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Application of workshop production control based on double tray management

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Abstract. The purpose of the paper is to study the workshop management control based on double pallet management. Pipe production is an important part of shipbuilding. By using the improved fuzzy clustering analysis method, the pipe family is constructed. The design of the processing tray is perfect. First of all, the production management flow of tube workshop with double pallets is introduced. Then, the design of the double pallet pipe fittings is carried out. Finally, the fuzzy clustering method makes intelligent division of data, which avoids manual division. The result shows that this method can improve the production efficiency, shorten the processing period and improve the production level of the pipeline workshop. Therefore, it can be concluded that this method can meet the demand of ship manufacturing.

Key words. Double tray, fuzzy cluster analysis, tube shop.

1. Introduction

Pipe production is an important part of ship manufacture. The processing capacity occupies a large proportion in the overall workload of ship construction. The production schedule of the pipe shop will directly affect the production cycle of shipbuilding [1–2]. At present, the research on pipe workshop is becoming more and more popular [3]. Some researchers have studied the classification and fabrication of outfitting pieces in modern shipbuilding modes. Throughout the shipbuilding process, the promotion of group technology and pallet management applications should be taken seriously [4]. Wu Di et al. used the "COM-object" method to extract the underlying data resources of TRIBON, and developed the ship outfitting pallet data management system based on TRIBON database [5]. Through the ship outfitting pallet data mining method based on multi Agent technology, Chen Ning et al. extracted the basic information from the TRIBOB, in order to facilitate the comparison and processing of relevant data [6]. Aiming at the self-made outfitting and outsourcing outfitting in shipbuilding, Deng Shuo designed an algorithm for optimizing the

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pallet allocation scheme. In addition, for the pallet distribution problem, he also proposed an optimization algorithm [7]. Xu Hanchuan and others proposed a tray optimization set management model. Aiming at the problem of multi-route selection in the process of fitting outfitting, an optimization strategy is proposed [8]. It can be seen that many scholars have done a lot of comparative research on workshop operation control management. However, for the characteristics of multi-species small batch of pipe workshop, the research on the workshop production control system is rare. How to make full use of group technology in the modern shipbuilding model for the construction of pipe family? How to give full play to the advantages of tray management model? It is worth further analysis and research to solve the problems of low production efficiency and serious tardiness in the pipe workshop.

2. Materials and methods

2.1. Double tray management mode

The double tray management mode of the ship pipe is the production management mode that combined with the inner processing pallet and the field installation tray [9–10]. Through the use of group technology, the inner processing pallet is the basic unit to achieve the pipe group processing. Outside the field tray as the basic unit, it implements the pipe unit outfitting and segmented outfitting. The double tray management mode of the pipe shop is shown in Fig. 1.

According to the modern shipbuilding mode, the field installation tray divides the ship into different areas, systems and stages. The intermediate product is oriented. The pipe is carried out with unit outfitting and segmented outfitting. Typically, in accordance with the location of the pipe, the order of installation or function, it determines the same area of the pipe combination [11–12]. The corresponding pallet table should include a list of each pipe unit combination, pipe installation drawings and so on. This form has been adopted by the vast majority of shipyards. According to the pipe characteristics and processing technology, the inner processing pallet is the product of making full use of group technology [13]. It is the basic unit of the pipe workshop processing, and is the "field installation tray" sorting set after the pipe family. The corresponding tray table includes the list of the pipe family, the tube and so on [14]. The processing pallet plan is mainly used to determine the order of processing of each pipe family, as well as the start and end time [15].

In the double tray management mode, the cross-regional installation trains with close delivery times are combined into the tray group. According to the similarity of pipe material, shape, working procedure and process, and considering the production equilibrium principle and other comprehensive factors, sorting and clustering are carried out to form the processing tray of the pipe workshop [16–17]. The processing tray is the turnover box of pipe workshop, and it is the basic unit of pipe workshop production management. The allocation of personnel, materials and accessories supporting, the settlement of the work hour quota, the control of the production process is all around it to operate. The workshop in the pipe manufacturing is completed. According to the assembly rules of the pipe, the clusters are sorted

