Decentralized and Integrated Management of Multi-variety and Small-Batch in WIP

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Abstract. In order to reduce the floor area of WIP (Work in Process) of Multi-variety and Small-Batch and improve the management and transportation efficiency, the WIP should be piled and scattered according to categories and stored with wheeled pallets as per the production process. FRID technology to identify the electrical labels should be applied to track the storage and location of the wheeled pallets in real time. In doing so, the quantity of WIP stored in the same floor area would increase several times, the speed of materials delivery goes up due to the wheeled pallets working as movable mini-warehouses, and the logistics volume in the workshop goes down. Standardizing the management of the in-process products in the workshop is helpful not only for ensuring the precision of products quantity and intactness of products, but also monitoring dynamically the flow of in-process productions in light of such information as categories, quantity and status of products, so as to provide accurate and real-time basis for the decision making of the production management department.

Introduction

In order to meet the diverse needs of customers, Multi-variety and Small-Batch production is becoming more and more mature. A large number of scholars from domestic and abroad have done a lot of research on Multi-variety and Small-Batch production, but the research on WIP are mainly concentrated in WIP inventory level control, WIP tracking management and WIP planning and scheduling, etc. For example, Zhang Jie proposed a mathematical model of in-process WIP inventory, and the management scheduling algorithm of WIP inventory is established to control inventory[1]. With the division and definition of state, Yu Xiaoyi put forward shop-discrete manufacturing enterprise tracking management method [2]. YH Lin raised the level of WIP by artificial neural network model which can be used to predict wafer production process[3]. Barzoki M R, Jahanbazi M, Bijari M attempts to analyze the impact of incomplete products on mass production in WIP inventory by economic production batch analysis[4]. Bai S X, Gershwin S B through the relationship between system capacity and starvation or blockage found the ideal buffer level and buffer size, they also made a reasonable allocation of WIP to minimizing inventory levels[5]. According to the above findings about WIP in the actual production process of storage, there is no deep study in management.

According to the statistics of WIP production workshop directly dispersed heap lag buffer cache space online side, accounted for the entire workshop 30%-40%, due to the large number of products in the same area, it is easy to appear a phenomenon that products have been accumulated, damaged, lose and not easy to extracted. In order to improve this state, improve production efficiency, this paper attempts to state the dispersion accumulation using an integrated management way to reduce the area to improve extraction efficiency of transportation.
Classification Management of Multi-variety and Small-Batch of WIP

Production in Process

Any parts, products are bound to experience the process from input to output. From the first step into the production of raw materials, finished goods until the final formation of all production material before the production process has not been completed, including production of manufactured products or parts, all belong to the category of products in the production process. In WIP is constantly flowing and changing, between the various production processes in the number of species, often change, directly affect the production efficiency of the enterprise.

Many varieties of small batch production with small production scale, product variety, complex structure, temporal constraints and complete sets of parts between the strict requirement, general equipment in the production process of a high proportion of irregular turns to produce other products, product logistics, information flow characteristics of complex, long production cycle, resulting in the amount of WIP in general, class, management difficulty is big.

WIP Classification

Between the products in each process flow is not continuous, that is to say the production process between WIP transfer is carried out in phases. when each process is in a state of work process between WIP transfer, while the production after the end of the work, the process will be unified processing products of the period to the next process to continue processing WIP, after the completion of transfer immediately into the next phase of production, and so on.

Complex product workshop WIP is divided into five categories: the complete lack of supporting assembly components WIP, inventory and WIP semi-finished parts, assembly parts semi-finished products. The state of all kinds of work in work includes: the state of a process, the state of waiting for a process, the state of the process to be processed, the state of scrapping the process, the state of inventory, the state of missing parts, the state of being disassembled, the state of being discarded and the state of missing parts is divided and discarded. But according to the statistics in the scrap preparation time and processing time and production cycle often accounted for only 5%-10%, more than 90% of the time is spent in the queue, waiting and transportation, so this paper is aimed at the research process in the wait state of WIP [6].

Dispersion of WIP

Many varieties and small batch production process is complicated. It takes many processes to complete the final product installation. But as a material distribution system, lean feeding system requirements of every production procedure specified in the specified time when the product model. Therefore, there is an appropriate amount of WIP inventory in the caching area of the line. Storage and general production workshop will be placed directly on the ground or in the pallet on waiting for the next working procedure is not suitable for many varieties of small batch production, not only increase the logistics volume but also increased the extraction time in transportation. In order to change the current situation to improve the efficiency of work in product management, the idea of dispersing the stagnation of WIP is put forward.

The so-called heap lag is dispersed in the dispersion type storage space in the storage process instead of the traditional process. The buffer set up in each process if the limited space you can set up a buffer in several processes between the products according to production batch processing, classification, stacked on shelves or pallet order to set aside, the corresponding passage for the operator or import forklift, can realize the material. The material import arbitrary delivery staff to control WIP inventory distribution through Kanban, upstream downstream process production process only needs.

In the study of buffer inventory management, to production system model is simplified. Some assumption of normal production, now the main analysis in between the various processes, the assumption that the batch production is equal to Mk process from raw materials to finished products need to go through the process of less than or, a storage buffer in WIP next to each procedure, the production system has a \( N_j \) buffer, the \( j=k-1 \) as shown in figure.
Integration Management

Wheeled Pallet Library Reference

In order to improve the management efficiency of WIP, the characteristics of the close connection between the working process and the manufacturing process are required from the logistics point of view. The main functions of this device are not only for storage, but also for faster and more efficient flow of materials. Therefore, the new wheeled pallet storehouse can meet the requirements of this device. The wheel tray library is modified by the pulley and tray, and its effect is similar to a small mobile shelf or a small mobile warehouse.

