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Application of Computer Aided Process Planning in Manufacturing Industries

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Abstract— In today's economy, products and processes tend to increase in complexity of design and functionality. Furthermore, they are in need of high-sophisticated manufacturing and assembly processes. On the other hand, increasing competition results in the demand for shorter product life cycles and forces companies to cut down development and delivery times. Thus, modern manufacturing has to adapt to new requirements of this dynamic environment. In this context, innovative information technologies in general and flexible as well as adaptive concepts for process planning and production control in particular are of increasing importance for business success. Among the whole manufacturing cycle of a product, a sequence of manufacturing stages needs to be optimized using the increasingly available computing resources. Computer aided process planning is seen as the missing link between CAD and CAM, which relates to the translation of design tolerances into manufacturing tolerances to be executed in the shop floor. In this paper, the general topic of process planning, the implementation and theoretical foundation of CAPP, the role of CAPP in concurrent engineering (CE), various classifications of CAPP systems and its application in job shop type of industries is presented.

Index Terms— Process planning; concurrent engineering; job shops; computer aided process planning

I. INTRODUCTION

Process planning is a task of transforming design specifications into manufacturing instructions. This task includes identification of machines and tools, operations and their sequence, and selection of machining parameters. In manual process planning a process plan for a new part is created by identifying and retrieving an existing plan for a similar part (sometimes called a master part) and making the necessary modifications for the new part. And if there is no plan existing for a similar product the process planner will prepare a new one from scratch using his experience and knowledge of the production plant capacity. Usually in organizations that use manual process planning the process plans are not kept in a form that allows their retrieval based on their design and manufacturing similarities. The usual traditional trend is to arrange the design and process plan documents based on their work order number, which fails to categorize the products according to their process similarity. This leads to the need for computerized systems that will allow the process planning function to be performed either totally or partially by a computer, providing the user with optimum process plans in a quick consistent fashion. CAPP works best when it is direct connection between CAD and CAM. i.e. CAPP is the linkage between the CAD module and the CAM module, which confers it a special place in the computer integrated manufacturing CIM system. Input data information for computer aided process planning system will be formalized part description (half – finished product description and finished part description) and production size. Whereas output data information is known to be a formalized description of the planned process. A retrieval CAPP system, also called a variant CAPP system, is based on the principles of group technology (GT) and parts classification and coding. In this type of CAPP, a standard process plan (route sheet) is stored in computer files for each part code number. The standard route sheets are based on current part routings in use in the factory or on an ideal process plan that has been prepared for each family. It should be noted that the development of the data base of these process plans requires substantial effort [1].

Before a retrieval CAPP system is used for process planning, a significant amount of information must be compiled and entered into the CAPP data files. This is what is referred to as the "preparatory

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phase" in the illustrative flow chart in fig 1. Typical process plan is a single common process for the part family, substituting planning of individual processes for every part separately. Part family, for which the typical plan is established, belongs to the parts technological type [2]. The parts technological type results from chosen coding and classification system. Part family consists of the different parts, because the criterions of classification specify only general similarity features. The flow chart for a procedure of