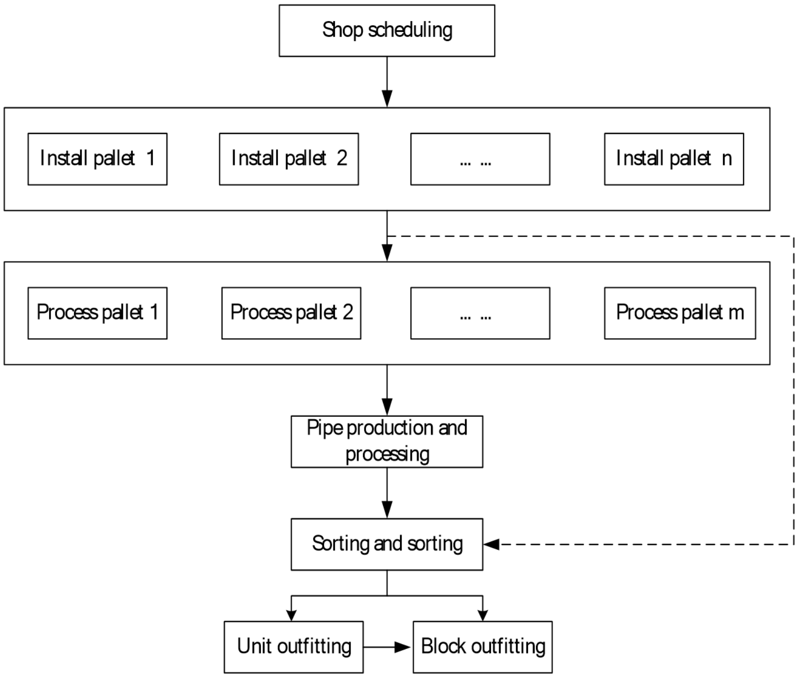

Fig. 1. Management mode of double tray in pipe workshop

again. It is reclassified as a mounting tray, so that subsequent outfitting operations can be carried out efficiently.

The core of the double pallet management mode is the manufacture of the pipe fittings. It takes the processing tray as the basic unit. The unit assembly of the pipe is assembled with the pallet as the basic unit. Its key lies in the processing tray and the installation tray determination, as well as the tray plan accuracy.

2.2. Production management flow of tube workshop controlled by double pallets

This paper will describe the production process of ship pipe workshop based on double pallet management. It provides a further description of the links and logical relationships among key links in the system. The production flow of the pipe workshop controlled by double pallets is shown in Fig. 2.

In order to control the production of ship pipe workshop based on double pallet management, it is necessary to change the production organization form of pipe workshop. In view of the phenomenon that the workshop is received by pallet before the pipe shop is installed, the production organization form of workshop is changed into a double pallet management model with pallet and tray. In the double tray management mode, the cross-regional installation trains with close delivery times are combined into the tray group. According to the similarity of pipe material, size, shape, working procedure and process, the fuzzy clustering algorithm based on part

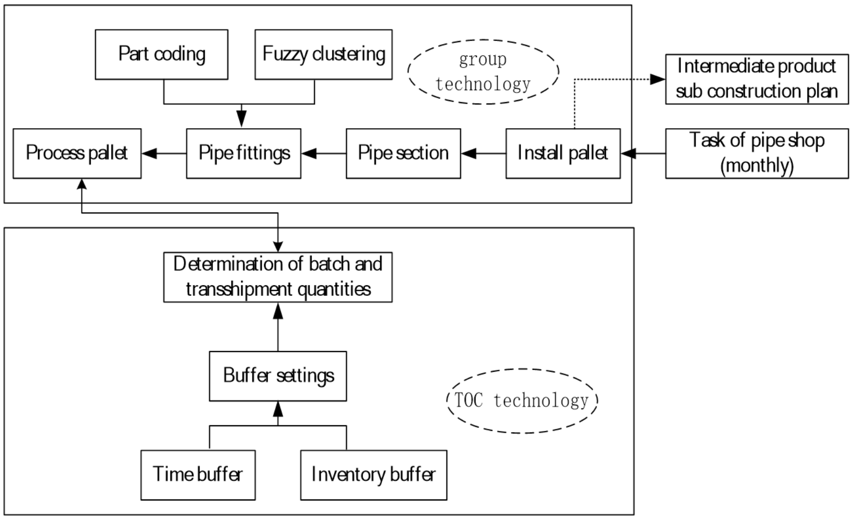

Fig. 2. Production management flow of tube workshop controlled by double pallets

coding is used to sort and cluster and generate pipe fittings. Then, according to batch management, the capacity of the processing tray is determined. According to the regulations, each pipe family is split into a processing tray in the pipe workshop. The processing tray is used as the turnover box of the workshop in the workshop. It is the basic unit of the workshop production management. The determination of processing pallet is the basis of the production control system of ship pipe workshop based on double pallet management.

