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APPLICATIONS OF THE GROUP TECHNOLOGY THEORY IN MANUFACTURING

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Abstract: *Group Technology is a manufacturing philosophy and strategy that assists a company in understanding what it manufactures and how those products are then manufactured. GT provides a means to identify and exploit the "underlying sameness" or similarities of parts and processes. Once identified, it is possible to capitalize on these similarities by processing together groups of similar parts (families), by standardizing and simplifying closely related and repetitive activities to avoid unnecessary duplication of effort and by efficient storing and retrieving of information related to recurring problems, thereby avoiding solving the same problem again and again.*
Key words: *group technology theory, CAPP systems*

1. INTRODUCTION

Group technology (GT) has a great significance in the engineering industry. There is the greatest utilisation of GT in planning activities, especially in process planning and in layout machine design. GT is a manufacturing philosophy that has proved successful by grouping parts into families to speed production and reduce costs. The GT is a very good key to accelerating the movement of a product to market and to the achieving WCM. The result of the GT is not only improved set up and throughput time, but also effective cost reduction through improved design rationalisation and better retrieval of the design data. In addition, the application of GT can lead to reductions of in-process inventory and tooling costs as well as NC programming costs. Manufacturing engineers also apply GT to improve NC utilisation.

Engineers can use the GT philosophy to avoid redundancy by retrieving previously completed items for re-use. This saves design, planning and project time and contributes positively to time-to-market. Although applying the GT philosophy can be viewed as simply applying common sense, it makes more sense for engineering management to have formal GT systems and procedures in place for as many applications as possible. The CAPP systems based on GT are very wide-spread in engineering industry [1].

2. THEORY OF GROUP TECHNOLOGY

Group Technology is a manufacturing philosophy and strategy that assists a company in understanding what it manufactures and how those products are then manufactured. GT provides a means to identify and exploit the "underlying sameness" or similarities of parts and processes. Once identified, it is possible to capitalize on these similarities by processing together groups of similar parts (families), by standardizing and simplifying closely related and repetitive activities to avoid unnecessary duplication of effort and by efficient storing and retrieving of information related to recurring problems, thereby avoiding solving the same problem again and again.

The major advantages of group technology include the following [6]:

a) It makes possible standardization of part design and minimization of design duplication. New part designs can be developed using similar, yet previous, designs, and in this way a significant amount of time and effort can be saved. The product designer can quickly determine whether data on a similar part already exists in the computer files.
b) Data that reflect the experience of the designer and the manufacturing process planner are stored in the database. Thus, a new and less experienced engineer can quickly benefit from that experience by retrieving any of the previous designs and process plans.
c) Manufacturing costs can be estimated more easily, and the relevant statistics on materials, processes, number of parts produced, and other factors can be more easily obtained.
d) Process plans are standardized and scheduled more efficiently, orders are grouped for more efficient production, and machine utilization is improved. Setup times are reduced, and parts are produced more efficiently and with better and more consistent product quality. Similar tools, fixtures, and machinery are shared in the production of a family of parts. Programming for NC is more fully automated.
e) With the implementation of CAD/CAM, cellular manufacturing, and CIM, group technology is capable of so greatly improving the productivity and reducing the costs in small-batch production as to approach those of mass production. Depending on the level of implementation, potential savings in each of the various design and manufacturing phases can range from 5% to 75%.

Group technology is the realization that many problems are similar, and that by grouping similar problems, a single solution can be found to a set of problems thus saving time and effort.

Although the definition is quite broad, one usually relates group technology only to production applications. In production systems, group technology can be applied in different areas. For component design, it is clear that many components have a similar shape (Fig. 9). Similar components, therefore, can be grouped into design families and a new design can be created by simply modifying an existing component design from the same family.

For manufacturing purposes, GT represents a greater importance than simply a design philosophy. Components that are not similar in shape may still require similar manufacturing processes. For example, in Fig. 10, most components have different shapes and functions, but all require internal boring, face milling, hole drilling, and so on. Therefore, it can be concluded that the components in the figure are similar. The set of similar components can be called a production family. From this, process-planning work can be facilitated. Because similar processes are required for all family members, a machine cell can be built to manufacture the family. This makes production planning and control much easier, because only similar components are considered for each cell. Such a cell-oriented layout is called a group-technology layout or cellular layout.

