industries, Ltd (ICP),Koyo Seiko Co.Ltd, Koyo Kikai Kougyou Co.Ltd, Mutshubishi Electric Corp. Kobe University, and Kyoto University.

EU region : Aachen Technological University WZL (Germany), Hannover University IFW (Regional Coordinating Partner, Germany), Tampere Institution of Technology (Finland)

Switzerland region : Scneeberger(SME) (Regional Coordinating Partner)

2. Research summary view

In this research project so far, the following has been conducted with regard to a manufacturing system that enables the manufacturing of various kinds and various lot sizes, i.e. an Agile Manufacturing System, in the field of machining.

Focusing on the field of machining automobile parts, problems were discussed on the subject of the Agile Manufacturing System - which is expected to be easily able to cope, in a flexible and economical way, with the diversified needs of consumers, and the reduced life cycles of products. The Agile Manufacturing System is distinguished from the conventional mass production-oriented manufacturing system which was based on the divided production process philosophy typified by a transfer machine line.

The feasibility of the Agile Manufacturing System was studied. A decentralized parallel manufacturing system based on process integration was considered effective in the compatibility of flexibility and productivity. Thus the productivity was studied using the method of system simulation in which a model, where a scenario (a history of production demands) for the manufacturing of automobile parts was taken as an example.

A drastic improvement in the productivity of machining modules is indispensable to achieve the investment effect within a system. Therefore, in expectation of improved machining efficiency with high-speed machining and process integrated module (ex: machining center) was built up experimentally, and an evaluation of high-speed processing on the module was performed.

According to the results established so far, productivity at least three times as high as that based on the conventional machining can be expected by means of high-speed machining.

On the other hand, dies and molds, which require high quality, are manufactured mainly on an item-by-item basis, and in connection with the reduced life cycles of products, reduction of production lead-time is urgently demanded. Therefore, a concurrent die production system, in which various machining functions were integrated, such as cutting, grinding, heat treatment, and measuring, was constructed. The intent was to achieve rapid manufacturing of dies. As a result, it was confirmed that, in comparison with the conventional procedure, a significant reduction in the manufacturing lead-time and an improvement in the quality of dies can be achieved. This process can also be effective.

3. Achievement Summary

3.1 Purpose of research

It is urgently demanded that the flexibility and the productivity of manufacturing systems be compatible on account of factors such as diversified consumer's needs, reduced life cycles of products, and uncertain consumer trends (Fig.1). In fields where cost merits have so far been enjoyed owing to mass production,

