A casting classification and coding system suitable for a CIMS in casting production

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This paper presents a comprehensive casting classification and coding system for the casting production industry. The general structure of the system is suitable for every joint within CIMS (Computer Integrated Manufacturing System). It is a hierarchical and flexible structured system. The first hierarchy, describing general information about the casting, is called the comprehensive code or first stage code and it consists of 15 codes, of which the first 9 digits are fixed codes and the latter 6 digits/characters, which concern process characteristics of castings, are flexible codes. The second hierarchy, called the second stage code, is used to describe the shape characteristics of the casting and its gating system in detail. The main structure and the realisation method used in this casting classification and coding system are also introduced.

Keywords: casting, management, classification and coding systems, CIMS

Introduction

Computer Integrated Manufacturing System (CIMS), one of the directions of development for factory automation (FA), refers to the integrated information processing requirements for the technical and operational tasks of an industrial enterprise[1]. With the aid of CIMS in a foundry factory, a shortened production period, ensured production quality, and reduced production costs could be achieved on a large-scale. This enables casting producers to improve the competitiveness of their products. CIMS is set to be a main module for the foundry industry in the future, even though currently it is more popular in machining manufacturing fields than in casting production[2,3].

The classification and coding system used in the foundry industry is the basis for the implementation of Group Technology (GT) which is based on the similarity theory. One aim of GT is to increase the productivity of varied and small batch products. On the other hand, GT is one key technology of realising an efficient integration for CIMS. In order for GT to develop in the future, it needs to be combined with CIMS, and specifically the classification and coding system in the casting production industry. Furthermore, the casting classification and coding system can join every part of CIMS with a common language. The casting classification and coding system allows databases to be created easily in CIMS, and plays an important role in sharing all kinds of casting information. Therefore, there would appear to be a clear need for a casting classification and coding system for a casting production CIMS[3].

Demand of casting production CIMS for classification and coding system

In recent decades, several countries such as UK, Germany, Japan and USA have researched and developed many kinds of classification and coding systems for application in the foundry industry[4–9]. These systems can be basically classified into two different categories:

The first tailors to the needs of a particular foundry field, such as grey cast iron or zinc die castings[4], in which some important factors, for example casting shape, materials, and the size of the foundry cast products, are involved. Because the coding system is specifically developed for a particular foundry, one of the main disadvantages of this category is that difference in shape and other aspects between foundries specialising in different casting environments are so great. It is very difficult to develop a generalised and comprehensive coding system from the existing code system.

The second category is used in countries such as Germany and Japan, and uses a comprehensive system that serves the whole foundry industry. These systems are usually based on the classification and coding system, and are issued as a national standard. For example, the Japanese S4-T3 system[9] is a comprehensive system resulting from a joint effort of a GT study group formed by representatives from industries, governments and universities. The system used in the Czech Republic and the Slovak Republic is a comprehensive system based on a national coding system for part shapes utilised for castings, forgings, and machine parts. It includes a national three-digit coding system for all basic materials.

It is evident that these systems have played an important role in the introduction of GT to the foundry industry. They also provide a benchmark for other countries to establish a classification and coding system for the foundry industry.

However, with regard to CIMS, the systems mentioned above have the following disadvantages:

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(1) The casting code is artificially generated. Although some users design the codes with the aid of a computer, they only adopt the interchange design method to create the casting code. The code can not be created automatically by Computer Aided Design (CAD), even though it is possible to realise it using an existing CAD system with a 3-D mode.

(2) The existing systems are developed before or during CIMS from concept to reality. Hence, it is very difficult for the system to meet the needs of a rapidly developing CIMS. Computer aided coding may be considered in some systems, but the development of new and high manufacturing technologies, particularly the needs of the CIMS, have not been considered. The integration of all the information in a database of product development, foundry process design, pattern/mould/die/model design, simulation and manufacturing, foundry production and management may also be ignored.