In the production control of the pipe workshop, this paper mainly uses the TOC (Theory of Constriction) idea and adopts the DBR operation mechanism. According to the principle of DBR mechanism, the primary task is to identify bottleneck resources, which is an important prerequisite to ensure the smooth implementation of DBR mechanism. The identification of the bottleneck can be determined by the capacity of the equipment, the load situation and the number of products in question. Secondly, the production schedule of bottleneck resources is planned, and the processing pallet is the basic dispatching unit. It not only makes full use of group technology, but also facilitates workshop production control. Through the rational formulation of the tray sorting on the bottleneck resources, the operation plan is formulated, thus determining the "drum" of DBR, so as to maximize the role of the bottleneck. Finally, the performance of the whole system is improved. Then, through buffer and batch management, reasonable buffer is set in reasonable place, and the bottleneck resource is maintained high utilization rate without the influence of upstream production fluctuation. In the absence of "hunger" status, reasonable processing batch and transfer batch are set. Thus, the inventory can be kept at a reasonable level while increasing production efficiency.

3. Results

3.1. Fuzzy clustering analysis of parts coding

Set all the parts that need to be classified as: $X = \{x_1, x_2, ..., x_n\}$. Among them, the x_i represents the i-th part in the collection of all parts that need to be classified.

If each part x_i has the attribute m (code bits), then each part's encoding can be represented as $X_i = \{x_{i1}, x_{i2}, ..., x_{ij}, ..., x_{im}\}$ $(i = 1, 2, ..., n;\ j = 1, 2, ..., m;\ m \geq 2)$. Among them, x_{ij} represents the attribute value (code value) of the jth bit attribute object (code bit) of the first i part.

A code bit represents an attribute object of a part. The code value of this bit indicates the information about the property object of the part. The part information is a collection of symbols used to describe a property object (such as a material, shape, etc.) associated with a part. The parts family is divided by using the part properties. First, for part grouping purposes (product design or product manufacturing), part attribute objects are selected. This article is mainly for the parts of the manufacturing process. The attributes mainly include material, size, shape, process characteristics and so on.

To this end, the part group to be classified can be represented by the part coding matrix R_0. Each row of the matrix R_0 represents the attribute value of each attribute of the same part. Each column represents the attribute values of the different parts under the same attribute object.

$$R_0 = [x_{ij}]_{n \times n} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \cdots & \cdots & \cdots & \cdots \\ x_{n1} & x_{n2} & \cdots & x_{nm}. \end{bmatrix}$$

Fuzzy clustering analysis is usually carried out using differential transformation for data standardization. The worst conversion formula is as follows:

$$x_{ij} = \frac{x_{\text{ij}} - x_{\text{min}}}{x_{\text{max}} - x_{\text{min}}}$$

. In the formula, x_{ij} represents the code value of the jth code bit of the part x_i. Symbols $x_{\max}$ and $x_{\min}$ represent the maximum and minimum values of the code values on the same code bit for different parts. Data is normalized to compress the data to the [0,1] interval to reduce the effect of the data dimension on the comparison.

For the similarity matrix construction of part coding, $[r_{ij}]_{n \times n}$ is used to represent the degree of similarity between the ith part and the jth part. The closer the r_{ij} is to 1, the higher the similarity between the two parts. r_{ij} is closer to 0, indicating that the similarity is lower. There are many ways to express r_{ij}. According to the standard Hamming distance method, r_{ij} can be expressed as

$$r_{ij} = 1 - c \sum_{k=1}^{m} |x_{ik} - x_{jk}|\,.$$

Among them, $\frac{1}{c} = \max\left\{\sum_{k=1}^{m} |x_{ik} - x_{jk}|, \forall i \neq j\right\}$, so as to ensure $r_{ij} \in [0\ 1]$.

The fuzzy similarity matrix R has reflexivity and symmetry. However, it usually does not have transitivity, and must be transformed into fuzzy equivalent matrix. Transitive closure is often used. The calculation process is as follows:

$$\begin{array}{l} R \bullet R = R^2 \\ R^2 \bullet R^2 = R^4 \\ R^4 \bullet R^4 = R^8 \\ \ldots\ldots \end{array}$$

When $R^k \bullet R^k = R^{2k} = R^k$ appears, it means that R is transitive. Therefore, the fuzzy similarity matrix $R = R^k = R^{2k}$ is obtained.

The appropriate threshold (also called confidence level) $\lambda \in [0\ 1]$ is selected. The fuzzy equivalent matrix R' is cut. As the threshold changes, the result will change. With the reduction of the threshold, the number of packets will decrease, and the number of parts in the same group will increase, while the similarity between the components will decrease. It can be seen that expanding the number of parts in each part family is at the expense of reducing the similarity of the parts within the family. The threshold must be chosen and adjusted according to the actual requirements, and the real purpose of the group will be achieved by dynamically grouping the parts.

