State-of-the-art in coding systems by a geometrical and technological approach

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Abstract: -. The goal of this paper is to show and justify the reasons to develop a new part coding systems that includes a more complete characterization of the parts. This new coding system not only could be used in common applications, also in computing process planning tasks. Particularly, this paper shows a possible application related with the conceptual design of Flexible Manufacturing Systems and the support to work with an objective automation process in their design.

Key-Words: - Group technology, Flexible manufacturing system, Π Buckinham theorem, Similarity, Ionic nitriding process, Neural networks.

1 Introduction

Nowadays international marketing is featured by being diversified, soddened and for having an incipient growing . Customers are getting rid for trades, looking for high quality products and low prices, and making these fitted to their necessities. Appling innovated technologies for improving the production, the distribution and global competition, clients will find more satisfaction in the market.

Industries must modify their policies of production in order to fit at the newest features that international markets establish. In order to keep their profits, these changes must be oriented to obtain features and goals as [1, 2]: flexibility of the manufacturing processes and the product, reliability of the process, improving quality of the product, integration of the organization, the process and the product, decreasing the launching time of new products, minimizing of wasting (every thing which does not add any value to the product), decreasing of leading and preparation time, automation of the processes, and growing of the productivity.

These way, if changes in product variety are needed, it will be vital to get a complete and flexible system that allows to characterize parts, and at the same time, to modify those changes automatically. In this sense, the coding part system play an important role.

2 Part coding systems

One of the parts standardization techniques used in GT is the coding systems, which help to geometrical-technological characterization for making families of parts.

Coding methods are employed in classifying parts into part families. Coding refers to the process of assigning symbols to the parts. The symbols represent design attributes of parts or manufacturing features of part families [5-16]. The variations in codes resulting from the way the symbols are assigned can be grouped into three distinct type of codes: monocode or hierarchical code, polycode or attribute, and Hybrid or mixed code.

The structure of monocode is like a tree in which each symbol amplifies the information provided in the previous digit. A monocode (hierarchical code) provides a large amount of information in a relatively small number of digits, which is useful for storage and retrieval of design-related information such as part geometry, material, size, etc. And on the other hand, it is difficult to capture information on manufacturing sequences in hierarchical manner, so applicability of this code in manufacturing is rather limited.

In polycode (attribute code) code symbols are independent of each other. Each digit in specific location of the code describes a unique property of the workpiece and it is easy to learn and useful in manufacturing situations where the manufacturing process have to be described. The length of a polycode may become excessive because of its unlimited combinational features.

Mixed code (hybrid code) is the mixture of both monocode and polycode systems. Mixed code retains the advantages of both systems. Most coding systems use this code structure. The first digit for example, might be used to denote the type of part, such as gear. The next five positions might be reserved for a short attribute code that would describe the attribute of the gear. The next digit (7th digit) might be used to designate another subgroup, such as material, followed by another attribute code that would describe the attributes.

Differences in information storage capacity between monocode and polycode are shown below assuming that a code consists of five symbols and that in each of the five code fields the digits 0 to 9 are used:

$10^1 + 10^2 + 10^3 + 10^4 + 10^5 = 111110$ for monocode.

$10 + 10 + 10 + 10 + 10 = 50$ for polycode.

The OPITZ classification system is a mixed (hybrid) coding system developed by Opitz, Technical University of Aachen, 1970. It is widely used in industry and provides a basic framework for understanding the classification and coding process. It can be applied to machined parts, non-machined parts (both formed and cast) and purchased parts. It considers both design and manufacturing information.

The Opitz coding system consists of three groups of digits: form code uses the digits 12345 for part geometry and features relevant to part design.

Supplementary code uses the digits 6789 for giving relevant information to manufacturing (polycode).

Secondary code uses the letters ABCD for production processes and production sequences.

The coding system KK3 is one of the most complete open hybrid coding systems. This code include more manufacturing operations. In general, these coding parts systems are useful for an objective characterization of manufacturing design process, and are also required for making easier to produce automatically the manufacturing analysis.

