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Research on Visualization Technology of Production Process for Mechanical Manufacturing Workshop

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Abstract: The visualization of workshop information can affect production management and efficiency. Information can be presented both graphically and non-graphically (for example, in the form of data lists or tables). Graphical representations are intuitive and clear, but currently, most of them are based on statistical data, which makes it difficult to convey logical linkages between information and cannot help managers make decisions effectively. With the aim of designing the workshop production system with visual processes in small-sized enterprises, the key visualization technologies of the process flow chart, including the visual design of process flow chart, process card management, process flow chart release, process control, and production schedule monitoring, were all addressed in detail. On this basis, the mechanical manufacturing workshop production management system was created using C#.NET as the programming language. The main contribution of the research is that the system designed used the process flow chart as the main line through all functional modules and integrated all process data on the process nodes of the process flow chart to realize the graphical monitoring of workshop production schedule. The visualization technology of the process flow chart makes the system simple to use and easy to understand, which significantly improves information management and work efficiency in the workshop. Additionally, it provides the technical foundation for flow-driven production information transfer in the workshop and can serve as a universal standard for the process module in workshop production management systems.

Keywords: workshop production management; process flow visualization; process flow chart model; production schedule control

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1. Introduction

The informatization management of workshop production has historically been a somewhat weak link in the development of manufacturing informatization [1]. In order to improve the level of workshop information management and aid in promoting overall enterprise competitiveness, various workshop production management systems and MES were developed to address the issue of poor information connection between equipment automation systems and ERP, PDM, and other systems.

Currently, there are many related commercial software available on the market, such as SAP S/4HANA Manufacturing, Beas Manufacturing for SAP Business One, MS Dynamics 365, and many Chinese commercial software with independent copyright (such as Yonyou (Beijing, China), Kingdee (Shenzhen, China), etc.). One of the leading developers of business process management software, SAP, helps companies of all sizes and industries achieve comprehensive enterprise resource management. Now, SAP S/4HANA can process large amounts of data using advanced technologies such as artificial intelligence and machine learning, and its integrated applications can connect all parts of a business into an intelligent suite on a fully digital platform. However, the cost is prohibitive and unsuitable for small- and medium-sized businesses. Beas Manufacturing for SAP Business One is particularly suitable for small- and medium-enterprise manufacturing. It combines the core functions of ERP and the digital core platform of MES and allows users to easily manage and monitor all processes and costs in the manufacturing process. MS Dynamics 365 integrates the functions and processes of CRM and ERP and can be integrated with more Microsoft services to achieve continuous intelligent evolution.

Although the commercial system is very mature and comprehensive, for some small-sized businesses, (1) its corporate structure may not be complete and comprehensive, so an ERP system may not be suitable for small-sized businesses. (2) Small-sized businesses tend to concentrate on producing some particular types of products that are very similar to each other, and their production processes are similar; thus, the requirements for the system are not too complex but can quickly complete the production planning of products. (3) Small-sized businesses must respond quickly to market changes with their products in order to remain competitive; for example, if client order requirements change, the new product must be able to be promptly produced and delivered on schedule. Order-based, small-batch production is not well suited for the standard ERP system, which is frequently created for large-scale items. (4) Small businesses must undergo information and digital transformation in order to keep up with the informatization of enterprise. However, due to financial limitations, small-sized businesses are more concerned with the information and digital transformation of their core industries: the production sector.

The Jiangsu and Zhejiang regions of China have many small enterprises, and they are active in the market economy. In this study, a workshop production management system based on product process was created for a machinery manufacturing company in Ningbo, China. There are over 70 different product types divided into five different categories and specifications in the company. Regardless of the size of the business, in the process of workshop production management, there are a lot of business processes in the various departments of workshop and production processes. The overall business processes between the various departments in the workshop are shown in Figure 1. They are as follows:

(1) The workshop director receives orders;
(2) The workshop director sends out production plan to the craftsman;
(3) The craftsman compiles the production process flow;
(4) The workshop director assigns the production tasks to the team leaders and the quality supervisor;
(5) The team leader assigns the production tasks to the workers;
(6) The quality supervisor assigns the quality inspection (QI) tasks to the quality inspectors;
(7) The worker carries out production tasks in accordance with the production process flow;
(8) The quality inspector inspects the work quality of the workers;
(9) The product is completed and stored.

