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A Simulation Strategy for Virtual Manufacturing

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Introduction

As time is becoming the most critical factor in today's global competition. Quality and functionality of product are no longer a competitive advantage, instead they are the basic requirements for entering a market and are expected by the customers. The distinguishing advantage now is more focused on a company's ability to rapidly provide a desired product at the desired place. In the rapid realisation of products two aspects are important viz., flexibility and the validation of manufacturing system development against its requirements. Given the importance of time, all aspects of the product and manufacturing development process need to be scrutinised for opportunities of time reduction. The ability to reduce the development time and in particular reduce the manufacturing system integration problems can provide appreciable competitive advantages to a manufacturer. It is thus important to develop and use tools that will enable the reduction of manufacturing system development time. Similar advantages can be gained during operations for major decisions that impact the whole manufacturing system. Operating policy and procedures can and do negatively impact the performance if not thought out well. Validation of the impact of such policies and procedures can help significantly improve the decisions and the performance of the manufacturing system. The implementation of virtual manufacturing concept is an approach suitable for validation of all major aspects of manufacturing system design and operation in an integrated manner. Mainly three approaches for the implementation of virtual manufacturing concept are listed in the literature (viz. simulation-based, model-based, and rule-based).

Discrete event simulation has traditionally been considered a powerful tool for production applications. Numerous special languages and software packages have been developed to simulate the production activities of a manufacturing system with limited applications for validating designs of production systems and comparing production strategies. Most of the existing tools are suitable for production lines, in which all products follow similar sequences of operations. They do not deal effectively with job shops, which produce small batches of numerous product types with diverse production routings. Moreover, they are suitable for push-type systems, in which the shop orders are launched upon the receipt of the customer orders. Most simulation packages are ineffective for just-in-time production, which is increasingly popular in current practice. However, if these problems are addressed effectively, simulation (and virtual manufacturing in general) has the potential to yield major contributions to the manufacturing community in terms of time saving and money saving, which are two most critical factors in today's competitive markets. In order for virtual manufacturing to have major impact in these areas, discrete event simulation should be integrated to the existing information systems of a manufacturing company. For example, production simulations should be built with minimal user input using existing data, such as Bills-of-Materials, Work Centre, Production Routings, Customer Demand and Shop Floor Control data.

Proposed Strategy

The present paper reports on the development of a rule based hierarchical simulation strategy for virtual manufacturing. A simple block diagram of the same is depicted below in Fig.1. The starting points are the inputting of details about the product mix and system modules through user interface. The product details and their work plans are stored in the Product Details Library (PDL) for any future use and to ease a pressure from the user to input them again in case product is identical. It is important to mention here that user is not required to identify and allocate the resources and the inputted work plans are system independent and truly based on the part's manufacturing requirements (i.e. part feature requirements). For system configuration design a modular architecture is employed. A system configuration is designed by assembling a number of system modules, wherein each system module contains various resources (such as work stations, buffers, robots, loading and unloading stations etc.). System modules are independent entities and stored in the System Module Library (SML) as standard templates, which can be used any time later for the design of complex manufacturing system

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configurations. The advantage of this approach is that one system module can be used in more than one system configuration at the same time. Various modules in the overall system configuration are connected using an independent material handling system for intra modular movements. Though each module is self sufficient for its material handling requirements. Additional information about the capacities of various resources in member system modules and their initial status is added to complete the system configuration design. System configuration variants are stored in System Configuration Library (SCL) for future simulation studies.

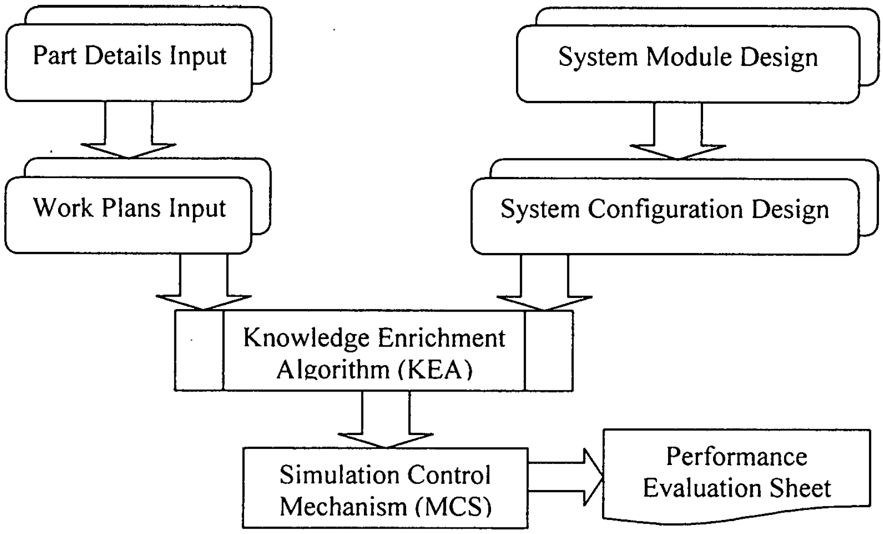

Figure 1: Overview of Simulation Strategy

A Knowledge Enrichment Algorithm (KEA) has been designed, which is activated after the selection of product mix and system configuration for simulation studies to upgrade the information available in various libraries. The work plans of various parts are processed further to identify suitable resources in various system modules and feasible routes for them in the system configuration. The system is capable of handling the parts needing different routes for their manufacture simultaneously, thus serving the needs of job shop manufacturing environment. This algorithm generates a comprehensive system configuration, which includes static and dynamic views of the system. The static view includes information about various modules and their resources with available capacities, product mix and their work plans with feasible routes. The dynamic view includes information capsules for capturing information about changing resource status, product mix progress, delays etc. during simulation process.

Simulation Control Mechanism (SCM) is designed to process and update all information about the movement of various parts in the system model, status of all resources in various system modules, and to record time of the occurrences of all events during the simulation process. An extensive rule base is prepared and implemented in SCM for decision making to effectively regulate the part movements and to tackle the problems arising due to system conflicts and deadlocks etc. A performance evaluation sheet is generated by the system as the final output and includes information about batch completion time, utilization of various resources, delays and waits during batch processing, and WIP. Several example batches have been taken as case studies to validate the working architecture of the proposed strategy and found to be working satisfactorily.

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