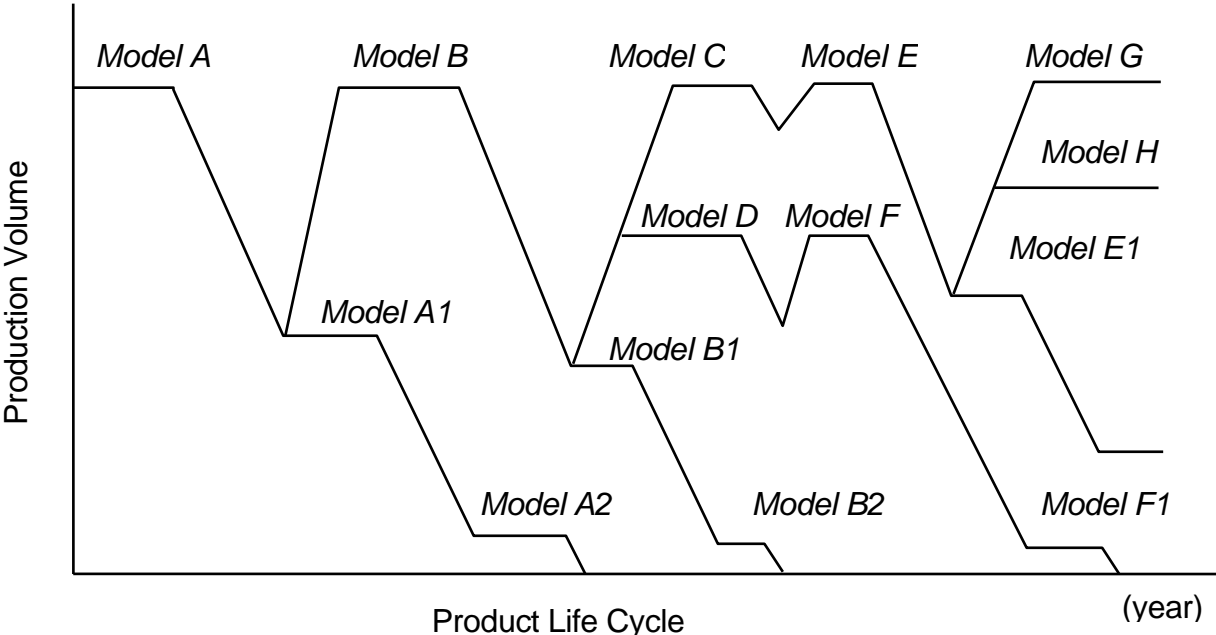


Fig.1 Increasing product variation and reducing product life cycle

such as the field of automobile parts machining, similar demands have also surfaced.

Therefore, expectations are growing for the Agile Manufacturing system, which is capable of coping with drastic demand variations. A decentralized parallel manufacturing system, whose core structure is a machining module in which various machining functions required for parts machining, such as machining and measuring functions, are integrated, can be considered as an effective manufacturing system because it incorporates Agile Manufacturing.

In this research, like this Agile Manufacturing System is called to HIPARMS (Highly Productive And Reconfigurable Manufacturing System). Consequently, this research aims at proposing a model of a manufacturing system by, Agile Manufacturing, verifying its effectiveness, constructing the system, and developing operations technology, machine elements technology, and utilization technology.

3.2 Significance of research

As shown in Fig.1.2.1, the current manufacturing system includes a transfer machine line (TR), a flexible transfer line (FTL), a flexible manufacturing system (FMS), a flexible manufacturing cell (FMC), and a general-purpose MC. The flexibility of these systems increase respectively or their productivity decreases. Even an FTL (in which an NC is introduced into a special-purpose machine constituting a TR thereby ingeniously permitting automatic switchover of several kinds of products) is inadequate in terms of both productivity and flexibility and thus resulting in the rapid obsolescence of expensive facilities.

It is presumed that in the future, the diversification of consumer's needs, and the reduction of product life cycles, will accelerate, and furthermore, consumer trends will become increasingly unpredictable. It is the manufacturing system located in the upper right part of Figure 2 that is capable of economically coping with such situations. In this research program, the manufacturing system located in the above-mentioned position is referred to as a manufacturing system for various kinds of products in various lot sizes; i.e., an Agile Manufacturing system. The intent of this system is to not only be able to manufacture a wide range of a variety of products, but also be capable of flexibly and economically coping with the various production ratios of a wide range of products. With regard to Agile Manufacturing Systems, there are two methods of development. One is a method in which a raw materials transporting function (which is close to that of an FMS, such as automatic multi-spindle head replacement function and pallet transporting function) is introduced into a conventional manufacturing system - otherwise known as a mass-production-oriented