Process flow, which serves as the vital link between product design and manufacturing, is crucial to the entire manufacturing procedure and has a significant impact on both product quality and manufacturing costs. The actual process flow is usually more complex, as shown in Figure 2. Processes may interact with one another serially or in parallel. There is a strict constraint that the previous procedure must be finished before the subsequent process can be carried out. Traditionally, the production is organized by the workshop after the craftsman manually completes the process flow and process card in accordance with the part drawings. There will be a lot of technical data created during this time, and the management of this technical information depends on how well the relevant managers can remember it and the professional level of the relevant managers.

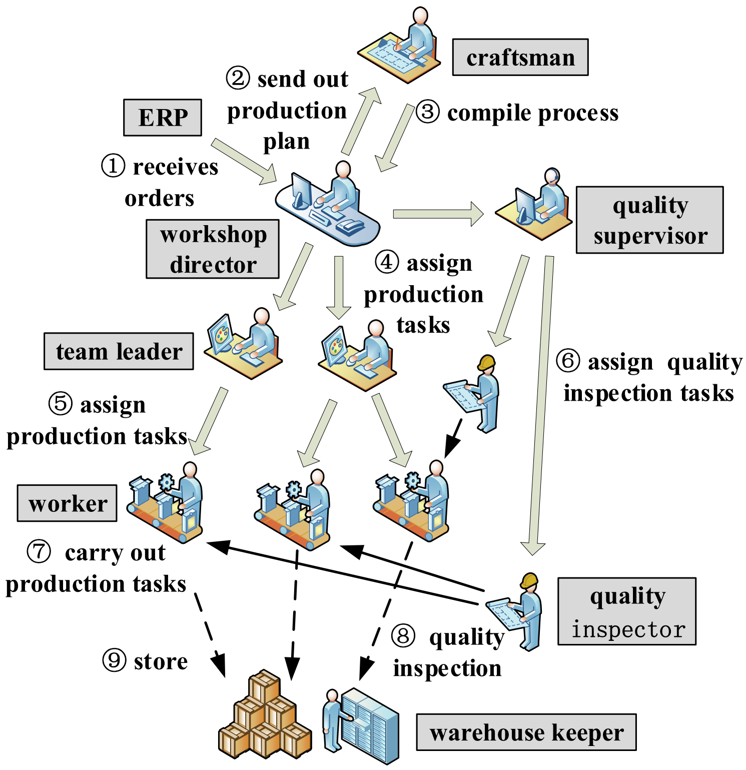

Figure 1. The overall business process in workshop.

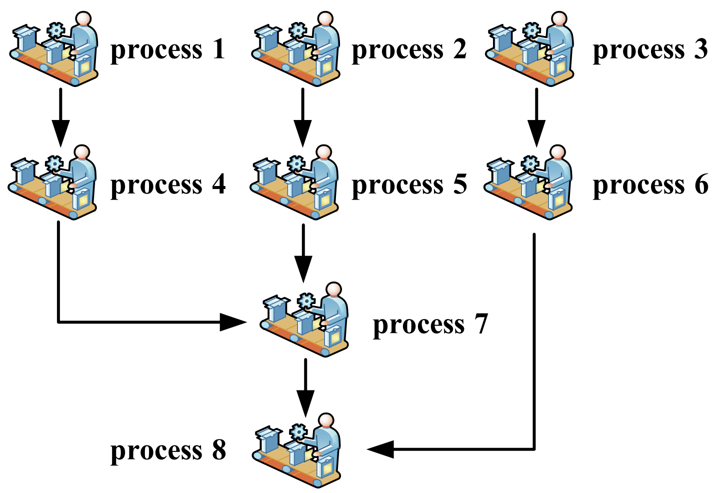

Figure 2. Process flow in workshop.