3.2. Design of fittings for double pallets

At present, the operation of the pipe plant organization is based on the installation of the basic unit for the tray. Therefore, the code is installed for the pipe, and it is unique. Figure 3 is the current pipe workshop common parts coding structure. It is mainly composed of five parts: Ship Engineering number, regional subsection number, pallet number, piping system number and pipe fittings number.

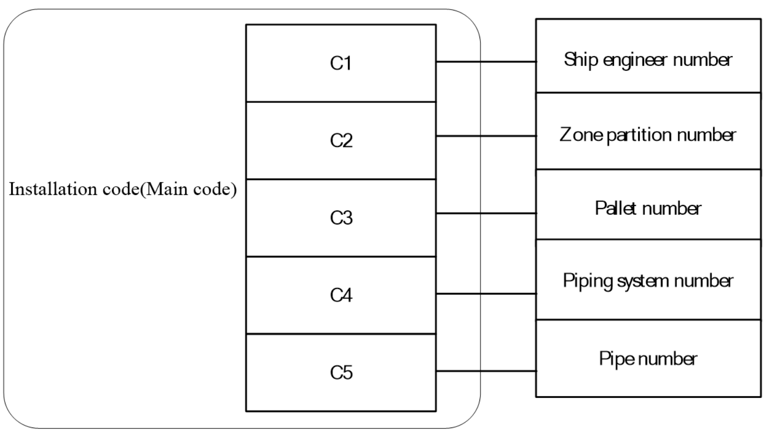

Fig. 3. Tube-oriented structure for the installation

According to the pipe processing status, and considering the processing characteristics of pipe fittings, the attributes of the pipe can be divided into two grades by AHP, as shown in Fig. 4. The application of group technology in pipe workshop is mainly to improve the utilization ratio of material and reduce the switching time of bending process. It should avoid piping backflow due to process differences. It takes full advantage of the professionalism of employees in the process of processing and welding of similar pipe fittings. Therefore, pipe material, pipe specifications, elbow conditions, assembly processing, assembly type and connection type are selected as attribute objects. The effect of group technology on surface treatment processes is not considered here because some pipe shops do not have this process.

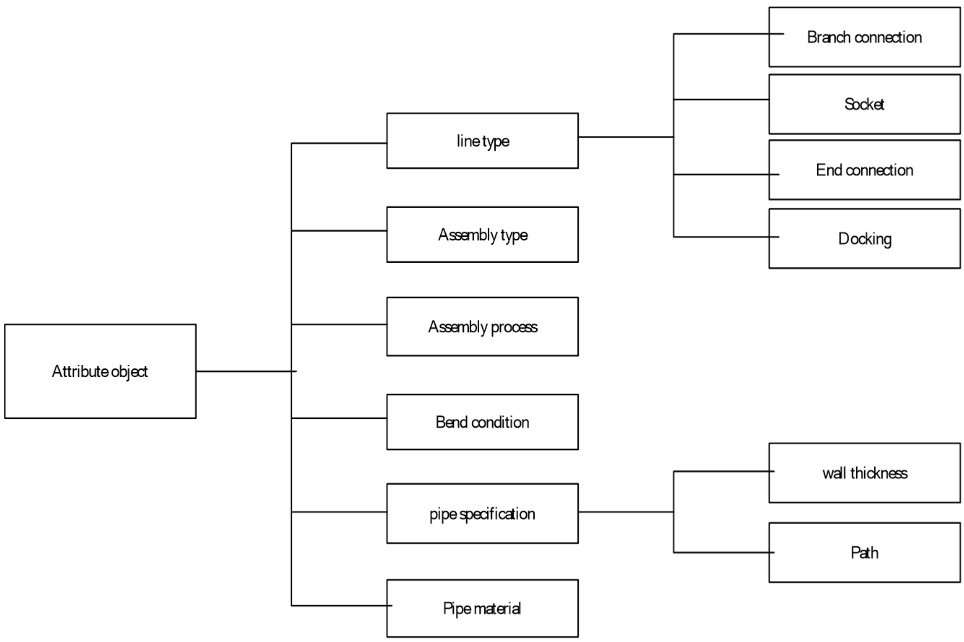

Fig. 4. Design of pipe attribute object for manufacturing

The processing coding structure of the pipe can be determined according to the coding attribute object of the pipe. Combined with double tray management ideas, the pipe can be installed as the main code. The processing codes are used as auxiliary codes, and the combination of the two codes form a new pipe coding structure. Among them, as the main code of the installation code is unique, which is mainly to facilitate the installation of fittings. However, as the auxiliary code, the processing coding is not unique. It is mainly applied to the formation of processing trays, easy to pipe processing, in order to achieve group technology in the pipe workshop applications. When building a pipe and processing pallet for a machining process, it only requires fuzzy clustering analysis of the machining code. The tube coding structure based on double tray management is shown in Fig. 5.