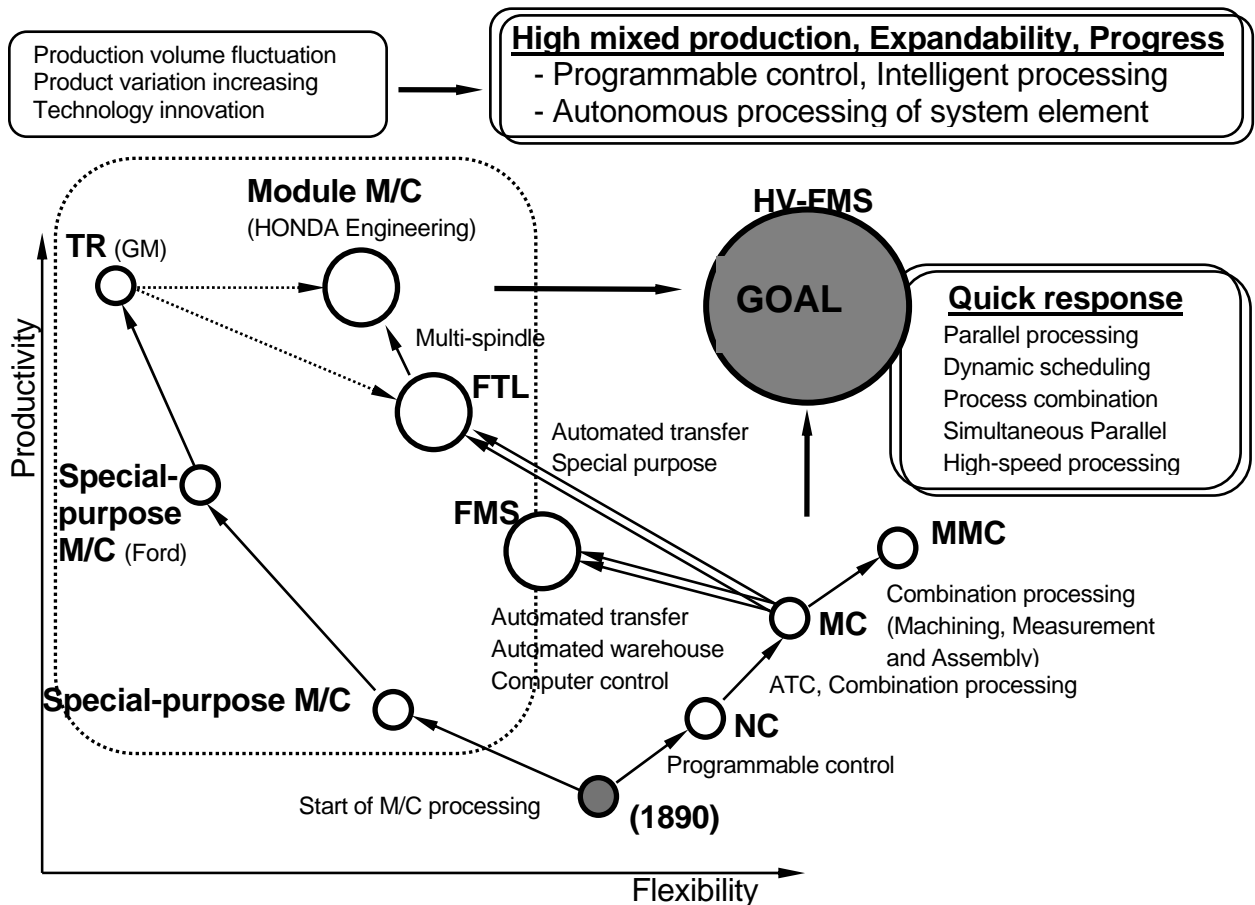


Fig.2 Machining process trend and future goal

manufacturing system. This is analogous to an existing TR having evolved into an FTL, it permits as many kinds of products as possible to flow interchangeably. The other is a method in which the productivity of a general-purpose NC machine tool, like a machining center that has machining functions already put together to provide sufficient flexibility, is improved, with the flexibility of conventional FMS maintained.

In this research program, the emphasis to improve the productivity of general-purpose machine tools was considered to be more advantageous in economical terms than the emphasis to improve FTL, and therefore it was decided that efforts be made to enhance the efficiency of machine. The reason for the above is as follows. In the case of a sequential line type of manufacturing system, such as an FTL, the system is compelled to stop whenever any machine is down. And, if mechanisms more complex than the existing ones are added, it is considered difficult to always maintain high production rates with respect to the entire system. On the other hand, when the productivity of existing general-purpose machines are improved, unlike conventional sequential line type systems, a parallel manufacturing system like the one shown in Fig.3 may conceivably be

created. Because of the parallelism, even if any of the machining machines within the system fails, the entire system need not be stopped; this leads to the conclusion that this system will be reliable and efficient.