In addition to process data, a variety of additional production data are also produced in the workshop, including equipment information data, materials data, personnel information, product information, etc. The interaction and presentation of these data may have an impact on how the workshop is managed in real time and how decision makers arrive at their conclusions. The Internet of Things is currently being used by numerous researchers to improve data collection on workshop equipment. Because the data used in workshop production are complicated, it makes sense to present the data visually so that workshop staff may make better use of the information and increase production efficiency. Although domestic and foreign scholars have engaged in extensive research and practice in workshop information management and computer-aided process planning (CAPP) and solved a series of problems such as production scheduling, data collection, process monitoring, logistics scheduling, etc., most workshop production management systems still present complex production processes as data lists or tables lacking an intuitive and visual graphical display. As a result, the overall structure of the process flow and the connections between different process nodes cannot be vividly displayed, which negatively impacts the user experience. Some systems are visual, but their primary focus is not process flow but rather the display of statistical data such as equipment statistics. As a result, the logical linkages between the data are obscured and should be better used to assist managers in making decisions.

The visualization technology of the mechanical manufacturing workshop production process flow was carefully examined in order to find a solution to this issue. The workshop production process flow chart model and the process flow chart storage scheme were proposed, and then, the mechanical manufacturing workshop production management system was developed. The system has the following functions: visual design of process flow charts, process card management, production process control, and production progress monitoring based on process flow charts. The production process management has become more intuitive and visible with the help of the graphical display of production process flows, which significantly improves the readability of key information and greatly improves the friendliness of the system interface. Users can easily and quickly observe the relationships between different process nodes in the process flow, which makes it easier for decision makers to make production decisions.

The remainder of this paper is organized as follows. We review related research in Section 2; then, we present the production process flow chart model in Section 3. In Section 4, we detail key technologies of visualization of production process flow chart. Finally, we provide our conclusions in Section 5.

2. Literature Review

The use of workshop production management can keep resource availability stable and industrial sustainability unaltered, improve workshop production efficiency and information management level, and make production organization more orderly so that the process runs more smoothly, and production cost decreases [2–5]. Approaches to procedure optimization have received increased attention [6]. Several techniques, including lean manufacturing, smart manufacturing, value stream mapping, total productive maintenance, the Internet of Things, fuzzy logic, and artificial intelligence, are now applied in various sectors for process improvement [7]. Lean manufacturing was defined by Womack in the 1990s [8]. Lean manufacturing increases the effectiveness of the operations management system in the workshop, which aids company employees in achieving operational excellence [9]. Under the background of Industry 4.0, multiple strategies are frequently used to improve production management. Lean and smart manufacturing were integrated in a hybrid way by Tripathi et al. [9] to enhance operational excellence in workshop.

The primary production management tool that creates a communication channel between the enterprise planning layer and the workshop control/automation layer is a MES system. The idea of a Manufacturing Execution System (MES) was developed in the mid-1990s [10]. In order to implement real-time management in the workshop, from order reception through finished items, the MES integrates basic production plans with real-time data on operations, materials, and processes from the equipment, controls, and workers in the workshop [11]. The primary functions of the MES include data collection and abstraction, precise operation scheduling, resource allocation and control, production task allocation to people and machines, product quality control, and equipment and tool maintenance [12]. Artificial intelligence (AI) with MES [13], digital twin (DT) [14], and augmented reality (AR) [15] are the three main research frontiers in MES.

Research on CAPP has also been extensively conducted by academics. Neibel [16] first proposed the concept of process plans with computers in 1965, and the first CAPP system was created in 1976 [17]. Since then, CAPP has been the subject of extensive investigation. There are numerous technologies used for CAPP, including agent-based technology, internet-based technology, feature-based technology, knowledge-based system, artificial neural networks, genetic algorithms, ant algorithm, fuzzy theory, and other intelligent algorithms [18]. With the development of optimization algorithms, there will be more effective CAPP technologies. The holistic component manufacturing process planning model based on the integrated approach integrating technological and business considerations was described by Denkena et al. [19]. Borojevic et al. [20] established the platform for integrated CAD/CAPP part design based on the basic machining features and the intelligent setup planning and operation sequencing using the genetic algorithm. Malleswari et al. [21] presented the automated machining feature recognition method by employing the STEP file. For the purpose of determining the machining process sequencing and machine assignment, Deja et al. [22] developed the extended feature taxonomy that corresponds to the requirements of the rational process plan selection for the targeted category of part types.