(3) The function of codes in existing classification and coding systems is to replace the shape with digits. This method gets the benefits of GT by the brief description of the casting figure. The information could reflect casting similarities and group casting families. This is enough to organise production and index design of production cell/unit in traditional production processes. That is to say, the role of the code is to help users to identify similarities and to divide castings into groups. The detailed information, which includes such dissimilarity, is completely processed by individuals after being grouped. Obviously, this is not suitable for CIMS, so it is necessary to set up a new classification and coding system suitable for CIMS in the foundry industry.

According to the characteristics of CIMS, the classification and coding system used by the foundry industry should meet the following criteria:

- First of all, a classification and coding system tailored to CIMS can be used to describe the detailed information, including similarities and differences, that can be given in brief or in detail. In these computer literate times, it is not difficult to identify and interpret a code, so GT can still be performed by describing the similarities of the castings, as it did in a traditional production model. Meanwhile, the demands of different joints within CIMS can be satisfied by dissimilarities, which are decided by the particular position of the classification and coding system in CIMS.
- Secondly, the description of the classification and coding system regarding the casting shape should be appropriate to the characteristics of castings. This ensures that the description is compatible with information inputted by both CAPP (Computer Aided Process Procedure) and existing CAD technology or/and feature moulding CAD.
- Thirdly, long and unnecessary codes should be avoided. A system tailored to CIMS is needed to describe detailed information about castings, but the length of codes, decided by the complexity of castings, should be changeable. Nevertheless, every joint within CIMS has different demands for casting information, so the classification and coding system should satisfy the different requirements of special departments within CIMS. Therefore, the structure of the classification and coding system should be flexible and hierarchical.
- Fourthly, the classification and coding system suitable for CIMS should reflect the characteristics of casting production. The main characteristics of the design and manufacturing of a casting pattern, such as casting kinds, shape and machined surface, should be considered. The demands of foundry techniques, such as moulding methods, sand demand, metal melting and treatment and casting cleaning, should also be considered. Meanwhile, the inherent relationship between casting classification and coding system, and parts' classification and coding system should be considered in order to reduce repetitive work.
- Finally, the classification and coding system should satisfy the demands on various levels. For example, the code requirements of engineers, technologists and of those in sales management are different. This needs to be addressed by the system.

General system idea

In order to satisfy the demands of every joint within CIMS and overcome the lack of existing classification and coding systems for casting production, a new classification and coding system is offered. The general structure of the system suits every joint within CIMS, and is flexible and divided into two hierarchies. The first hierarchy, adopted to describe general information of castings, is called the comprehensive code or the first stage code. It consists of 15 digits/characters. The first 11 digits are fixed codes, which means that every casting has at least 11 digits. The last 4 digits/characters are flexible codes, which are related to the process characteristics of castings and the parts in detail, as shown in Table 1.

The second hierarchy, called the second stage codes, is used to describe, in detail, shape characteristics, foundry method and gating systems of castings. It mainly serves the foundry pattern/die/model production and casting process, but can also meet the needs of other processes.

The flexibility of the system means that the length of codes can be changed according to the specifications of particular castings. The length of the codes, from the top to bottom in Table 1, is changeable. The length of flexible codes depends on the technique characteristics of castings. That is to say, the first stage codes of the casting may have a length from 11 (the minimum) to 15 (the maximum) digits/characters. The length of the second stage code is completely decided by a casting's shape and complexity.

The characteristic numbers of flexible codes are also changeable. In some existing systems, the characteristic code is basically represented with a digit or a character. The flexible codes in the new system are described as a string. When a casting has two or more characteristics, its code is a collection of various strings. So the length of the

Table 1 The general structure of casting classification and coding system

Code position			Rotary casting	Non-rotary casting
Fixed Code	Classification*	1	The first shape classification	The first shape classification
		2	The second shape classification	The second shape classification
		3	The third shape classification	The third shape classification
	Dimension	4	The maximum rotary diameter	The maximum length
		5	The ratio of length to diameter	Dimension ratio of L:W:H
		6	Main wall thickness of casting	Main wall thickness of casting
	Materials	7	The main kinds classification	The main kinds classification
		8	The subsidiary classification	The subsidiary classification
	Weight	9	Weight of casting	Weight of casting
	Foundry* technology	10	Foundry method	Foundry method
		11	Gating and rising system	Gating and rising system
Flexible code	Foundry demand	12	Foundry special demand	Foundry special demand
	Technical demand	13	Heat treatment code	Heat treatment code
		14	Other special demand code	Other special demand code
		15	High precision demand code	High precision demand code