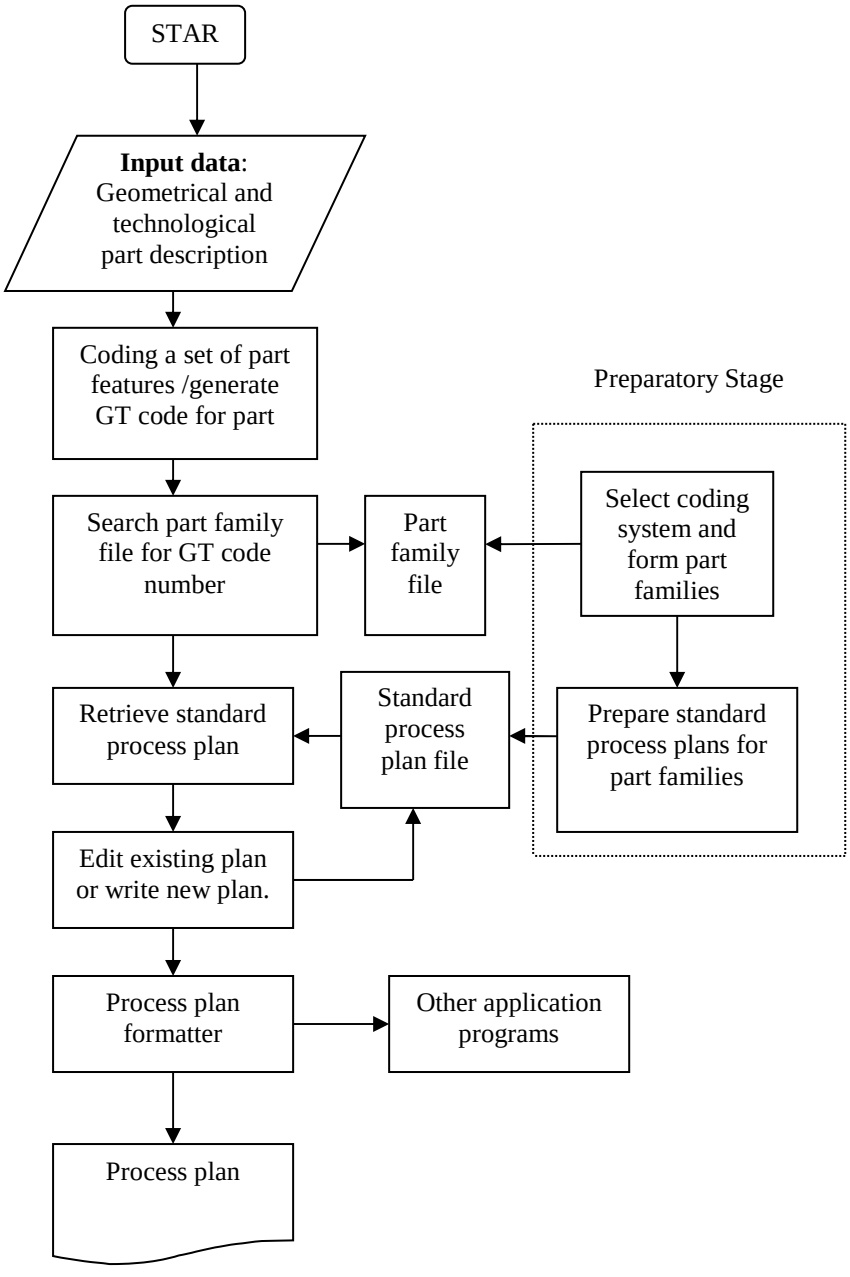

Figure1 The flowchart for process planning procedure on the basis of Typical Process model [2]

typical process planning is shown in Figure1. It was developed based on the assumption that specified set of parts exist, but process plans for this parts don't exist. Creation of typical process plans database is the result of designing activities. After the preparatory phase has been completed, the system is ready for use. For a new component for which the process plan is to be determined, the first step is to derive the GT code number for the part. With this code number, a search is made of the part family

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file to determine if a standard route sheet exists for the given part code. If the file contains a process plan for the part, it is retrieved (hence, the word "retrieval" for this CAPP system) and displayed for the user. The standard process plan is examined to determine whether any modifications are necessary. It might be that although the new part has the same code number, there are minor differences in the processes required to make it. The user edits the standard plan accordingly. This capacity to alter an existing process plan is what gives the retrieval system its alternative name: variant CAPP system.

If the file does not contain a standard process plan for the given code number, the user may search the computer file for a similar or related code number, the user may search the computer file for a similar or related code number for which a standard route sheet does exist. Either by editing an existing process plan, or by starting from scratch, the user prepares the route sheet for the new part. This route sheet becomes the standard process plan for the new part code number.

The process planning session concludes with the process plan formatter, which prints out the route sheet in the proper format. The formatter may call other application programs into use; for example, to determine machining conditions for the various machine tool operations in the sequence, to calculate standard times for the operations (e.g., for direct labor incentives), or to compute cost estimates for the operations [3,4].

II. THE USE OF CAP IN MANUFACTURING EVALUATION

The need for an early evaluation of manufacturability is well recognized. And such effective merger of manufacturing and other life – cycle issues into the early stages of design is possible only by using some recent computer aided engineering applications like CAPP. Many managers and directors as well as manufacturing engineers are frustrated with many different databases created for a single product. They are constantly seeking a single source for all information on the product. This problem might be resolved by using the concept of single database management (SDM) that includes all the data from design, analysis, process planning, tooling, quality/inspection plan etc [4].

III. APPLICATION OF CAPP IN ETHIOPIAN INDUSTRIES

Most of the job shops in Ethiopia such as Akaki Spare parts and Hand Tools Factory, and Metal Products Development Center (MPDC) are not profitable. The main reason for low profitability is failure to cope up with the dynamic environment of a job shop. As the product variety treated in a job shop is high, it resulted in increased lead time, and production cost. Such a higher lead time also affects the production quantity and the productivity of the shop as a whole. One way of tackling this problem could be the use of automated design and manufacturing methods in a concurrent manner. One such application is computer aided process planning.

For the discussion of application of CAPP in Ethiopia the Metal Products Development Center (MPDC) is taken as an example in this paper. In metal products development center, the development of route sheets (manufacturing methods) is done on individual part basis and released to the machinist on the floor with the workshop drawing of the part. The method or process planning section is a separate section from the product design department and is run by experienced production engineers. The development of the route sheet is carried out manually and feed into computer on an Excel – sheet. A sample route sheet for a given part is shown in Figure2.