The informatization of production workshops has been applied in various industries. Ji et al. [23] put forward the digital management technologies and their application in casting enterprises. Wu et al. [24] introduced the production management system used in the furniture industry. With the development of internet technology, some workshop management systems have achieved network transmission of workshop production information based on internet technology, wireless network technology, etc. Luo et al. [25] designed the workshop production management system based on android platform and realized the real-time monitoring and management of workshop status. The web-based workshop production management system was created by Liu et al. [26], with a particular emphasis on the design of the process planning module. Bi [27] developed the wireless terminal-based workshop production information system and completed the mobile internet application of workshop management. Some commercial software such as SAP S/4HANA Manufacturing and MS Dynamics 365 have been able to achieve cloud storage. Under the development requirements of Industry 4.0, it is possible to accomplish intelligent control of workshop equipment by using IoT technology to gather equipment information. Sruthi and Kavitha [28] surveyed various IoT platforms such as Xively, ThingWorx, Thing Square, Sensor Cloud, etc. Zhang [29] discussed the human–computer data gathering system based on RFID that offered a database for tracking and monitoring production. Heidarpour et al. [30] used the data logger device to obtain the data from hydraulic hammers to remote monitoring and adjust process planning. Using OPC technology for data transfer, Wei et al. [31] designed a visual monitoring system that performs tasks like visual production process monitoring and resource management for production lines. Lu et al. [32] used Microsoft's visualization tool PBI as the core of development to handle the production data imported from the existing Excel tables in small- and medium-sized businesses, which presented a visual and explicit interface to realize real-time monitoring and management of production lines. Rosales et al. [33] visualized factory data through augmented reality and mixed-reality-based smart devices. On the main design line of production management system, Zhang et al. [34] developed the production management system with workshop planning and scheduling monitoring as the core. Wu et al. [24] introduced the production management system used in the furniture industry based on customized products. Nicole Oertwig et al. [35] proposed the user-centric process management system for digital transformation in small- and medium-sized businesses in Germany.

Even though there have been several studies on workshop production, most production management systems do not adequately support the production processes, which leads to poor process visualization and information flow between processes. The use of CAPP technology for process optimization is the main focus of research on workshop processes. In this study, the visual technology of the process flow chart was utilized to visualize the information of production processes that small-sized businesses are concerned about and realize the graphical process design and release. Finally, in this way, the production process control based on the process flow chart and the graphical monitoring of the workshop production schedule can be achieved.

3. The Production Process Flow Chart Model

3.1. The Description of Production Process Flow Chart Model

There are typically multiple working processes and many working steps in one working process during the manufacturing of mechanical products. Each process contains a substantial amount of process data, such as process information, step information, operation instructions, inspection standards, and so on. Each process may be serial or parallel. Since the manufacturing process flow chart for mechanical products contains not only process nodes and their relationships but also related process data, it is an amalgamation of heterogeneous as well as complicated data.

This study builds the production process flow model of mechanical products based on typical features of mechanical product manufacturing, as illustrated in Figure 3. The model is made up of two parts: process data and process flow charts, where the latter primarily consists of process nodes and connection links, and process information, step information, step descriptions, and inspection standards are the primary varieties of process data. Their details are as follows:

(1) Process nodes contain process number, process name, coordinate positions, background image, and font setting;
(2) Connection relationships include previous process, follow-up process, arrow pointing, style, line width, and straight/broken line type;
(3) Process information is made up of process ID, process number, process name, product ID, part name, processing equipment, processing material, assigned team, warehousing options, downstream process number, and remarks;
(4) Step information contains step ID, process ID, step number, step content, specific content, piece rate unit price, and reference time;
(5) Step description includes ID, process ID, resource type, resource document, and notes;
(6) Inspection standard is made up of ID, process ID, inspection sequence number, inspection standard, inspection mode, input type, and inspection frequency;
(7) Product information contains product ID, product name, product model, product number, version number, creation time, process flow chart file, and status;
(8) Bad history record includes ID, process ID, resource type, resource document, and notes.

