Developing a Model for Integrating Process Planning and Production Planning and Control in Cellular Manufacturing

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Developing a Model for Integrating Process Planning and Production Planning and Control in Cellular Manufacturing

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Abstract - **Organizations willing to succeed in global competition have to integrate their internal and external processes. This specially includes planning and production control (PPC) processes. Optimized allocation of the production resources and quick response to demand change results in lower cost and improvement of production performance. Practitioners and researches have been trying to achieve these goals using production planning techniques. Although the results are significant, it seems necessary to integrate production operations in order to improve the production performance. Designing an efficient PPC system and integrating it with process planning in a cellular environment is of the same importance**.

The goals, information and decisions taken in production planning and control and process planning are often very different and difficult to integrate. In this paper, firstly the latest production planning framework in cellular manufacturing has been reviewed and modified. This framework has been customized to meet requirements and constraints of the Iran electronics industries. The application of the models has been considered as a case study for a production system in electronics and telecommunication sector in a plant in Iran. The validity of the presented model has been tested by the experts of several sections of the plant, studied as the case.

Keywords - **Production Planning and Control, Process Planning, Group Technology, Cellular Manufacturing, IDEF0 Modeling**

I. INTRODUCTION

Production systems are under the intensive pressure from global competition. With product life cycle growing shorter, time needed for marketing and different customer needs has forced producers to improve efficiency and productivity of production activities. Without major investments, Production systems must be able to adapt or quick response to demand changes. Cellular manufacturing as an application of Group Technology (GT), emerge as a promising production system.

Cellular manufacturing is involves the processing of a Collection of similar parts (part families) on dedicated clusters of machines or manufacturing processes (cells) [9].

The performance of a production system depends not only on the quality of the decomposition of the system in cells and departments, but also on the quality of the production planning system that is being used to plan and control the flow of work[1]. It also depends on the quality of level that is considered to integrate product design, process planning and production planning and control. However, the compatibility between these systems is of the greatest importance to take full advantage of the benefits of cellular manufacturing. So that, the design of the suitable architecture of PPC system that meets all of the requirements of the production system and also provides a suitable field for sharing same objectives of process planning and production planning and control is a very important activity.

Some contributions are found in literature, indicating the applicability of the well known approaches of planning and control to cellular manufacturing such as Material Requirements Planning, Kanban and Hierarchical Production Planning. Meanwhile the integration of production planning and process planning in CM are also discussed.

Cellular Manufacturing creates coordination requirements that are related to operational planning. A direct translation from tactical requirements planning, based on planned operation lead times, to operational detail planning of the production process is problematic. The characteristics of the cells can vary, for example with respect to the degree of autonomy, multi-functionality of personnel, presence of bottlenecks, shared resources, duplicated machines etc. Therefore, each cell has to be planned and controlled separately (Production Activity Control (PAC) planning function); whereas at the same time another planning function is required for coordinating activities between cells (Factory Coordination (FC))[1]. The operational planning consists of cell controllers (PAC) and a factory coordination level, which coordinates activities of the various cells. Disaggregation of production routes between cells, determination and selection of an optimal production route from process planning resource databases are some of decisions made at operational level. In this paper, the production planning framework in cellular manufacturing presented by Bhat [1] is reviewed and modified. Then regarding to importance of control in CM and effective role of process planning in successful implement of CM, an IDEF0 model especial to cellular manufacturing environments is developed.

The remainder of the paper is organized as follows. In Section 2, the latest production planning framework in cellular manufacturing has been reviewed and modified and finally a comprehensive Model for production planning and control in cellular manufacturing has been presented. In section 3, advantages of integrating process

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planning and production planning and control in CM have been discussed in detail and in section 4 an IDEF model has been presented based on the proposed framework in CM respected to characteristics of electronics and telecommunication industries in Iran. Finally, section 5 has been addressed to present a general conclusion of the paper.

II. A comprehensive framework of production planning and control in CM

Various production planning frameworks in cellular manufacturing based on ideas of material requirements planning, just in time and optimized production technology are developed by system analysts.

