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DESIGN & DEVELOPMENT OF A SIMULATION MODEL TO ANALYSE SCHEDULING RULES IN AN FMS IN A VIRTUAL MANUFACTURING ENVIRONMENT

A thesis presented in partial fulfilment of the requirements for the degree of Master of Technology in Manufacturing and Industrial Technology at Massey University

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1997

ABSTRACT

Due to the rapid changes in the needs of the customer for new products, the future manufacturing systems must cope with these changes. Hence, the need for the manufacturing systems to support these changes in the products with shorter lead times within a single manufacturing facility. The Virtual Manufacturing System (VMS) is one concept which can assist in meeting these demands. The VMS concept enables the manufacturing system designers to emulate and test the performance of the future manufacturing systems.

This research has given an overview of the new concepts of Virtual Manufacturing Systems and Virtual Manufacturing in general. A Virtual Reality Software tool has been used to realise the VMS concept. A Virtual Manufacturing Environment representing a Flexible Manufacturing System (FMS) has been modelled. A simulation control language is employed for developing simulation control logics and decision making control logics for the development of the FMS model.

The modelled FMS is implemented and tested through simulation experiments. The testing is done by analysing the traditional scheduling rules in a manufacturing facility. Average Machine Utilisation, Mean Flow Time, Average Queue Lengths and the System Production Rate are measured as the System Performance Measures for the evaluation of the scheduling rules.

This research has identified that the Virtual Manufacturing Software is a powerful tool which can identify optimum configurations and highlight potential problems before a final and expensive manufacturing system is established physically.

ACKNOWLEDGEMENTS

I would like to express my sincere thanks to Dr. Saeid Nahavandi for his valuable suggestions and guidance during the progress of my research and the successful completion of the thesis. I would also like to express thanks to Prof. Don Barnes for his guidance during the write-up of the thesis.

My thanks to all the staff members and fellow postgraduates in the department of Production Technology for their help and support during the course of my research.

Also my thanks to my friends for providing me with lighter moments in my hour of stress.

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Chapter 1

INTRODUCTION

This chapter gives an introduction to the concept and definition of Virtual Manufacturing System (VMS) and the technologies related to VMS. It elaborates the scope of the research and research objectives. It also includes an overview of this thesis.

1.1 Concept of Virtual Manufacturing System (VMS)

In this research, the concept of Virtual manufacturing systems (VMS) is based on the concept developed by Masahiko Onosato et. al. (1993) which is explained as follows:

A manufacturing system in the real world could be decomposed into two different subsystems :

A real and physical system (RPS)
A real and informational system (RIS)

An RPS is composed of real entities that exist in real world. Entities such as, materials, parts, products, machine tools, jigs, sensors, controllers, and so on. When a manufacturing system is in operation, these components of the manufacturing system have physical behaviours and interactions such as motion, transfer and transformation.

An RIS involves many activities of information processing and decision making such as, designing, planning, scheduling, controlling, estimating and so on. It consists of computer activities as well as human activities of a real manufacturing system. Consider a real manufacturing system made up of an RPS and an RIS. Activities in the RIS are physically separated from the substantial entities in the RPS, and the RIS has relation to the RPS by exchanging information. The RPS sends status reports to

the RIS by means of sensors, data terminals, and other communication channels. Control commands generated by the RIS are sent to the RPS so as to operate machines there. The RIS can effect and know the RPS only by means of control commands and the status reports respectively.

1.2 Definition of VMS

If all the activities of the RPS can be represented in a computer system that interprets control commands and returns status reports from and to the RIS, and if the responses from the system are equivalent to the RPS, then no one in the RIS would know whether the status reports are returned from the RPS or from the computer system. A computer system that simulates the responses of the RPS is called "Virtual and Physical System" (VPS).

Similarly if there is a computer system that can simulate the functions of the RIS in such a way that the machines in the RPS cannot distinguish whether control commands are coming from the RIS or the computer system. Then such a computer system which simulates an RIS and generates control commands for the RPS is called "Virtual and Informational System" (VIS)

The following four manufacturing system types can be formulated by having different combinations of the physical and informational systems :

1) RPS + RIS : Real manufacturing systems
2) RPS + VIS : Automated manufacturing systems
3) VPS + RIS : Virtual manufacturing systems (physically)
4) VPS + VIS : Virtual manufacturing systems (fully)

This research is based on the manufacturing system of type 4.

1.3 Technologies related to VMS

According to the various manufacturing systems as described above, CIM (Computer Integrated Manufacturing) is including the activities concerning computerisation and integration of RISs in real manufacturing systems. When an RIS is fully computerised and integrated by CIM, it is also considered as a VIS.

A Flexible Manufacturing System(FMS), which will be explained in detail in chapter 3, corresponds to an RPS. Since machines in FMSs can be highly automated by computers and have good controllability, it is easier to realise a VPS for FMSs than that for non-computerised manufacturing systems.

Virtual Reality (VR) is now attracting much attention of researchers and industries. Virtual reality is a technology by which a user can observe or operate objects in computers as if they were in the real world. So, VR is closely related to VPSs.

1.4 Scope of the Research

The basic objective of VMS is to model and simulate a VPS and a VIS and establish a communication link to the RPS and the RIS. Since this covers all the major areas of a manufacturing system, the scope of this research is limited to the development of a Simulation Model in a Virtual Manufacturing Environment, which emulates a Flexible Manufacturing System model i.e., VPS as mentioned in the above sections, which is explained in detail in Chapters 4 and 5. Later on this model is tested for the evaluation of scheduling rules in an FMS. As Virtual Reality is closely related to VPS, a Virtual Reality Software system is used in this research to achieve the research objectives.

1.5 Research Objectives

The objectives of this research include :

- Development of a simulation model of the Manufacturing Pilot Plant and the Industrial Engineering Workshop of the Department of Production Technology using Virtual Reality Software. The Manufacturing Pilot Plant is involved in manufacturing printed circuit boards and the Industrial Engineering Workshop produces plastic components and the injection moulds for those components.
- Development of a Simulation Model of an experimental FMS in a Virtual Manufacturing Environment using Virtual Reality Software.
- Testing of the model by analysing traditional scheduling rules in a manufacturing facility. This is done by analysing the effect of the scheduling rules on the System Performance. The system performance indices set for this research are, Mean Flow Time of Jobs, Average Machine Utilisation, Average Queue Lengths and the System Production Rate.

1.6 Overview of the Thesis

Chapter 2 covers an overview of the recent trends in Virtual Manufacturing and the related literature. Chapter 3 gives details about Flexible Manufacturing Systems (FMS), Scheduling of FMS and relevant literature, Chapter 4 explains in detail the methodology adopted for this research in achieving the research objectives. Chapter 5 covers the simulation experiments conducted in this research for analysing the scheduling rules in a manufacturing facility. Chapter 6 discusses the simulation results and the analysis of the results and finally Chapter 7 draws the conclusions from this research.