* Including second stage code

string is not fixed according to the amounts of characteristics of casting. The first character in each string is used as a separation mark symbol. For example, ''F'' represents foundry special demand, ''R'' classifies heat treatment, ''T'' is a special demand code, and ''G'' represents high precision level. The digit numbers between the symbols are feature codes of the flexible codes. For example, ''2'' represents $HR_C > 50$ in the foundry special demand code, ''4'' represents quench, and ''5'' represents temper in heat treatment code. So the string of flexible code ''F2R45'' means the casting hardness is achieved by quench and temper.

The way to describe this casting code can realise an arbitrary combination of all sorts of information. It overcomes the problems resulting from the methods of complete combination arrangement, optional arrangement method and so on. The puzzle codes – a result of high level characters covering low level characters – are also overcome, so as to avoid multiple meaning of the casting code. Furthermore, the flexibility of the system makes the length of the code differ according to the casting's complexity. This enables users to briefly identify the complexity level of the casting from the code length.

In a factory or company, some departments are production-oriented and others are design-oriented. The hierarchical structure of the system can meet their different demands. If the department does not need detailed information about casting shape, it can be given by the first stage code. If the department needs detailed information, it can be given by the second stage code or by the combination of the first and the second stage code. Furthermore, the flexibility of the casting's code is strengthened.

Several description methods

Classification codes

As mentioned above, the classification of castings is one of the main attributes in identifying similarities. This makes it the most important part in the classification and coding system. Although the traditional chain or tree structure codes can be used to describe the important shape factors of casting, these methods have a lower information capacity and rough shape description. Hence, it is difficult to meet the needs of CIMS.

Two stage codes are adopted in the new classification and coding system to the code casting shape. The first three-position in first stage comprehensive code uses a $10 \times 10 \times 10$ three-dimensional matrix to describe the casting's classification. The second stage code is used to define the sub-category of the casting's actual shape in the first stage codes.

In the first stage code, the first 3 digits represent the casting's classification. The first digit divides the casting's general shape or functions into 10 broad classifications. The second digit divides every board classification into 10 smaller classifications. Thus, the first 2 digits form a 10×10 two-dimensional matrix. The third digit divides each smaller classification into 10 brief figures according to the casting's shape. It should be noted that the figures are not intended to produce a diagram of the castings, but simply a geometric sketch combining the important factors serving for index and technique design. So there are 1000 different shape features to be described in first three positions.

The secondary stage codes

Only the main factors are considered to describe shape in existing classification and coding systems. These do not give exact positions of parts in castings. This shape-code cannot satisfy the requirements of CIMS. The two-stage shape-code (as shown in Fig. 1) is adopted in this system in order to meet the requirements of CIMS, and create a favourable condition for producing codes automatically. It can be inherited directly from a part's classification and coding system because both of them are compatible. This can efficiently reduce the repeat inputting work.

