An Integrated Energy-saving Scheduling Framework Based on IoT

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Abstract. With the increasing demand for personalized and the accelerating pace of market competition, the production mode of manufacturing enterprises has changed from large quantities and single varieties to multiple varieties and small quantities, from push production to order-oriented pull production. With the increase of product types, the production management process of processing-assembly enterprises becomes more complex, and unreasonable production management will lead to frequent production process problems. This paper analyses and summarizes the traditional Just-in-time production (JIT) management architecture for processing-assembly enterprises, and proposes an energy-saving integrated scheduling system framework based on IoT technology, and analyses the key technologies under the integrated scheduling framework.

Keywords: Just-in-time, Internet of Things, Energy conservation, Workshop scheduling.

1. Introduction
Just-in-time production (JIT) has been paid much attention by enterprises since it was presented. JIT requires manufacturing enterprises to produce parts or products on demand and in quantity when there is demand, thereby reducing the inventory cost in the whole production process, reducing the waste in the production process and improving the production efficiency of enterprises [1].

In order-oriented processing-assembly enterprises, from order to start production, and then to the final product assembly molding, the whole process needs to be managed and controlled by production management to ensure the timely completion of the product. After analyzing the production process of the processing-assembly enterprise, the production process of the order-oriented processing-assembly enterprise is determined as follows:

Step 1: Order receiving. According to the order requirements and enterprise existing production capacity and equipment and raw material resources, determine whether to accept the order, if accepted, under the production department to confirm;

Step 2: The order is entered. After receiving the order, it is entered into the enterprise management information system, which is stored in the database for further query processing.
Step 3: Determine the production products and quantity. Compare the inventory of finished products in the production management system, and determine which products and quantity to produce next;

Step 4: Determine the production plan for parts and finished products, and decompose the total production plan in the production management system according to the product BOM structure, and determine the purchasing plan, parts and finished product production plan;

Step 5: Break down production plan. Production management system will split the task to get daily production plan;

Step 6: Determine the process route. According to the available equipment machine and the process characteristics of parts to determine the product feasible process route;

Step 7: Determine the scheduling scheme. After determining the product process route, according to the scheduling goal priority principle, the actual scheduling scheme is determined;

Step 8: The production of parts and assembly molding. According to the scheduling scheme to produce the required parts, ensure the quality of parts in the production process, finish machining in assembly shop after finishing machining parts;

Step 9: Monitor the production process. Ensure the smooth completion of production, and ensure that orders can be delivered in time.

2. Establishment of Energy-saving Integrated Scheduling Framework based on IoT

In the traditional production management, the three links of process planning, product design and assembly are carried out independently, but they interact with each other. If the coordination is not appropriate, it will lead to low production efficiency and increase in inventory costs. Therefore, in the current situation of energy shortage, this paper proposes an energy-saving integrated scheduling system based on the newly developed IoT technology.

2.1. Related Theoretical Basis of IoT Technology

The Internet of Things technology integrates technologies in the three major fields of electronics, communications, and computers, and realizes the connection of everything on the basis of the Internet. Technically, the entire Internet of Things architecture is divided into three layers, perception layer, network layer and application layer [2], as shown in Figure 1. The following is a brief introduction to these three layers.

![Figure 1. Three-layer architecture of the Internet of Things](image)

Perception layer responsible for information collection and information transmission between objects. Information collection technologies include sensors, bar codes and two-dimensional codes,
RFID radio frequency technology, audio and video and other multimedia information. Information transmission includes sensor networks such as remote and near-distance data transmission technology, self-organizing network technology, collaborative information processing technology, and information acquisition middleware technology. The perception layer is the core ability to realize the comprehensive perception of the Internet of Things. It is a part that needs to be broken through in the Internet of Things including key technologies, standardization and industrialization. The key is to have more accurate and comprehensive perception ability, and to solve the problems of low power consumption, miniaturization and low cost.

Network layer is the use of wireless and wired network to encode, authenticate and transmit the collected data. Widely-covered mobile communication network is the infrastructure to achieve the Internet of Things. It is the highest degree of standardization, the strongest industrialization ability and the most mature part of the three layers of the Internet of Things. The key is to optimize and improve the application characteristics of the Internet of Things to form a collaborative sensing network.

Application layer, providing rich applications based on the Internet of Things, is the fundamental goal of the development of the Internet of Things, combining the Internet of Things technology with the needs of industry informatization, and realizing the solution set of extensive and intelligent applications, the key lies in industry integration, the development and utilization of information resources, low-cost and high-quality solutions, the protection of information security and the development of effective business models.

2.2. Energy-saving Integrated Scheduling System Based on IoT

Based on the Internet of Things technology, an energy-saving integrated scheduling system is shown in Figure 2.

![Figure 2](image-url)
The integrated scheduling system consists of five layers, namely, order layer, planning layer, execution layer, data decision-making layer and data perception layer.