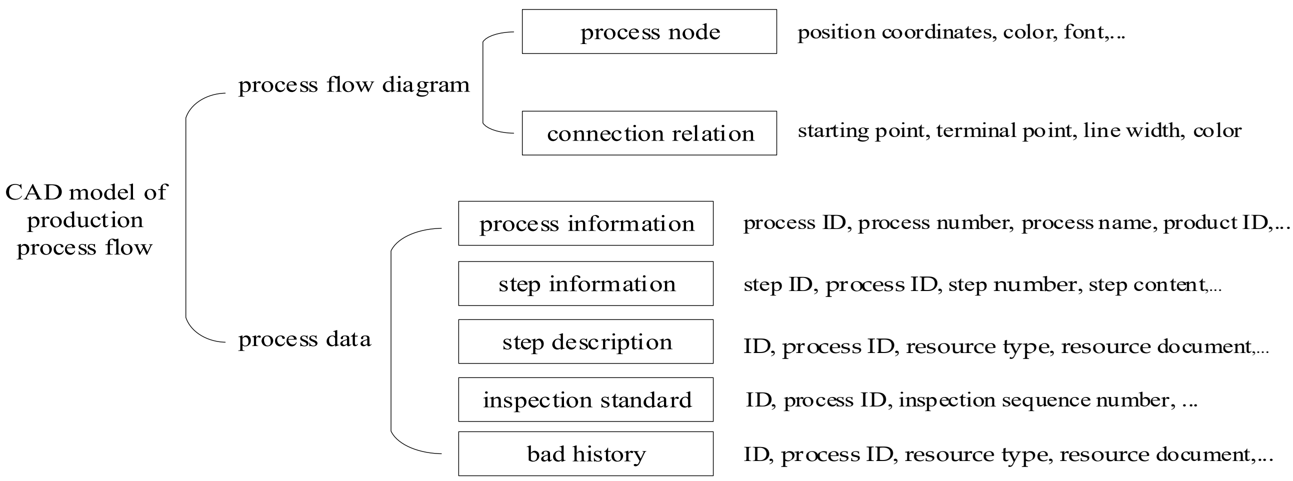

Figure 3. CAD model of production process flow.

3.2. The Storage of Production Process Flow Chart Model

The process flow chart and process data in the CAD model cannot be stored together simply in the workshop production management system due to the high operation response requirements of the process flow chart and the size of the information contained in the process data. This work employs the following strategy to address this issue, as illustrated in Figure 4.