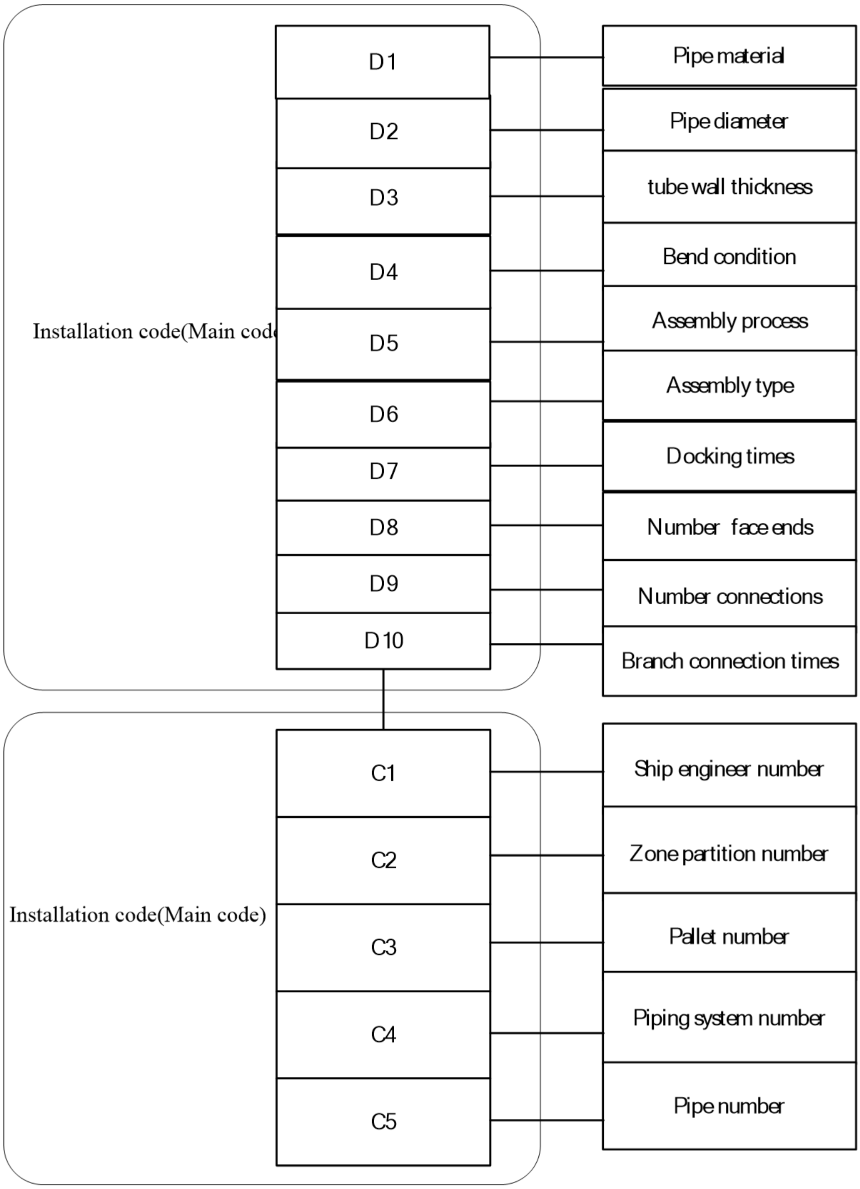

Fig. 5. Pipe coding structure based on double pallet management

4. Conclusion

The shipbuilding industry of our country has been developing rapidly for several decades. Shipbuilding output continues to grow, and the market share in the world continues to expand. In 2013, China's shipbuilding capacity has been ranked first in the world. At the same time, the international competition of shipping enterprises is more and more fierce. In order to meet the market demand, ship enterprises have been carrying out technical and management reforms. The vessel production is an important part of ship manufacture. Its processing capacity occupies a large proportion in the overall workload of shipbuilding. The production schedule of the pipe shop will directly affect the production cycle of shipbuilding. At present, the tray management of the vessel pipe workshop is not perfect. The production efficiency is low and the processing cycle is long. These problems affect the overall progress and economic benefits of ship enterprises. In this paper, a double pallet management model for pipe workshop is introduced. A pipe coding system based on double pallet management is designed. By using improved fuzzy clustering analysis based on coding, the pipe family is constructed. Finally, the design of processing trays has been improved.

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