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A methodology for evaluation of process and production planning

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Abstract

This paper presents a new methodology for the evaluation of process and production planning activities for decision-making within a computer integrated planning environment. The planning tasks of large production systems involve the management of large amounts of dynamic data, which has to be analysed for decision-making. Through the proposed methodology we aim to improve the effectiveness of both the performed evaluation and the decision-making tasks undertaken when dealing with the different ranges of plans required to satisfy shop floor dynamic requirements and objectives. © 2000 Elsevier Science B.V. All rights reserved.

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1. Introduction

Manufacturing planning decisions are made at different phases of the product and process development cycle, such as process planning, master production scheduling, capacity planning and production order scheduling. Actual decisions about the production process are delivered to the shop floor in the form of process plans and production schedules.

The integration of planning functions has been cited as a key issue in state-of-the-art manufacturing systems. Process and production planning in particular, which are two multi-task activities of particular importance in a batch manufacturing environment, are prime candidates for the integration effort. Synergies can be generated by changing the traditional and non-integrated use of these systems into collaborative tasks, where enhanced advantages are obtained from the functions performed by each system in conjunction with the shared use of information. Process and production planning integration will result in shorter lead-times and more efficient manufacturing systems with a high competitive advantage.

Traditionally, process planning and production planning are subject to different constraints due to the differing main focus of each of these tasks. Process planning is more concerned with the technological requirements of each job, while production planning and control (PPC) systems are responsible for planning the utilisation of production resources (e.g. machine capacities, labour, production quantities), which are required to satisfy certain performance criteria, over a given planning horizon, taking into account a specific demand pattern. In reality these differences usually result in conflicting objectives and the evaluation of planning tasks is carried out using a *single criterion* for both process and production planning. The decision-making module has an important role within all integrated system architecture [1]. An effective system for evaluation of alternative plans becomes critical within the overall integrated concept of process and production planning. Thus, the relevance of suitable techniques which allow decision-making problem dimensions to be reduced.

This paper presents a new methodology that is being developed for the evaluation and selection of alternative plans, generated within an integrated environment. Despite the nature of the hierarchical structure identified within a factory and the boundaries that can exist in decision problems, we consider the methodology described to be of a sufficiently general character to be applicable regardless of any particular level within a factory.

2. The need for a new evaluation methodology

Process and production planning have been described as two distinct problems being solved separately. The usual separation of process and production planning can be

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explained by the need to divide planning problems in a number of easier to solve sub-problems. While process planning is focussed on individual products, production planning typically deals with a set of orders, competing for available capacity.

The separate use of process and production planning does not allow consideration of the interdependencies that exist between the two problems, which, in particular in small batch manufacturing, may lead to non-effective utilization of resources and poor solutions of the overall planning problem [2]. Detailed production planning or scheduling is usually performed after process planning, constraints being imposed by the process plan. In [3] it is stated that this approach leads to intuitive and opportunist process plans generated on the shop floor to solve unpredictable problems, and neither the process plan nor the planned schedules are truly followed on the shop floor. Very often the decisions made at shop floor level have a substantial impact on the performance of the entire manufacturing system. According to [4], different people measure performance in the actual shop in different ways and more often than not upper echelon objectives are in conflict with those on the shop-floor. Fig. 1 shows schematically the hierarchical structure of a manufacturing organization.

In complex systems, characterised by a large number of interacting variables, decision-making can result in the establishment of conflicting goals. From among the large number of variables used to characterise manufacturing system performance, only a few are used in the evaluation and generally speaking correlation is not taken into account. It is difficult for the decision-maker to evaluate and relate the evolution that occurs within a set of variables. This difficulty increases with the number of variables taken into account.

In [5] it is showed that decision-making at shop floor level is usually based on a limited number of criteria. Furthermore, in many cases a single criterion is used for determining the "best" solution. According to Chryssolouris and Chan [5] the large amount of information available at the different levels of a manufacturing system can have only very limited usefulness without an adequate decision-making methodology. In a real decision environment, more than one criterion should be used simultaneously and the relative importance of criteria selected to decision-making changes should be modified continuously due to the dynamic nature of shop floor behaviour. A set of problems commonly identified in the use of planning tasks is presented in Fig. 2.

The above-mentioned weaknesses justify the development of a new evaluation approach. In the light of some of the difficulties presented above, we believe that the possibility of reducing the amount of data for decision-making, without losing information relevant to the manufacturing process, could be a great advantage. Consequently, several specifically designed performance measures are required for the evaluation and guidance of manufacturing process management.

Feed-back to the integrated used of Process and Production Planning tasks should be based on performance measures or derived criteria which allow the scheduler or any other user to evaluate the performance of the manufacturing system. Also the approach used should be able to model decision-maker preferences in order to find an alternative with the "best" performance.

The relevance of evaluation and decision-making within an integrated use of process and production planning has been discussed in the literature. Chryssolouris and Chan [5] present the assignment of the various production tasks to different factory resources (labour and machines) as a common integrating element of these two activities. The MADEMA (Manufacturing Decision-Making) approach is proposed to solve decision problems related to the assignment of production resources with a multiple criteria decision-making technique and integrates process planning and scheduling. Lenderink and Kals [2] focus their study on the problems resulting from reduced flexibility in production planning when machine tool specific process planning is required. Both process and production planning are analysed and a solution is proposed selected from a number of partially worked out process plans. Thus dependencies

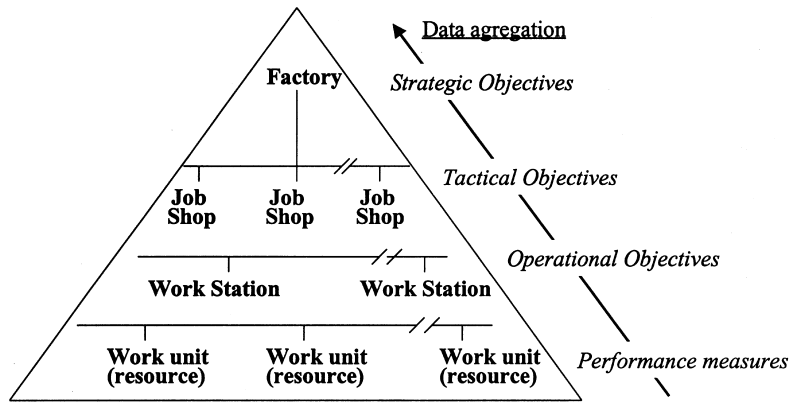

Fig. 1. Hierarchical structure and data aggregation levels within a factory.