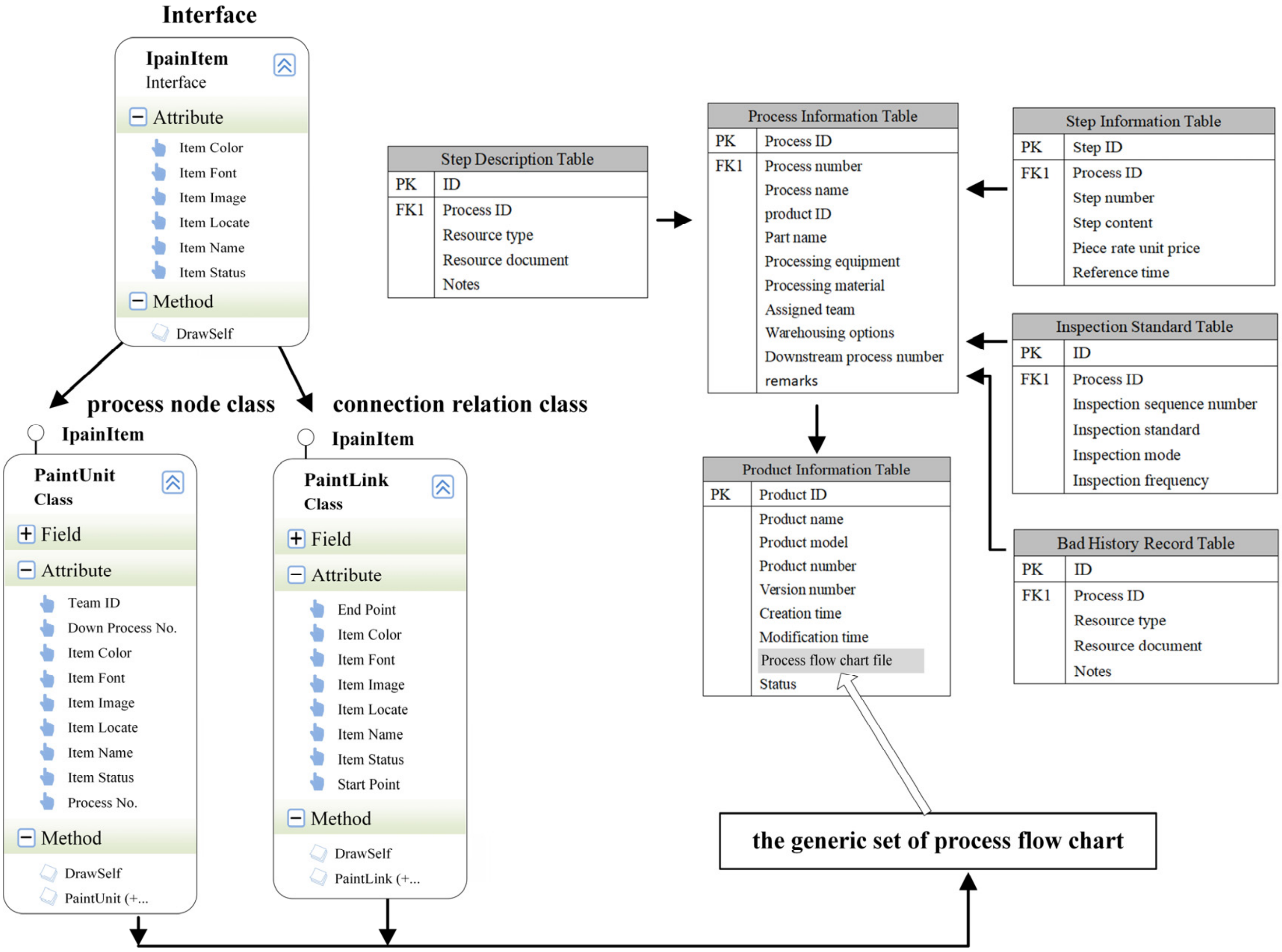

Figure 4. Storage program of CAD model of production process flow.

First, an IPaintItem interface is defined based on the object-oriented design concept in C#.NET [36]. This interface has the attributes of item color, item font, item locate, item name, item status, and DrawSelf method. Next, the PaintUnit class (operation node class) and PaintLink class (connection relation class) are defined, both of which implement the IPaintItem interface. Finally, the process flow diagram can then be expressed in the form of a generic collection list <IPaintItem> and stored by serialization. The product information table, process information table, step information table, step description table, inspection standard table, and bad history record table are built in the relational database SQL Server. The generic set of process flow charts after being serialized is stored in the field of process flow chart file in the product information table. There is a one-to-many mapping between the product information table and the process information table, which are connected by the field of product ID. The process information table also has a one-to-many mapping relationship with the step information table, the step description table, the inspection standard table, and the bad history record table, which are all related by the field of process ID.

Based on the aforementioned process flow chart model storage scheme, the process information flow from product to process flow chart to process to process-related information can be separately saved, associated, and read by accessing the database in the workshop production management system.

4. The Key Technologies of Visualization of Production Process Flow Chart

The mechanical manufacturing workshop production management system was created using SQL Server as the database, VS2019 as the development environment, and C#.NET as the programming language. Figure 5 illustrates the basic interface. The system has a C/S architecture. For data access, a SQL Server database was set up on the server side. The workshop production management system is utilized by the client to carry out the various operations for the production process and associated process data. The system, which is simple to use and has an easy-to-understand interface image, uses the process flow chart as the main line through several functional modules. The process flow diagram is taken as the core thread and the underlying core data of the system. The system's various functional modules, such as process modeling, process card preparation, process control, and production progress monitoring, are all data-driven and displayed through the process flow diagram.