The following techniques are employed in GT:

1. Coding and classification.
2. Production-flow analysis.
3. Group layout.

2.1. Classification and Coding of Parts

In group technology, parts are identified and grouped into families by classification and coding (C/C) systems. This process is a critical and complex first step in GT. It is done according to the part's design attributes and manufacturing attributes:

1. *Design attributes* pertain to similarities in geometric features and consist of the following:
   a) external and internal shapes and dimensions,
   b) aspect ratios (length-to-width or length-to-diameter),
   c) dimensional tolerances,
   d) surface finishes,
   e) part functions.
2. *Manufacturing attributes* pertain to similarities in the methods and the sequence of the manufacturing operations performed on the part. As we have seen, selection of a manufacturing process (or processes) depends on many factors, among which are the shape, the dimensions, and other geometric features of the part. Consequently, manufacturing and design attributes are interrelated. The manufacturing attributes of a part consist of the following:
   a) the primary processes used,
   b) the secondary and finishing processes used,
   c) the dimensional tolerances and surface finish,
   d) the sequence of operations performed,
   e) the tools, dies, fixtures, and machinery used,
   f) the production quantity and production rate.

From these lists, it can be appreciated that the coding can be time-consuming and that it requires considerable experience in the design and manufacture of products. In its simplest form, the coding can be done by viewing the shapes of the parts in a generic way and then classifying the parts accordingly (such as parts having rotational symmetry, parts having rectilinear shape, and parts having large surface-to-thickness ratios). The parts being reviewed and classified should be representative of the company's product lines. A more thorough method is to review all of the data and drawings concerning the design and manufacture of all parts [4].

Parts may also be classified by studying their production flow during the manufacturing cycle; this approach is called production flow analysis (PFA). Routing sheets clearly show process plans and the operations to be performed. One drawback to PFA, however, is that a particular routing sheet does not necessarily indicate that the total manufacturing operation is optimized. In fact, depending on the experience of the particular process planner, routing sheets for manufacturing the same part can be quite different. The benefits of computer-aided process planning in avoiding such problems is obvious.

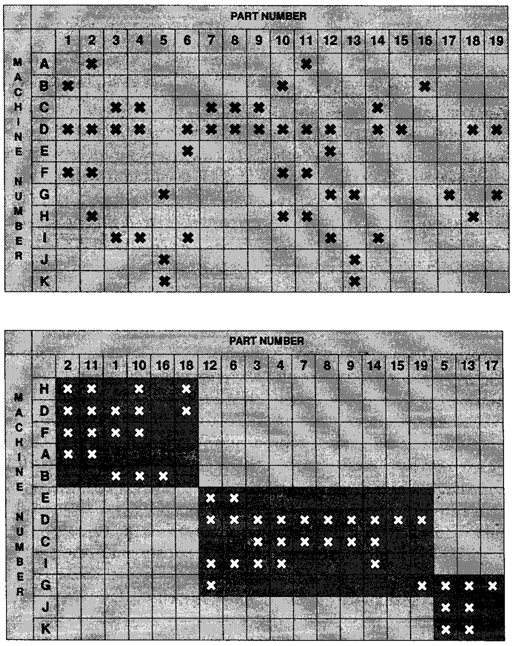
2.2. Production-flow Analysis

One of the more effective approaches to forming cells in facilities design is Production Flow Analysis (PFA), developed by Burbridge in 1975. Production Flow Analysis is a structured technique used for determining part families and machine groups simultaneously by analyzing route sheets for parts (or assemblies) fabricated in the shop. PFA groups into families parts that have similar operational sequences and machine routings; grouping the machines that perform these similar operations into cells. The PFA technique has several advantages as a means to identity potential workcells [5]:

1. this technique can be used when the shape of the parts has little or no relation with the manufacturing methods needed to produce them; thus, the tendency to identify part families solely on the basis of similar function, part names or physical appearance is avoided,
2. PFA can identify workcells more quickly and with much less effort than can the classification and coding system,
3. because PFA is based on routing sheets, the technique focuses solely on current manufacturing methods and uses existing processing equipment anc tooling,
4. PFA offers a way to reorganize existing facilities and gain some advantages of cellular manufacturing with the least possible investment.

Initially, a machine-part chart must be formed. This is an M x N matrix, where: M - number of machines, N - number of parts, X - if part has an operation in machine. If the machine-part chart is small, parts with similar operations might be grouped together by manually sorting the rows and columns. However, a more appealing method is to use a computer procedure to perform this work. Fig. 1 illustrates the use of PFA to form part families. For this technique to be successful, accurate and efficient routings must exist for each part. In many companies these routings do not exist. If routings exist, they are often inaccurate from lack of maintenance or they may be very inconsistent. The latter situation will occur if routings are established without using a coding and classification system. Also, using

PFA involves judgment, because some parts may not appear to fit into a family when one or more unique operations are required. Furthermore, additional analysis is required to determine when a particular machine should be duplicated in another group [2].