A very useful review of existing frameworks for designing production planning in cellular manufacturing can be found in [1]. Bhat presented a detailed hierarchical framework for production planning and control in cellular manufacturing. This framework consists of planning functions, relations between these functions, planning horizon, period length and re-planning frequency applied to these functions and the level of decision making in the production system at which the function operates. Also, his framework contains some information on abstraction levels for certain planning functions (e.g., demand management).

According to the application of Banerjee [3] methodology in production planning and control for cellular manufacturing systems, a comprehensive framework for designing a production planning and control system in a specific production system should specify both

- the required planning functions and
- the direction and contents of the relations between these functions.

In the framework presented by Bhat [1] following steps can be performed to modify the framework:

(1) Capacity is considered as a black box while it seems to be necessary that in order to check capacity in various level of production planning, known planning functions related to capacity (e.g., Rough Cut Capacity Planning and Capacity Requirements Planning) have to be used and added to framework.

(2) Decisions in each level are taken for satisfying objectives of same level and taking account imposed situation from upper levels and feed backs of lower levels. In each level, if imposed situation from upper levels can not be satisfied, its necessary that plan of upper level are revised by feedback loop until feasible plans in lower levels can be achieved. Because of that, it is necessary to add feedback loops to framework.

(3) Cell coordination is not explained in detail. Thus the coordination procedure is vague. To overcome this weakness, models presented by bauer [7] are used to clarify functions of cell coordination.

(4) Nevertheless variant modules are addressed in this framework; process planning functions are not illustrated. To integrate process planning in various level of production planning, known macro process planning and micro process planning, have to be used and added to framework.

Fig. 1. Shows this comprehensive framework of production planning and control in cellular manufacturing that according to an electronics plant in Iran are customized. Data flow has been changed to cope with the characteristics of the case study. In this industry most of the parts and raw materials are imported which increase the level of uncertainty. This is not compatible with kanabn system; hence the classical PAC model is used. Cell coordination and production activity control are explained in detail. So the models presented by Shahid [8] and Bauer [7] are used to clarify functions of cell coordination and production activity control respectively by FC and PAC.

Decisions of FC level of planning and control concern with:

(1) Disaggregation production routes between cells along with determination and selection of an optimal production route from process planning resource databases result in consideration of the following:

(i) Current operating situation on the factory and the shop floor of cells and optimizes the flow of material and the use of the resources involved in manufacturing and assembly,

(ii) Various management goals like reducing the work in process and the severity of bottlenecks, minimizing shop floor throughput in cells and lead-times and improving delivery date adherence.

(2) Determination orders appropriate sequences between the cells and planned throughput times per cell.

(3) Control Intra-cell good flows.

(4) Determination of batches that contain families of parts and consideration of the cell as one planning unit.

(5) Control the available capacity of cells, schedule manufacturing orders and share resources between cells, dispatch and release work orders to cells.

(6) Monitor work orders released to cells and share resources and send updated information to upper decision levels.

III. Integrating process planning and production planning and control

The goal of process planning is to propose the routing of a previously designed part and results in a sequence of operations and their Parameters. It concerns and requires detailed in formation about the process. The goal of production planning, on the other hand, is to schedule, sequence and launch the orders introduced on the routing sheet into the job shop according to the enterprises strategic goal and the actual conditions of the production plant. The goals, information and decisions taken in process planning and production planning and control are often very different and, because of that, it is very difficult to integrate them [4]. Both process planning and production planning aim at minimizing costs and times