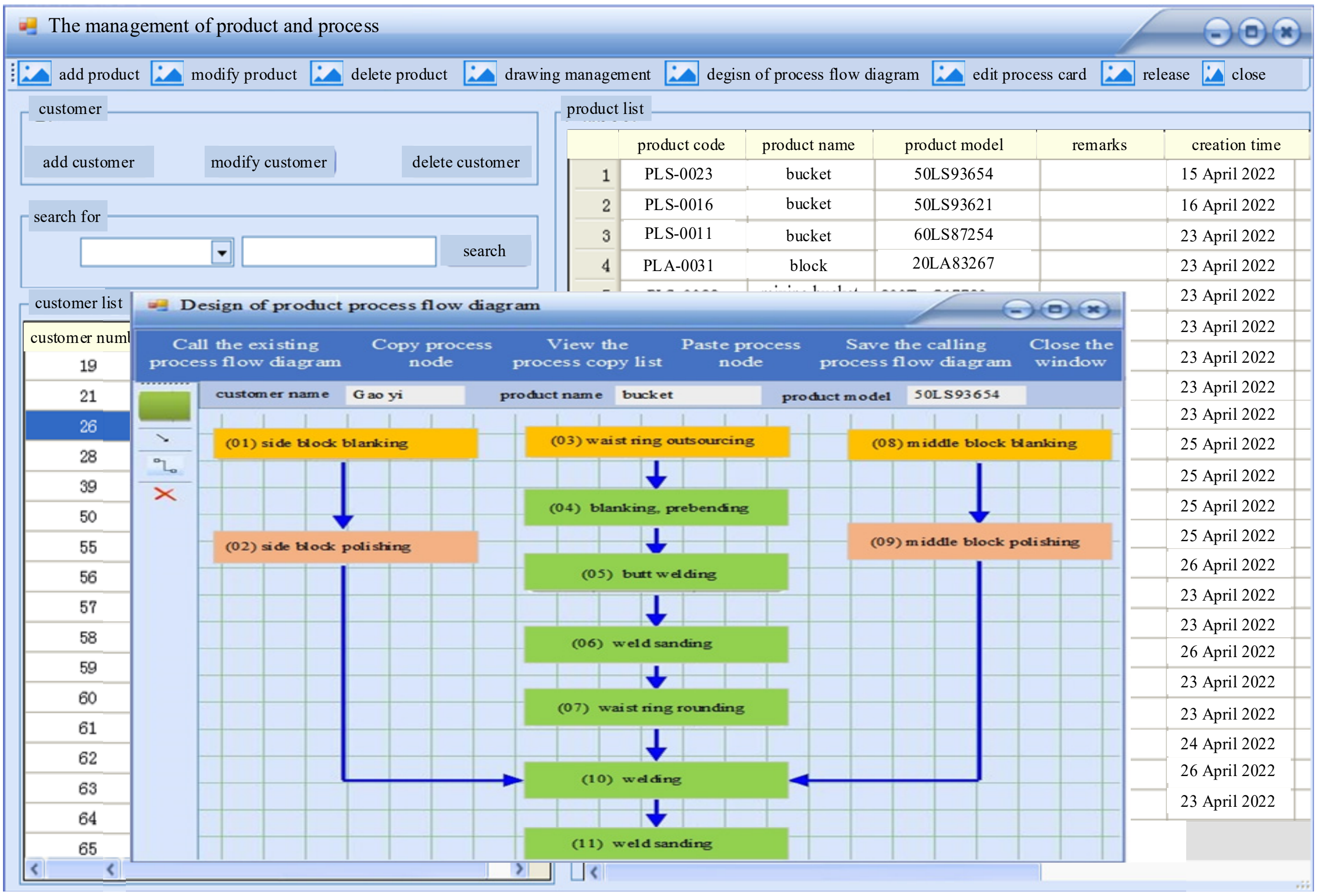

Figure 5. System interface.