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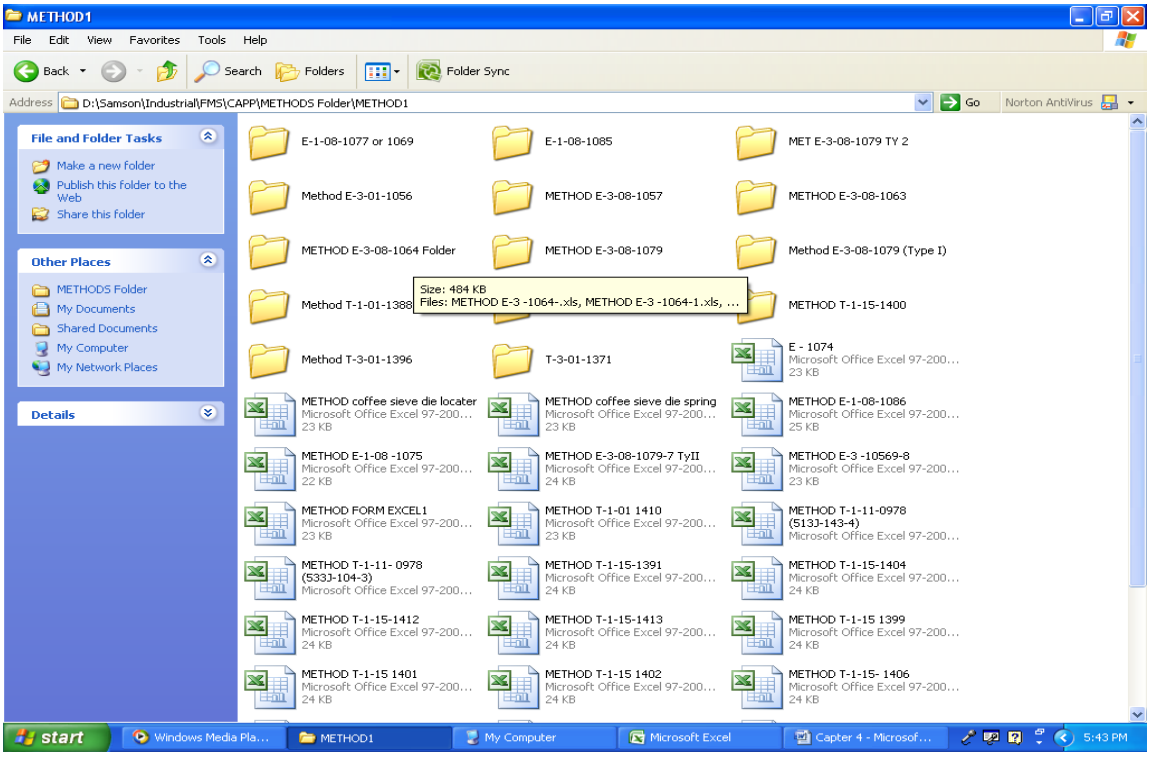

Figure2 Existing Work order based route sheet file saving practice

These method files (or route sheets) generated are saved according to their work order number (Figure2). The technical information contained in the work order number is very limited and it tells only the sequence of order release, the year of order release, and weather the product falls in the equipment or the tool category. Therefore, it is recommended that a part family code be generated in the company, so that the route sheets will be saved and latter retrieved according to this part family code.

Most of the spare parts produced and specially the parts of tools (dies and punch sets, injection molds and the like) are pretty standard. And therefore they can easily be categorized according to their design and manufacturing features, materials, tolerance ranges, surface finish requirement, etc. An example of such grouping based on manufacturing features for injection molds include: Major core and cavity plates; Other plates for mounting and support; Guide pillars; Guide bushings; Finger cams etc.

The manufacturing process, tolerance ranges, materials, machining and heat treatment requirements and the like for parts under each of the above categories is similar. Therefore, it can be seen that, especially the tool workshop of the organization can benefit a lot from the application of a CAPP system.

The part family classification can also be applied for spare part and commonly used parts of equipment (like shafts, gears, flanges, screw shafts, hubs, etc). Using a Retrieval CAPP system the level of classification detail will grow through time as many number and type of parts are treated.
In the context of MPDC the Retrieval CAPP system is found to be favorable for the following reasons: Simpler programming and installation; Ability to design a variety of components based on an existing standard plan; It is easier to learn and use; Already existing practice of computer saved and retrievable route sheets, which can be retrieved and modified for the planning of similar parts.

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IV. CONCLUSION

Application of CAPP is very useful in manufacturing organizations. Especially the application of a Retrieval CAPP system is found out to be attractive in terms of its being less capital intensiveness, lower training requirement, easier implementation, and ability to use already developed rout sheets after categorizing them with a coding system. The use of CAPP also enables the design engineers to work on route sheet development in parallel with the product design. This has got an advantage of reducing the total production lead time and empowers the designer to have a closer look at the detail processing and production cost of the product. The other affirmative trend in developing countries like Ethiopia for the application of automated manufacturing applications is the ever increasing utilization of computers and other IT – Setups like computer.

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