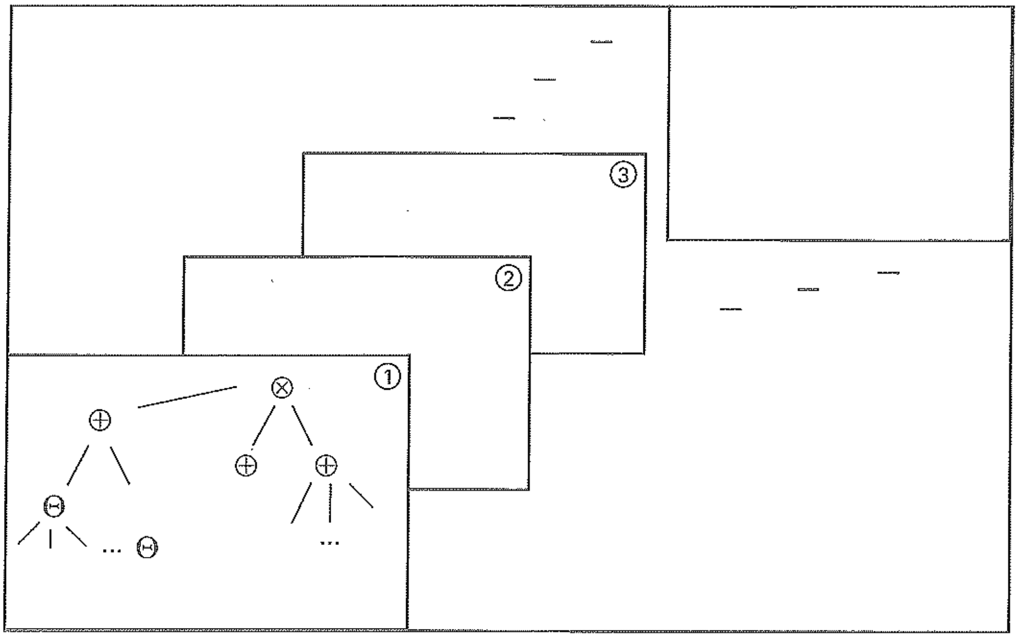

Fig. 1 The structure of the second stage code

The general coding principle of the secondary stage shape-code is the sectional description for rotary castings and positional description for non-rotary castings. The secondary stage shape-code of the gating and rising system for a rotary casting may be as same as that for a non-rotary casting. Sections in a rotary casting consist of main factors and subservient factors. Meanwhile, positions in a non-rotary casting consist of main factors and its subservient factors in every direction in space. This method can describe not only all the shape characteristics of castings, but also the position relationships between the main factors and subservient factors. At the same time, certain rules can be used to shorten the length of the second stage code.

Material codes

The general material classifications, such as carbon steel, alloy steel, grey iron and ductile iron, etc are often symbolised by a digit/character in existing classification and coding systems. This means that the material specification must be abstracted into a general materials classification in order to code materials. But the actual material specification is often used in other CIMS joints. Therefore, it is essential that the general classification can be transferred into the material specification automatically or artificially. These can cut down coding and recognition time. The code can be used directly by the material's supply department and the machining planning department which are related to the material handling. The code can be used effectively in every joint of CIMS.

The new system describes the material actual specification with a two-dimensional matrix. It is completely dependent on the number of materials to be used. The material specification of parts can be directly changed to a casting code while coding. Furthermore, the specification is taken from the codes in the data base from each joint of CIMS without inputting information repetitively. The system can also describe some processing information more exactly and briefly.

Heat treatment codes

The existing casting classification and coding systems give only approximate descriptions of the heat treatment. Some systems describe it just with ''has'' or ''has not'', and some systems ignore it because it is difficult to describe heat treatment in detail with limited codes. The heat treatment for casting production is an auxiliary process. So the heat treatment code in this system is described by a half-tree structure. The structure can be used to give specific details about the heat treatment, such as the heat treatment method and the requirements fulfilled by heat-treatment. The favourite advantage of the half-tree structure code is that it can limit some branches according to the material classification. Other advantages include effectively shortening the code length of heat treatment and showing different heat treatment methods and techniques according to different materials.

Conclusion

The implementation of the comprehensive classification and coding system has many potential benefits for the casting production industry, from designers to users and producers. The primary benefits are derived from the flexibility of a code that can satisfy the different joints within CIMS as used in casting production and related fields. The data structure used in the system is designed for existing widely used technologies and their potential development. Since the new system is harmonious with existing classification and coding systems, including castings and parts systems, a rapid transformation can easily be achieved. In addition, the shape classification code and foundry method code include different stage codes, and can therefore give suitable information for different departments within a system. As the new system covers all kinds of casting technologies, the implementation of the system will improve competitiveness within the foundry industry. It will be a powerful tool in the realisation of foundry factory automation.

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