Production Management and Optimization in Injection Molding Companies Based on MES

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Keywords: Manufacturing Execution System (MES), Injection molding company, Production management.

Abstract. Based on the analysis of the characteristics and production management problems of injection molding companies, discussing the possibility of Manufacturing Execution System (MES)’s application in injection molding companies’ production management and designing the ways to build fundamental functions of MES. This paper respectively presents production management ways based on MES in production preparation, trial production, official production and packaging. This paper also introduces several methods to deal with the data which MES collects, in order to bring more economic benefits to the company.

Introduction

Now, ERP/PPS and automation technologies have been widely used in manufacturing enterprises. ERP/PPS focuses on improving the utilization ratio of enterprise resources, improving the work efficiency of the finance department. Automation technology focuses on replacing repetitive, high-load labor with high risk work, improving the quality of products and production efficiency. But these two methods can't make a decision on the production status in real time, resulting in company’s inability to respond to market changes in a timely manner.

The MES is between ERP/PPS and workshop execution layer. MES is not only a system to collect data, but also the system of production scheduling and execution. All relevant orders, equipment, tools, raw materials, the real-time information of human resources are collected and fed back to related applications, so the abnormal production situation can be corrected timely, from this point, the emergence of MES system truly make production management attainable. This paper takes injection molding enterprises as an example and puts forward a production management improvement scheme based on MES system.

Characteristics of Injection Molding Enterprises and Problems in Production Management

Injection molding is a typical discrete production process, molding enterprise is highly standardized, has variety of injection products, produce in large batches \cite{1}. MES can be used in injection molding enterprises because of high degree of automated production. Injection molding enterprises will encounter many problems without MES. 1. Firstly, there are many reasons for the poor quality of injection products, even if know the manifestation of defective products, to find out real reason is like looking for a needle in a haystack. 2. There is no accurate record of service life of a mould, resulting in the maintenance is done passively. 3. Unable to trace the product due to the lack of relevant records. 4. There is possibility of employees using the wrong raw materials. 5. Unable to obtain accurate production data, the management doesn’t know the true cost of the product, which results in failure to price the product scientifically. The above problems can be solved by introducing MES in production management.
Production Model Establishment

In order to increase the flexibility of enterprises and improve the utilization ratio of injection molding machines, some enterprises have separated the production of injection molding and packaging process, supplying the same products to different customers and using different packing ways for different customers. To reduce packaging material inventory, enterprises only pack products before delivery to customers. WIP flows in turnover boxes between different departments. Production model as shown in the figure below:

![Production Model](image)

Figure 1. Production model of injection molding enterprise.

Construction of the Basic Function of MES

MES plays a role of bridge which connects planning layer and workshop layer in the enterprise. The basis of this effect is data transmission between MES and other levels. The data transmission of MES in the injection molding enterprise is introduced in the following content.

Docking with ERP/PPS System

The main purpose of the connection between MES and ERP/PPS is to accept work orders and technological parameters. The ERP/PPS system converts the data to an XML format, then data exchange with MES via a WEB SERVICE [2] or MSMQ.

Docking with Workshop Control Layer

In the injection molding enterprise, the data collection mode of production process includes automatic collection mode and manual input mode [3].

Automatic collection mode. Include barcode, RFID technology and OPC. Barcode uses optical signal to read information, cost of bar code label and acquisition equipment is low. RFID technology uses radio frequency technology. An RFID reader can recognize multiple RFID tags simultaneously. RFID tags and RFID identifiers are relatively expensive [4]. There are a lot of pollution sources in the production workshop, especially the injection molding machine and the mold will be sticky with oil, which needed to be cleaned regularly. So the mold and injection molding machine should be equipped with RFID. The standard turnover box should also be equipped with RFID in order to achieve fast loading operation. OPC [5] is a kind of specification, uses OPC SERVER as a protocol conversion layer, connects OPC SERVER with injection molding machine and other PLCs in the robots, then OPC SERVER reads data into XML data format and input data into MES through MSMQ, in the meantime OPC CLIENT is available for automation layer’s real-time monitoring and history analyzing.

Manual input method. In the view of economy and feasibility, the method of manually inputting is an indispensable way to collect data for MES system. For data that cannot be collected automatically, data collection can be carried out manually by employees. Some collection methods are shown in the following table 1.
Table 1. Data collection object and collection method classification table.

<table>
<thead>
<tr>
<th>Data collection object</th>
<th>Acquisition method</th>
</tr>
</thead>
<tbody>
<tr>
<td>The production quantity</td>
<td>collects the pulse signal</td>
</tr>
<tr>
<td>The number of defective</td>
<td>products is manually recorded or OPC</td>
</tr>
<tr>
<td>Raw material number</td>
<td>barcode</td>
</tr>
<tr>
<td>The mould number</td>
<td>RFID</td>
</tr>
<tr>
<td>Injection molding machine</td>
<td>RFID</td>
</tr>
<tr>
<td>Production list, invoice</td>
<td>barcode</td>
</tr>
</tbody>
</table>

Implementation of Production Management Based on MES

By optimizing the production process, the data transmission and logic processing of MES are integrated into the production process. According to the production model, the production process can be divided into preparation, trial production, production and packaging.