Order level: used for order processing. The manufacturing company evaluates its own production capacity and judges whether it can accept the order according to the requirements of the order. If accepted, the order is decomposed, and the production tasks and purchases are determined according to the raw material inventory and product inventory. Task. After the product is assembled and passed the debugging, deliver the order to the customer in time.

Planning layer: According to the characteristics of available equipment and workpieces, the planning arrangement is completed after the order is decomposed. When arranging the plan, the data obtained from the data decision-making layer are considered, and the process planning, production and assembly are integrated together, considering the mutual influence, unified scheduling, improving production efficiency and reducing costs. Such as integrating process planning with production, reasonably arranging process routes according to equipment status and processing tasks, integrating production and assembly scheduling, increasing the parallelism of production and assembly, and reducing the waiting time of parts. At the same time, when integrated scheduling, energy consumption is considered in the optimization target to achieve the goal of energy saving.

Execution level: After the plan is completed at the planning level, the processing and assembly of the product are completed according to the process route and scheduling plan. After the product is processed, the product is debugged, and after the acceptance is passed, it will be delivered to the customer in time according to the order.

Data decision-making layer: After receiving the data feedback from the data perception layer, according to the data analysis, it can be determined in a timely manner whether the processing environment is normal (such as whether the equipment is available, whether it needs maintenance, etc.), whether there are abnormal situations (such as whether there is an urgent order or Cancellation of orders occurred), whether the processing quality is normal, and if there are any abnormalities, timely feedback to the planning and execution layers to ensure the timeliness of the data;

Data perception layer: Real-time acquisition of required parameters through sensing equipment, and timely feedback to the data decision-making layer after the data is obtained to ensure the timeliness and effectiveness of the data.

In the framework of integrated scheduling system, it can be seen that the three links of process planning, production and assembly are integrated and unified scheduling. At the same time, the data perception layer and data decision-making layer provide data support for the planning layer to ensure the real-time and authenticity of data. In the integrated scheduling system, the processing-assembly enterprises obtain the real-time processing environment of the workshop in time according to the data obtained from the data decision-making layer from the data perception layer, and make corresponding plans according to the real-time processing environment, so as to reduce the occurrence of accidents in the production process and reduce the production costs such as enterprise energy consumption.

3. Key Technologies to Realize the Energy-saving Scheduling
In the integrated scheduling system, seemingly simple frame diagram involves many key technologies, which are analyzed below.

3.1. Data Acquisition Techniques
In the data perception layer, timely and accurate data acquisition is the key link of the Internet of Things technology. At present, the data acquisition technologies are sensors, bar codes, two-dimensional codes and RFID radio frequency technology. With the progress of technology, sensors with low price and good performance have become the key components of data acquisition, but the accurate and rapid acquisition of real-time data also puts forward higher requirements for sensors.
3.2. Data Decision-making Technology
Data decision-making technology, that is, data processing aggregation technology. After the data are collected in the data perception layer, the data are processed by the data decision-making layer to aggregate into effective event information for subsequent processing. Data decision-making technology is the key to whether the collected data can really be put into use. With the increase of data volume, the technical requirements of data decision-making technology will also increase.

3.3. Process Planning and Production Integrated Scheduling Model
Process planning and production integrated scheduling is to select the appropriate production route according to the resources in the production environment, considering that there are many process routes in the processing of parts. After determining the optimization objectives, considering the electricity price factors, the integrated scheduling model of process planning and production is established to determine the process route, processing sequence and starting time of parts selection.

3.4. Integrated Scheduling Model for Machining and Assembly
The integrated scheduling of processing and assembly is a mixed-flow production line composed of a processing line and an assembly line, which needs to complete the processing task of the required parts before completing the assembly of the product. In order to reduce the delay time in the production and assembly process, considering the parallelism of processing and assembly and the electricity price factor, an integrated scheduling model is established after determining its optimization objective to determine the starting time and processing sequence of parts and assembly processes.

3.5. Scheduling Algorithm
After the establishment of the scheduling model, it is necessary to use intelligent algorithms to solve the model. At present, there are many algorithms for solving the scheduling problem, such as genetic algorithm [3, 4], particle swarm algorithm [5], migratory bird optimization algorithm [6] and firefly algorithm [7]. However, according to the different models and problems, the algorithm needs to adjust some of its links to achieve the purpose of quickly solving the model.

4. Conclusions
The development of IoT technology makes the workshop intelligent, and the availability and timeliness of data make the scheduling process data transparent. This paper analyzes the traditional production management process for processing-assembly enterprises. Due to the characteristics that integrated scheduling can improve production efficiency, combined with the federation of things technology, this paper puts forward the framework of energy-saving integrated scheduling system based on federation of things, and analyzes the key technologies involved in workshop integrated scheduling.

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