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論文要旨

Chapter 1 Introduction

Computer systems and manufacturing cell controllers have recently made much progress in both softwave and hardware view points, and individual computers and controllers are now able to share decision-making capabilities in the manufacturing systems. The network architectures are widely utilized for the information exchange in the design and the manufacturing, and some standardized models, such as STEP and CNC data model, have been developed for the information exchange through the information networks for the design and the manufacturing.

Manufacturing has transformed from mass production to batch production and the conventional manufacturing systems are not adaptable to very small batch productions with the dynamic changes in volumes and varieties of the products. New manufacturing system architectures have therefore been proposed, aiming at realizing more flexible

management and control structures of the manufacturing systems, which can cope with dynamic changes in the volume and the variety of the products, and also the unforeseen disruptions, such as breakdown of manufacturing equipments and interruption of high priority jobs. They are called as autonomous distributed manufacturing system like biological manufacturing system, random manufacturing system, fractal manufacturing system and holonic manufacturing system(HMS).

The objective of this research is to develop an integrated process planning and scheduling system, which is applicable to the holonic manufacturing systems.

The process planning system considered here creates suitable process plans for the individual products to be manufactured. The process plans give suitable sequences of manufacturing equipments needed to manufacture the products and machining time of the products.

The scheduling system creates suitable production schedules, based on the feasible sequences of the machining equipments of the individual products, which are created by the process planning.

As regards to the scheduling problems in HMS, a distributed real-time scheduling system has been proposed, aimed at creating a suitable production schedule when executing the machining process in the HMS. However, it is assumed that the process plans of the products are predetermined and fixed in the planning phase independently from the production schedules. So, integration of process planning and scheduling in the planning phase is considered in this research, which create both suitable process plans and production schedules concurrently for a set of products to be manufactured, before executing the machining process in the HMS.

Chapter 2 Basic architecture of HMS

This chapter provides a detailed description of the basic architecture of HMS considered in the research, from the viewpoint of the distributed decision making process of the autonomous components. It also describes about the holon and holarchy. The holonic components of the target HMS and the manufacturing process in HMS are also clarified.

Chapter 3 Integration of process planning system and scheduling system for single product

This chapter provides a detailed description of integration of process planning and scheduling for a single product. A systematic method is proposed here to create suitable process plans that minimize the objective function including both the flow time and the machining cost of the product, taking into consideration of future schedules of the machining equipments. The method is based on Genetic Algorithm (GA) and Dynamic Programming (DP) for selection of suitable machining sequences of the product and suitable sequences of the machining equipments. A prototype of the process planning system is implemented and applied to the process planning of the machine products. Case studies show that the proposed methods are effective to create suitable machining sequences and suitable sequences of machining equipments taking into consideration of the future schedules of the machining equipments.

Chapter 4 Integration of process planning system and scheduling system for multi-products

This chapter provides a detailed description of integration of process planning by product holons and scheduling holons for multi-products. Systematic methods are proposed here to select suitable combination of the process plans and to create suitable schedules for all the products, based on GA and dispatching rules, The case studies are carried out and show that some particular dispatching rules are suitable for some particular objective functions. It is found that the dispatching rule called Shortest Processing Time/Total Work Remaining (SPT/TWKR) is the most suitable when make span is the objective function, the dispatching rule called Shortest Processing Time (SPT) is the most suitable when total machining cost is considered as the objective function, and the dispatching rule called Apparent Tardiness Cost (ATC) is the most suitable when weighted tardiness cost is taken as the objective function. A prototype of the process planning and scheduling system is implemented and applied. The case studies show that the proposed method selects a suitable combination of process plans and creates a suitable schedule.

Chapter 5 Integration of process planning and scheduling for multi-products with scheduler driven modification of process plans

This chapter provides a detailed description of integration of process planning and scheduling for multi-products based on the process plan modification system. Three different methods are proposed to modify the process plans aimed at balancing the machining loads of the machining equipments. They are, (a) load balancing method before process planning, (b) centralized method for load balancing after scheduling, and (c) distributed method for load balancing after scheduling. Some case studies are carried out to verify the effectiveness of the proposed methods. It is shown that the method (a) load balancing method before process planning and method (b) centralized method for load balancing after scheduling is effective in the case where there is concentration of machining loads on some machining equipments and not so effective in the case where there is no concentration of machining loads on any machining equipments. However, the computation time of the methods (a) and (b) is not so long, Whereas, the method (c) distributed method for load balancing after scheduling is effective for both the cases, however, this method requires the computation time longer than the methods (a) and (b).

