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ADVANTAGES OF THE GROUP TECHNOLOGY THEORY IN MANUFACTURING

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Abstract: *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. 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.*
Key words: *group technology theory, CAPP systems*

1. INTRODUCTION

Today's industry competes in a truly international marketplace. Efficient transportation networks have created a "world market" in which we participate on a daily basis. For any industrial country to compete in this market, it must have companies that provide economic high-quality products to their customers in a timely manner. The importance of integrating product design and process design to achieve a design-for-production system cannot be overemphasized. However, even once a design is finalized, manufacturing industries must be willing to accommodate their customers by allowing last-minute engineering-design changes without affecting shipping schedules or altering product quality.

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. Yet, even the time and cost saved by using retrieval-based process planning systems pleased many users. Many of today's process planning systems are still of this type. This approach came to be called "variant" approach, since it varies the existing plan manually to make a new plan.

2. THEORY OF GROUP TECHNOLOGY

Since the beginning of human culture, people have tried to apply reason to their actions. One important way to apply reason is to relate similar things. Biologists classify items into genus and species. We relate to such things as mammals, marsupials, batrachians, amphibians, fish, mollusks, crustaceans, birds, reptiles, worms, insects, and so on. A chicken is a bird with degenerated wings. Tigers, jaguars, and domestic cats are all members of a single family.
The same concept applied to natural phenomena also can be applied to fabrication and information phenomena. When a vast amount of information has to be kept and ordered, a taxonomy is normally employed. Librarians use taxonomies to classify books in libraries. Similarly, 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 (Fig. 1); 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.

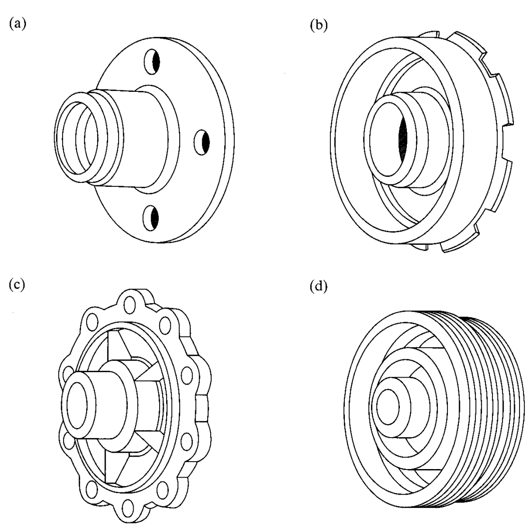

Fig. 1 Grouping parts according to their geometric similarities

Although this simple concept has been in existence for a long time, it was not until 1958 that S. P. Mitrofanov. A Russian engineer, formalized the concept in his book “The Scientific Principles of Group Technology”. Group technology (GT) has been defined as follows:

> “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. 1). 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, 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.

Although both production-flow analysis and group layout are based on coding and classification methods, they still can be distinguished as different activities. In the following sections, basic group-technology concepts are discussed in detail.

3. 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. 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:

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.

5. 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.

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.

There are basically three ways machines can be configured on a factory shop floor. The layout configuration that is the most appropriate depends on the volume and variety of different parts to be processed. The relationship between part volume and part variety is shown in Fig. 22 for each of the three types of layout configurations, which are typically called:

- Product Line Layout,
- GT Manufacturing Workcells,
- Functional Layout.

6. CONCLUSION

Group Technology was used to help locate similar parts, thus becoming process plans. It was not until after ten years had elapsed that some kind of generative approach was taken. Although the introduction of AI and an expert system boosted both the interest in the problem and the capability of the systems, the results are still far from desirable. Paper was prepared in time of realization of project VEGA No. 1/3177/06.

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