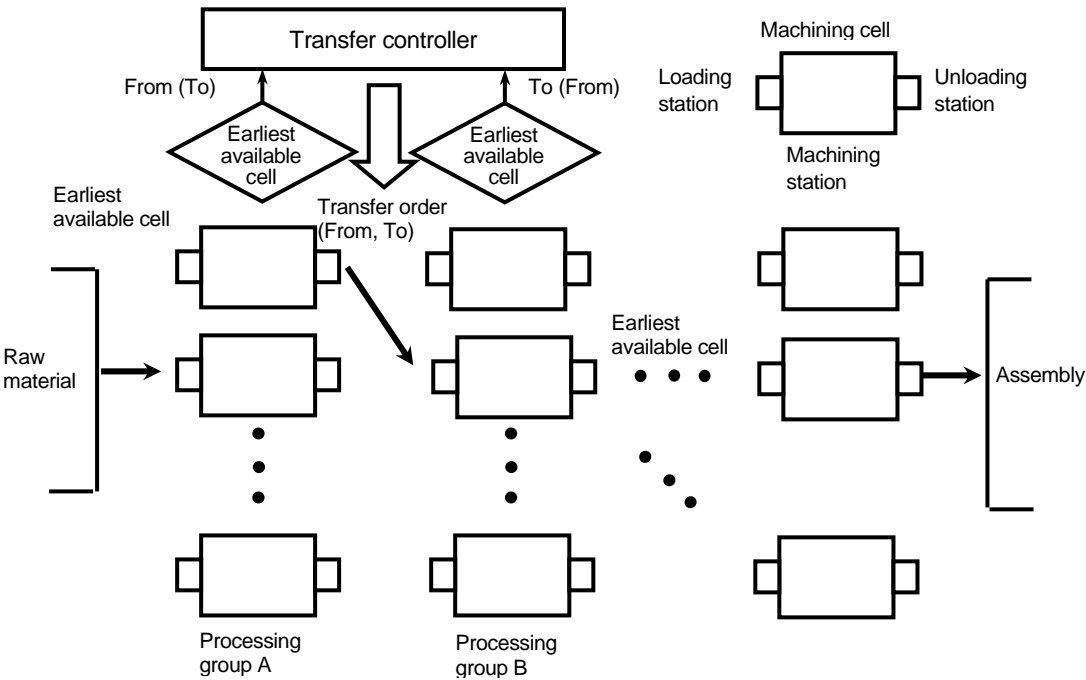


Fig.3 The work piece flow in HV-FMS

4. Research and Development on Planning and Operation Methods for Agile Manufacturing Systems

In this study we considered to extend the agility of the manufacturing system with square arrayed MCs. The generalization algorithms adding tool sets to MCs and the specialization algorithms deleting redundant tool sets are proposed as the self-organization functions of the system based on the auction methods. Simulation studies exhibited the effectiveness of the proposed algorithms.

5. Elementary Research for Machine Unit Technology and Machining Technology

There are key technologies that are process integration technology and increasing machining performance of machining cells for HV-FMS. In this section, R&D of elementary technologies are described.

Elementary technologies consist on high speed machining technology, process integration technology, and intelligent machine tool technology. High speed machining technology includes high-speed technology of main spindle system and high-speed and high-acceleration technology of feed drive systems as mechanical elementary technologies. It is also included tooling technology and machining technology for high-speed

cutting. It is possible to do high-speed and high efficiency cutting with all of these technologies. (Fig.5)