3 Application of part coding systems in the process of conceptual design of Flexible Manufacturing Systems

Technology of FMS began its evolution thirty years ago. During this period this technology has gathered plenty of developing. However, still it is demanding better tools that make easier the design of this type of production systems.

The design stage of a FMS is a hard work and must to attend seriously the following: Introducing multiple criteria, where some of them need to be quantifying according to higher levels of the industry. Some preferences like performance, starting capital, financial parameters, flexibility and quality must be considered; Existence of great variety of control strategies and configurations available for the designer; Represents 30% of the implantation project time of a Flexible Manufacturing System and 20% in costs[3]. That is why we see the coding systems as a tool for characterizing the parts and manufacturing operations required for what the FMS is designed and for taking more objective decisions.

3.1 Main strategy

The strategy will develop a scientific integral tool that will provide the elements for automation of FMS and metal cutting processes from their early stages.

This tool will involve steps from the conceptual design to the acquisition and constructions of the equipment.

The areas of research in order to reach the strategy are:

1) Decision analysis to define the automation requirement for metal cutting industries.
2) Flexibility-Quantity analysis for selection of manufacturing technologies.
3) Creation of a new part coding system based on geometrical and technological criteria.
4) Assignation algorithm based on coding parts system.
5) Development of an automated strategy for metal cutting part manufacture.
6) Assignation algorithm for selection of tool machines and an operation list.
7) Assignation algorithm of the automation degree automation of a machine tool.
8) Design algorithm of the material handling, transport system and layout of a FMS.
9) Integrative design algorithm for a FMS.

This stage pursues avoiding subjective preferences, expertise and preparation of the designers. The point 3 from these methodology “Creation of a new part coding system based on geometrical and technological criteria” will be described below.

3.2 Strategy of FMS concept design using an existing coding system

The new algorithm involves technical resources as coding parts, group technology, and manufacturing analysis.

Geometric and technical characterization is the first step to manufacture. Group technology helps and provides several advantages to develop this characterization. Some advantages of Group technology are [17-20]: External and internal forms–manufacturing operations ratio, information about the shape, processes to develop the form, and quality, creation of several data bases for product design, manufacturing process standardization and layout improvement. This manufacturing analysis allow system designer to choose production technologies and system architectures that fit according the following factors:

- Drawings of the parts.
- Sequencing.
- Capacity and Limits of the available equipments.

Coding systems are standard techniques that will help to provide part families.[21-27]. The main feature of the algorithm developed is that the grouping criterion is a geometrical and technological characterization of the parts. This means that machines that form bottlenecks in the system is because exist parts that cannot be grouped in only one family [28-33].

The operations assignation algorithm was based on the KK3 Coding System. Some advantages were found:

- Machining operations can be inferred.
- The algorithm structure allows to identify operations to generate coding parts.
- It makes easier the operation assignments.
- It allows to identify the features of a coding system.

The disadvantages of this algorithm were:

- Information about operations is poor.
- Physical and technological capacities of the equipment is not well defined.
- It is not possible to define assignation operations.

Although this algorithm has a great value for starting the design process, this shows some enhancing points in the following topics:

1) The Group Technology.
2) The Fabrication Analysis.

The algorithm developed can be improved applying other Coding System or enhancing the KK-3 Coding System and the number of families that will be formed. The developing of a new coding system, which allows the application of other processing techniques like fuzzy logic or neural networks could be the next step.

4 Developing a new coding system

Two reasons have made classifying and coding techniques less popular. The first one is because there is not enough knowledge about the use and application of the classifying and coding systems, and the second is because there is a lack of knowledge about the organizing principles used in design of the robusted patterns of classifying and coding supported by software and a database that allow to manage the system.

The new system will be implanted on a functional and relevant process for industry and high level research. The first approach will be based on the dimensional analysis that is similar to fluid mechanic applications.

Most of the systems do not have a mathematical support about the coding indexation. Using the dimensional analysis as a first approach to get ratios between mechanical, physical, electrical properties (among others), which are possible to bound in digit that support a specific feature of the process where the material will be transformed. Classical coding systems do not allow changing the manufacturing process easily. Dimensional analysis is a tool that helps to involve specific parameters for a particular manufacturing processes.