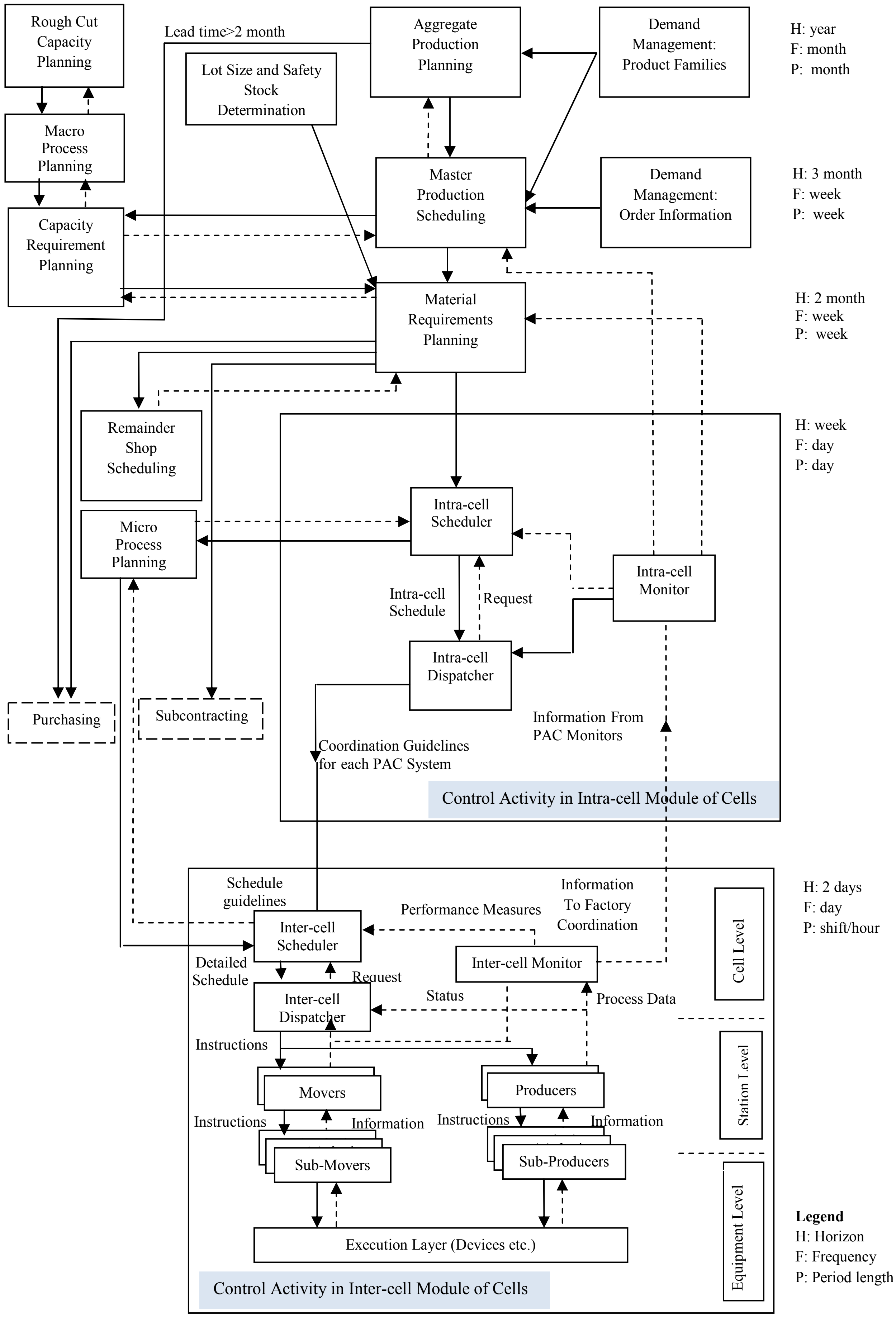

Fig. 1. A Comprehensive model of integrated production planning and control in cellular manufacturing

within the limits of the constraints, while meeting the requirements. For process planning these requirements refer to meeting the product quality, while production planning should make sure that the due dates are met. If process planning imposes major constraints on the production planning task, these planning processes may be seen to be conflicting, where ideally they should be co-operating. The conflict is mainly caused by the fact that these separate planning processes do only take their own requirements, costs function, and constraints into account. Both planning and production planning have complementary goals in order to improve continuing company productivity and, eventually and competitiveness.