a) Unsorting machine-part matrix

b) Resultant machine-part matrix after sorting

CELL NUMBER	MACHINES	PARTS
1	H, D, F, A, B	2, 11, 1, 10, 16, 18
2	E, D, C, I, G	12, 6, 3, 4, 7, 8, 9, 14, 15, 19
3	G, J, K	5, 13, 17

c) Assigning machines and parts to machine cell

Fig. 1 *Production flow analyses*

2.3. Group Layout

A typical company makes thousands of different parts, in many different batch sizes, using a variety of different manufacturing operations, processes and technologies. It is beyond the capability of the human mind to comprehend and manipulate such vast amounts of detailed data. People still need to make decisions regarding how to run a manufacturing company and succes in today's competitive environment at home and foreign markets. The pressures on management are continuing to escalate as global competition drives the need for producing a greater variety of high quality products, in smaller lot sizes and lower costs. These outgoing demands continuously increase the level of complexity present in a manufacturing environment. What is needed, are both the strategy and a tool that can be used to achieve such a purpose [3].

The layout design of a manufacturing facility is one of the most important factors affecting product quality and cost. The manner in which the equipment is configurated on the shop floor affects material flow, manufacturing leadtimes, work in-process inventories, inprocess quality, the manner in which work is scheduled, processed and controlled through production. Layout configuration is not only a long-term strategic decision, but it is also a determinant for achieving World Class Manufacturing.

The GT philosophy has a fundamental role in determining the layout configuration, particularly for companies involved in producing discrete parts in small to medium batch sizes. Since these types of operations essentially involve high levels of complexity in terms of a multitude of different parts, machines and other processing requirements, the need and opportunities to standardize and simplify are great.

3. CREATION OF NC PROGRAMS ON THE BASE OF GROUP TECHNOLOGY

In the product realization process, the first and most important step is making a process plan. The quality of a product and the cost of producing it are strongly influenced by the process plan. Production planning, scheduling, part programming, facilities layout, etc. - all these functions take process plan as their input. In the past the majority of manufacturing systems were operated by humans. Since such a system responds slowly and is able to adapt to incomplete information, an inflexible and slow process plan generation mechanism is acceptable. Either manual process planning or retrieval-based variant process planning systems can satisfy the need. Today, the production method is gradually moving toward automation. Flexible automation has been especially stressed in recent years. The need for dynamic responses, fast plan generation, and smooth interface between design and manufacturing functions become essential in operating the new manufacturing systems. Computer-Aided Process Planning (CAPP) or automated process planning is an approach that uses computers to generate a process plan. When constructed properly, such a system can satisfy the above mentioned needs. However, the task of automating the process planning function is not a simple one. No single algorithm can model the complexity of the thinking process of an experienced human planner. The development of CAPP started in the late sixties. The pioneers created the process planning problem as a machining optimization problem. In the early seventies the Group Technology (GT) concept was introduced. Several GT-based retrieval systems were developed. GT code, part family, standard process plan, and plan editing were some terms familiar to users. Those systems by no means generated new process plans automatically.

CNC program is very similar as technological process plan. Is possible to speak that CNC programs are one kind of technological process plans. If group technology theory can be used for automated creation of technological process plans, can be used for automated creation of CNC programs, too.

In manufacturing, thousands of items are produced yearly. When one looks at the parts that construct the product, the number is exceptionally large. Each part has a different shape, size, and function. However, when one looks closely, one may again find similarities among components; a dowel and a small shaft may be very similar in appearance but different in function. Spur gears of different sizes need the same manufacturing processes and vary only in size. Therefore, it appears that manufactured components can be classified into families similarly to biological families or library taxonomies. Parts classified and grouped into families produce a much more tractable database for management [7].

On Department of Manufacturing Technologies of Faculty of manufacturing Technologies of TU of Košice with a seat in Prešov is prepared program for creation of CNC programs with use of group technology theory named GroupNC. First windows of GroupNC program is showed in Fig. 2.

Fig. 2 *Windows of GroupNC program*

4. CONCLUSION

Group technology has a great significance in the engineering industry. There is the greatest utilisation of GT in planning activities, especially in process planning and in layout machine design. GT is a manufacturing philosophy that has proved successful by grouping parts into families to speed production and reduce costs. The GT is a very good key to accelerating the movement of a product to market and to the achieving WCM. The result of the GT is not only improved set up and throughput time, but also effective cost reduction through improved design rationalisation and better retrieval of the design data. In addition, the application of GT can lead to reductions of in-process inventory and tooling costs as well as CNC programming costs. Manufacturing engineers also apply GT to improve CNC utilisation. Research Grant Agency of the Slovak Ministry of Education supported this work, contract No. 1/3177/06.

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