The design and selection of WIP storage equipment should be based on product characteristics such as shape, size, quality, storage methods tailored to the rational use of space, make full use of the gravity principle, all WIP are not allowed to touch the ground, must according to the production process of complete sets on the tray base or according to production process classification on the tray base. A pallet can be folded and placed in a certain amount of WIP, instead of only one by one way. This tile storage tray can support library containers and overall handling system operation, to deposit and withdraw the reserved channel convenience goods, and meet the FIFO principle, improve the access efficiency. It is worth noting that this kind of transport device the integrated management is set according to the internal structure of shape characteristics required storage material is not fixed.

Use round pallet magazine classification storage of scattered pile lag WIP, WIP should follow the following principles in the dynamic allocation of Library tray:

1. the same principle, the same products stored in a tray, reduce WIP access, handling time, effectively improve the work efficiency. WIP
2. the correlation principle, the production workshop of Multi-variety and Small-Batch products should be based on the close contact between the degree of storage, for the same process WIP, complete with the products can be stored in a library to find the tray, and shorten the operation frequency of pickup.

The state of work in process, assuming that the production state data model is defined as:

\[ B = \sum_{p=1}^{Z} \sum_{q=1}^{J} B_{pq} \]  \hfill (1)

\[ B_{pq} = \{ A_{mq} / m \in (1,2,3,\ldots,M); j \in (1,2,3,\ldots,J) \} \]  \hfill (2)

Type (1) in B that Z buffer tray. The sum of all (2) B_{pq} P storage buffer Q tray in the library work set, wherein A_{mq} represents the M batches of the product J of the product.

RFID Electronic Tags and Positioning Technology Reference

Because of the characteristics of the wheeled tray storage, you can take it as a small mobile warehouse to use, can alleviate the buffer area problems, in order to facilitate the control of each buffer tray and WIP information, you can set a RFID tag on each pallet, and storage information on the tray base, such as in number, amount of WIP, batch, processing information into the tag[7].

Through the RFID technology, the system can real-time positioning in position tracking process flow in the whole supply chain, can achieve the scientific and automatic inventory management,
implementation of WIP distribution operations quickly and accurately, improve the efficiency of WIP management, management system will also change. The logistics management information system RFID positioning system can realize the logistics distribution in the foundation of logistics information accurate on the fast and flexible response based on.

**Integrated Management Modeling**

Although the lag is scattered pile of WIP buffer in the process of piling up be arranged, if more procedures and buffer number will also increase, and if there is not a reasonable planning lag in reactor, storage, transportation, distribution efficiency is limited. Thus the integrated management mode is proposed for this situation. Integrated management is the introduction of new wheeled pallet storehouse into workshop logistics and the use of dual frequency RFID electronic location tags to track in real time, locate and transmit information of products in pallet library, so as to form a subsystem of material management.

**Construction of Model**

In order to improve the efficiency of WIP management of FS company, the production process of the buffer storage logistics total WIP minimum as the optimization objective; if the buffer in frequency of storage, the products in the production transportation distance as the observed variables, can establish a mathematical model for research and analysis.

If the total logistics is set to run in the WIP in production logistics distance and buffer access frequency of WIP product, you need to define the frequency of storage F and WIP in the cache to the production line from the L variable. Two wheeled pallet transport distance L can be a buffer between the distance or is obtained by RFID positioning technology. The transportation frequency F is obtained by Kanban management or according to the storage capacity of the pallet bank.

Object function:

$$S = \min \sum_{p=1}^{Z} \sum_{q=1}^{l} B_{pq} \times L_{p,q} + \sum_{q=1}^{l} F_{q}$$  \hspace{1cm} (3)$$

Constraint condition:

$$\begin{cases} 
\sum_{q=1}^{l} B_{pq} = 1 \\
B_{pq} = 1 \forall 0, \ p = 1,2,3……Z; q = 1,2,3……l
\end{cases}$$ \hspace{1cm} (4)$$

Type (3) in S for logistics minimize the amount of work, L is the shortest comprehensive distance from P to p 1 caching area, The transport frequency of F for the wheeled tray library q. The first constraint in type (4) indicates that a tray library can only appear in a cache area, the second constraint indicates whether the Q wheeled tray library for transporting the P cache is selected. Bpq is 1 or 0. for the state variable assumed in this article[9].

**Implementation and Result of Model Algorithm**

Through the LINGO software we can find out the optimal solution of the model. The simulation of FS axle shop management issues with this method of integrated management, reduce the cache area at the same time, not only to achieve the real-time tracking of goods, improve the WIP management efficiency, but also reduces the amount of workshop logistics.

**Conclusion**

Standardizing the management of the in-process products in the workshop is helpful not only for ensuring the precision of products quantity and intactness of products, but also monitoring dynamically the flow of in-process productions in light of such information as categories, quantity and status of products, so as to provide accurate and real-time basis for the decision making of the
production management department. In this paper, the scattered pile of lag and put forward a kind of integrated management mode with wheeled transport units and pallet electronic label positioning technology of Multi-variety and Small-Batch products, reduce WIP area, in improving the WIP management efficiency, reduce the amount of workshop logistics.

The deficiency is based on the Multi-variety and Small-Batch by WIP wheeled tray library management mode, without considering the efficiency of artificial storage, without considering the cost of the artificial storage mode, just consider the efficiency of extraction and transportation. In the case of the object flow, the transport distance of the wheel pallet Library which are not in the buffer area is not accurate enough. In the next study, we will study these deficiencies.

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