That cited, optimal manufacturing routes, from the point of view of process planners, are often very different from the optimal routes in the opinion of production planners. Their respective goals can be as different as reducing the cost of each part in the first case, and reducing the time a specific machine is occupied in the second. In addition, these optimal routes can vary over time since they depend on the current situation of all the factors involved in the production process (availability of machines, parts, workers, etc.). Nevertheless, although process planning and production planning do not share all of the same objectives, their objectives are complementary in the sense that they should lead to a single optimal solution that shortens the manufacturing cycle as much as possible while increasing production flexibility and, in turn, company productivity. In order to be able give optimal manufacturing orders at any given time regarding, for example, production times or costs, automated systems to assist in process planning, also known as computer aided process planning (CAPP), will be designed to varying degrees of success. These CAPP systems were originally developed as a link between design and manufacturing, filling the existing gap between computer aided design (CAD) and computer aided manufacturing (CAM) [5] and responding to the need for material requirement planning (MRP) to work with standard and optimized routes which can be used in production planning [4]. The inputs in these systems are the technological variables involved (tolerances, materials, and etc.) that allow the calculation of a specific output: the routing, which is a sequence of manufacturing operations containing details about the depths of pass, the speeds, the dimensions, the assembly steps, the tools and etc [6]. However, the fact that these CAPP systems are completely separate from the management variables under the control of the production planner (stocks, available machines, workers and etc.) means the sequence provided by the system must be the optimal one according to the defined objectives. Even so, such an optimal process plan may not guarantee the best way to manufacture the part in the plant at a specific moment, as it could lead to the overload, or under-use, of some machines, with subsequent bottle-necking. In general, and depending on the severity of these bottlenecks, this problem is reduced in what Grabowik [10] calls production rescheduling: the CAPP system is required to generate alternative routes and to implement them during the following shift or the following day according to the PPC analysis. For this reason, if the CAPP system does not take into account the existing management restrictions, it is recommended to generate more than one plan.

Many authors proposed models for integrating production planning and process planning. Larsen and Alting [14] suggest that in general process planning includes two major phases, the first to be classified as time-independent and the second as time-dependent [12]:

- Analysis phase. Technical analysis of candidate solutions
- Selection phase.

In literature the terms “macro process planning” and ‘micro process planning’ are often used for the time-independent rough planning and the time-critical detailed planning part. Sheng and Srinivasan [13] suggest that macro process planning refers to the determination of a feature sequence through the analysis of geometric and process interaction. Micro process planning refers to intra-feature planning, i.e. the optimization at the feature level [15]. Cay and Chassapis [16] define macro process planning as the manufacturability layer while the detailed process plans are generated through micro process planning. Other authors discern machine-independent (macro) and machine-dependent (micro) process planning. In this paper, the prefixes ‘macro’ and ‘micro’ indicate the level of detail in the process plans. *Macro process planning* concerns the rough technological planning of production activities on an aggregate level. *Micro process planning* concerns the detailed technological planning of production activities resulting in the manufacturing instructions. Due to the diversity and product dependency of process planning sequences, the prefixes do not specify a fixed set of clearly defined process planning (sub) tasks. Due to importance of process planning levels in cellular manufacturing, micro process planning and macro process planning modules are added to the framework (see fig. 1.). It’s noted that the latest model is presented by Ciurana [4]. He developed a model that can be applied to the development of an integrated process planning and production planning using an IDEF0 methodology to design an activity model, which integrates process and production planning. He used an activity model to develop a system that allows the user to plan the process and the production at the same time in collaborative engineering work. He focuses on integrating process planning and production planning and activities related to production control adapted to shop floor characteristics are not developed.

V. CONCLUSION

This paper developed a comprehensive model for integrating process planning and production planning and control in cellular manufacturing (CM). We have reviewed the latest production planning framework in cellular manufacturing and tried to modify it. Capacity planning functions, feedback loops and process planning functions were added to this framework in order to in enrich planning system. This framework was customized to meet requirements and constraints of the Iran electronics industries.

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