Chapter 6 Conclusions

This chapter provides the conclusions for the whole research work.

List of Publications

No.	Articles' Title	Author(s)	01	Corresponding Chapter
1	Integrated process planning and scheduling in holonic manufacturing systems - Optimization based on shop time and machining cost-	N. Sugimura R. Shrestha J. Inoue	Proc. of Int. Seminar on Assembly Task Planning, pp. 36-41, (Besancon, France, 2003)	Chapter 2 Chapter 3
2	A study on process planning for holonic manufacturing - Process planning considering both machining time and machining cost-	R. Shrestha J. Inoue N. Sugimura	Proc. of Int. Conference on Leading Edge Manufacturing, pp. 753-758, (Niigata, Japan, 2003)	Chapter 3
3	A study on integrated process planning and scheduling system for holonic manufacturing system	N. Sugimura R. Shrestha T. Takemoto	Proc. of 37th CIRP Seminar on Manufacturing Systems, pp. 323-329, (Budapest, Hungary, 2004)	Chapter 4
4	A study on process planning and scheduling systems for holonic manufacturing - Manufacturing multi-products	R. Shrestha T. Takemoto N. Sugimura	Proc. of Japan-USA Symposium on Flexible Automation, CD-ROM, pp. 1-8, (Denver, USA, 2004)	Chapter 4

No.	Articles' Title	Author(s)	Journal's Name, Vol., Pages, (Year)	Corresponding Chapter
5	Study on process planning system for holonic manufacturing (3rd report, Process planning considering machining schedules) (In Japanese)	N. Sugimura R. Shrestha Y. Tanimizu K. Iwamura	Trans. of the. JSME, C, Vol. 79, No. 696, pp. 289-295, (2004)	Chapter 3
6	A study on integration of process planning and scheduling system for holonic manufacturing - scheduler driven modification of process plans-	R. Shrestha T. Takemoto N. Sugimura	Proc. of 5th Int. Conference on Machine Automation, pp. 341-346, (Osaka, Japan, 2004)	Chapter 5
7	A study on process planning and scheduling systems for holonic manufacturing with modification of process plans	R. Shrestha T. Takemoto K. Ichinose N. Sugimura	Int. J. of Manufacturing Technology and Management (to be published)	Chapter 4 Chapter 5
8	A study on integrated process planning and scheduling system for holonic manufacturing system (In Japanese)	R. Shrestha N. Sugimura K. Ichinose Y. Tanimizu K. Iwamura	Trans. of the JSME, C, (submitted)	Chapter 4 Chapter 5

JSME; Japan Society for Mechanical Engineers

審査結果の要旨

本論文は、ホロニック生産システムにおける工程設計とスケジューリングの統合化について論じたものであり、次のような成果を得ている。

(1) ホロニック生産システムにおける分散型の意思決定と強調とにより、加工対象工作物の加工工程を設計するとともに、生産設備の生産スケジュールを決定する手法を提案している。すなわち、工作物ホロンによる分散型工程設計とスケジューリングホロンによるスケジュール作成を行う手法を提案している。

(2) 工作物ホロンが、自身の目的関数に基づいて、加工フィーチャの適切な加工手順を決定するとともに、使用する加工設備のシーケンスを決定する問題を、遺伝的アルゴリズムおよび動的計画法を用いて解く手法を提案し、その有効性を検証している。ここでは、目的関数として、加工時間および加工コストの両方を考えている。

(3) 複数の工作物ホロンが設計した加工工程の候補に基づいて、適切な加工工程と加工設備の生産スケジュールを同時に決定する手法を提案し、その有効性を検証している。ここでは、遺伝的アルゴリズムとディスパッチングルールを組み合わせた手法を提案している。

(4) (3)の手法を用いて作成された加工設備の生産スケジュールの情報に基づいて、複数の工作物ホロンが自身の加工工程を再設計する手法を提案し、その有効性を検証している。ここでは、加工設備の加工負荷を平準化することで、加工工程を再設計するとともに、生産スケジュールを再構成する手法を提案している。

以上の諸成果は、機械生産システムの工程設計技術およびスケジューリング技術に関する新しい知見であり、新たな生産システムの研究開発に寄与するものである。また，申請者が自立して研究活動を行うに必要な能力と学識を有することを証したものである。