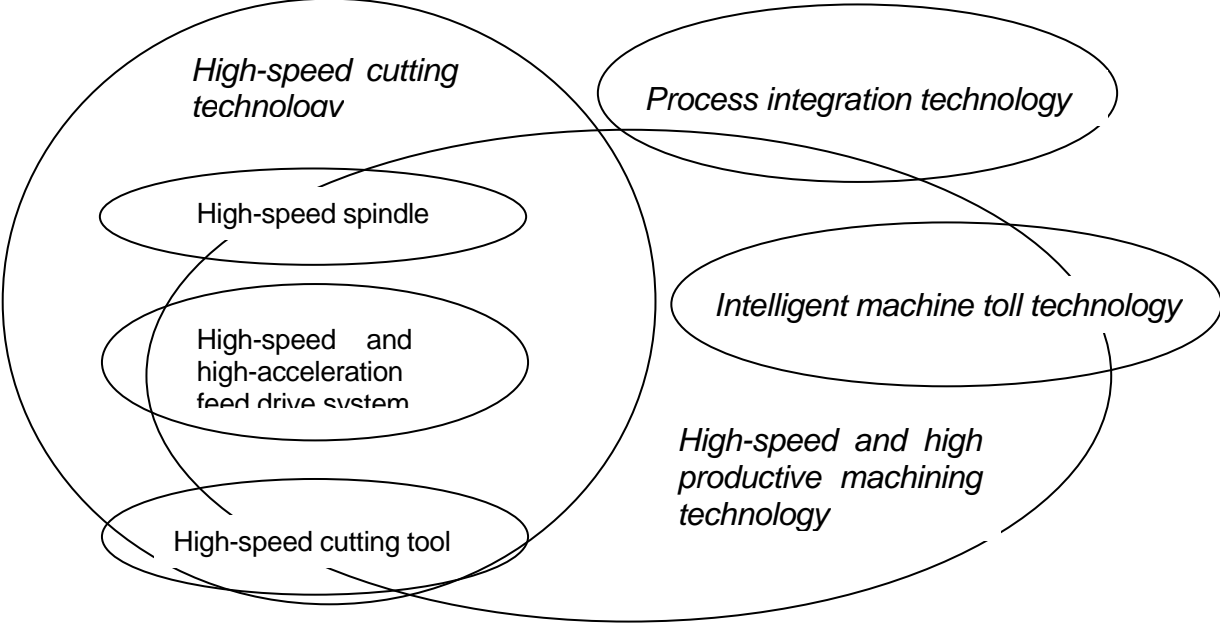


Fig.5 Relationship of elementary R&D subject.

The process integration technology not only decreases manufacturing lead-time but also increases machining accuracy without re-chucking. Then, process integration technology is researched in this project as MMC that has not only cutting functions but also heat treatment, grinding and measuring functions for die and mold manufacturing with high accuracy and short lead-time.

It is possible to do high speed and high-productive machining with these technologies. Inmost of all case, however, skills are necessary for machine operators. It is necessary that machine control system for skill-less operator to do high-speed cutting easy. In this project, the subject of R&D about this is how to monitor without appended special sensors and how to control adaptively.

6. Research outcome

Concerning the extended HV-FMS, it was assumed that product mix varies in square array MC layout in operation phase. Self-organized tool distribution method was examined by generalized operation to incrementally arrange the tool set according to need.

Regarding the machine tools and machining technology, when high speed and high efficiency machining technology was applied to real machining of the component parts of machine, advantage and effect of this

technology was verified by the case study.

Furthermore, high precision hard turning with CBN tool have studied for real bearing parts. As the result, very high precision machining, which accuracy is under 1.2 micrometer, was accomplished in practical multi tasking CNC lath.

7. Conclusion

A decentralized parallel manufacturing system model (Agile Manufacturing System) was proposed. Research and development of this system was conducted with regard to flexibility and quality assurance.

The following items can be cited as future tasks.

(1)Research and development of technology for the construction of the HV-FMS proposed in this research program.

- The study of the method for optimizing the locations of both facilities and equipment, including machining cells, AGVs and pallet stations.

(2)Research and development of high-speed, intelligent machining cells, and high-speed machining technologies.

-The development and the evaluation of high-speed main spindle and bearings.

-Research and development of high-speed cutting tools and machining technologies.

-Research and development of dry or MQL machining technologies.

-Research and development of high-speed and high-accuracy feed drive system.

-Research and development of on the machine heat treatment technologies.

-The study of a method for high-speed and intelligent machining of machining cells.