4.1 Coding System Support Techniques

Dimensional analysis, among many others techniques, is related with similarity, however, the approach is different to the manufacture when this is applied to group technology. Dimensional analysis particularly helps when experimental techniques are being developed because it is possible having an influencing guide of the phenomena related.

Fluid Mechanics uses dimensional analysis but do not give a complete solution, but a partial solution indeed. The successes of this analysis depends the skill to define parameters that would be applied. If one of the variables is omitted. the result will be incomplete and incorrect conclusions.

The Π Buckingham theorem can be extrapolated to machining and mechanized applications and these can be applied to GT directly. Machining relationships are a good instance for showing how easily Π Buckingham theorem can be applied.

The relationship argued by F.W.Taylor defined by equation (1), where cutting rate and tool life equal a constant makes possible to establish a link with FLT system (force-length-time) Eq.(2):

$$VT^n=C \quad (1)$$

$$C = f(L,T) \quad (2)$$

A large version from the equation of Taylor, defined by Eq. (3) exists, where variables such as: feed, cutting depth and the material hardness are involved:

$$C = V\,T^n\,d^x\,f^y \quad (3)$$

$$VT^n f^m d^p H^q = KT^n{}_{ref} f^m{}_{ref} d^p{}_{ref} H^q{}_{ref} \quad (4)$$

Where f is the feed rate, d is cutting depth and H is the hardness of the material. as you can see in equation (4). Exponents x, y, m, p and q can be determined experimentally. K is a constant value analogous to C.

Parameters shown now can be incorporated in a similarity system for a GT that allows making foundation for modeling and limitation in design and manufacturing process. Most of the mechanical components, not only use parts produced by tool machines, also conforming and welding processes and, surface and coating technology make an important contribution for making a selection and manufacturing of parts.

An algorithm that forms part families will be designed based on a similarity matrix. Working with mechanical and physical properties of materials a new coding system can offer different and a larger forms to classify parts in a general manufacturing frame. A large research in ionic nitriding has been developed at ITESM-CEM materials laboratory. Nitriding process needs the part to be heated to start diffusion process. Ionic bombarding allows part starts heating. Although there is not a directly relationship between variables of the plasma and the temperature of the part, it exists a current density-temperature ratio generated in the part.

4.2 Including non metal-cutting manufacturing operations

Prior to surface coatings, coding systems related with casting, forging, welding processes have been developed [34-36].

Ionic nitriding involves a glow discharge where a electric field generates a plasma, which works with parts and nitriding reactor as well. Reactor walls are the anode, while parts and components that will be treated work as cathode. The anode acts as a cell of electrodes where a voltage is generated over an adequate gas that is circulating between them.

The dimensional analysis and group technology will help to improve efficiently performance in the ionic nitriding process [34-41].

4.3 Future Work

The nature of the process and numerous nitriding experiments have revealed that complicated geometrical forms and different orientation and position inside the reactor change dramatically results of the treatment. Neural networks will be used in order to reduce the lead-time by means of reducing the learning process to study the different geometries, and hence the cost for determining the optimum parameters, geometries and positions before nitriding process start. Wave length values are fixed according the most common emissive systems of N_2. The spectra obtained is unique for mix of gases involved during the process.

A neural network will be able of learning the features of the process, and these will be characteristic parameters of the heat treating.

Family group will be formed through the introduction of the parameters in a software that will give the codification of the parts in a reliable form [42-52].

5 Conclusions

Group Technology, Coding Systems and Manufacturing Analysis are integrated in a strategy in order to justify the automation of the characterization of manufacturing processes applied to FMS design.

Most of the coding systems get a low informative level about manufacturing operations involved and get it lack of fabrication analysis objectiveness, and detailed geometrical characterization. Traditional Coding Systems do not involve mechanical and physical properties and the features of forming and finishing. Then, a new system for coding parts is required, where detailed machining operations can be inferred, physical and technological characterization of parts is completely defined, and possible assignation of operations. The first approach for designing the code will be based on the dimensional analysis The Π Buckingham theorem can be extrapolated to machining and mechanized applications and these can be applied to GT directly, and for the information processing fuzzy logic or neural networks could be the implemented.

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