Preparation Work & Trial Production

Preparation work and trial production are necessary steps for injection molding. With the help of MES, production preparation becomes fast and accurate, which can improve the overall production efficiency of the enterprise, reduce unnecessary waste. Its specific process is shown in figure 2 below:

![Preparation and production flow chart.](image)

Figure 2. Preparation and production flow chart.
Formal Production

The application of MES in the formal production process can make the workshop produce paperlessly and improve the efficiency of information transmission through electronic information transfer. Through the MES real time production information collection and feedback, production managers can clearly know the amount of WIP, product quality, production efficiency. The formal production process based on MES is shown in figure 3.

Packaging Operation

The packaging needs to consider different requirements of different customers for product packaging. A production list often contains multiple shipments. MES needs to associate the finished product label corresponding to the shipping task with the semi-finished products’ barcodes in the production task list in the database for the product traceability. The flow is shown in figure 4 when the capacity of the turnover box is greater than the capacity of finished box.

![Figure 3. Formal production flow chart.](image-url)
Operator

START

Use PDA to scan shipment code

Follow MES tips to find package material, scan RFID and package barcodes on the turnover boxes

PDA uploads shipment number to MES and executes the query request

MES transmits packing requirements and finished taormat to PDA according to order number

Print label according to the requirement and stick it to the packing box

Associate the semi-finished products and finished products in database

Abnormal call

END

Figure 4. Packaging operation flow chart.

Abnormal Call

MES abnormal call function improves the speed of response to accidents, reduces the failure recovery time, ensure the normal operation of production. [7] If anomalies occur, operator can make different abnormal calls in MES for different anomalies. When the operator chooses an abnormal call, MES will notify the responsible person to handle the anomalies and record the downtime. MES abnormal calls can be classified, as shown in table 2:

Table 2. Abnormal call classification table.

<table>
<thead>
<tr>
<th>Abnormal call</th>
<th>application status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality call</td>
<td>when quality problems occur frequently</td>
</tr>
<tr>
<td>Material call</td>
<td>when material problems occur</td>
</tr>
<tr>
<td>Reset call</td>
<td>when the injection molding machine fails</td>
</tr>
<tr>
<td>Mould call</td>
<td>when injection molding machine tool problems</td>
</tr>
</tbody>
</table>

Die Life and State Control

When the mold is maintained, the operator needs to scan the mold's RFID and record the operation. When the operator finishes a maintenance of the mold, the MES system will update its maintenance life. MES will notify the relevant staff when maintenance life or service life of the mold reaches the warning limit. When the maintenance life or service life of the mold is 0, the MES system will lock the mold, and all the relative work cannot be carried out to prevent production accidents.

MES Information Processing

Key Performance Indicators (KPI)

Injection molding companies often reduce the number of injection molding machines, reduce the time of die change, optimize the number of the mold to get more liquidity, improve the efficiency of its economy, this led to OEE becomes the injection molding companies’ most important KPI. Due to MES’s data collection, OEE can be calculated easily. The traditional OEE calculation model is
limited by the inaccuracy of the production schedule caused by the incomplete data acquisition function in the past, and the planned downtime of the equipment is not considered. Now, with the help of MES, a more complete OEE calculation method can be adopted to achieve the performance evaluation of the whole production management including production planners. The formula is:

\[ OEE = E \times A \times PR \times Q \]  
(1)

E, A, PR, and Q are shown in figure 5. Using the data which MES has collected, OEE index was obtained. OEE can provide real-time feedback to all production related personnel through the workshop LED screen, so that they can timely discover and correct problems in production.

![Figure 5. OEE calculation diagram.](image)

**Activity Based Costing (ABC)**

In the past, manufacturing enterprises in our country used traditional cost accounting system, namely, manufacturing cost method. Advances in technology have led to a decline in capital intensive and direct labor hours. If still adopt the manufacturing cost calculation method, it will lead to cost information distortion, cannot help management evaluate the results of production activities. The method of ABC based on MES system is designed:

The first step is to determine the cost drivers. For different operation cost bases, the corresponding cost drivers are different. By analyzing the production status of injection molding enterprises, the cost drivers table is obtained, as shown in the following table:

<table>
<thead>
<tr>
<th>Job content</th>
<th>cost drivers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw material handling, injection molding, packaging</td>
<td>machine working hours</td>
</tr>
<tr>
<td>Quality inspection, equipment and tool</td>
<td>operation frequency</td>
</tr>
<tr>
<td>Carrying</td>
<td>strength</td>
</tr>
</tbody>
</table>

The second step is to combine the production data collected by MES and use ABC to carry out the cost accounting and obtain the direct labor, direct materials and manufacturing expenses based on the production task order.

Through the above process, the cost of product can be obtained and the management can make the decision, which can also be used as the basis for measuring the production management level.

**Product Traceability**

It is very important for injection molding enterprises in automobile manufacturing and medical supplies industry to attain product traceability. Based on the designed production process above, the product traceability system can be integrated into MES by scanning the labels. When enterprise need to track back some products, workers can scan finished product labels, then MES will output the corresponding production task list, inspection plan, operators, production time, mold information. When product quality problems occur, they can be quickly identified by MES trace back function.
Conclusion

Production management based on MES system can effectively regulate the behavior of employees and production process, improve production efficiency, in the meantime, by reviewing production management KPI, gradually perfect the enterprise internal management. With the improvement of technology, the semi-automatic and manual process in injection molding enterprises will be less and less, and the development of MES system will be more and more important. In the near future, the MES system will be bound to bring a new change in the injection molding industry.

Reference