4.1. Visual Design of Process Flow Chart

The essential component of the workshop production management system is the visual design of process flow charts, and its interface is shown in Figure 6. At the top of the interface, one can read and present flow charts from databases, copy/paste the process nodes, view the process copy list, save the process flow charts, and close the window. The function menu on the left side of the interface from top to bottom contains the following: drawing process nodes, drawing process lines (straight and broken lines), and delete objects.

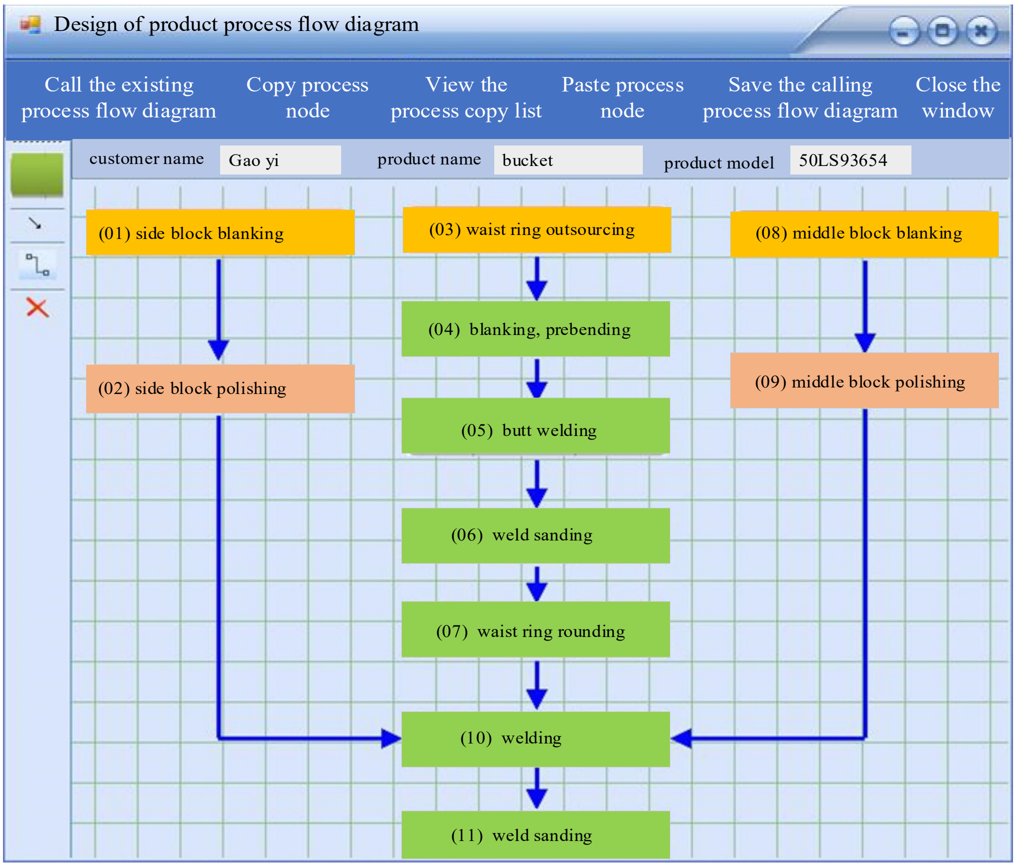

Figure 6. Flow diagram design module.

A product process flow diagram can be created in one of three ways:

(1) Draw completely by hand. Each process node is dragged and dropped individually; then, they are progressively connected in a straight or broken line based on serial and parallel relationships to create a process flow diagram;
(2) Copy or paste some of the current process nodes. One can open the current flow chart, select the process nodes one wants to copy, and then paste them into the desired flow chart if a few of the process nodes in the process flow diagram match those in the existing flow chart. The remaining part is drawn by hand. This technique significantly improves the drawing efficiency;
(3) Alter an existing process flow diagram directly. One can call an existing flow chart and edit it if the process flow chart one wants to create is comparable to one already in existence. This approach can effectively reuse the original process flow chart, which will considerably increase work productivity.

The following is the exact method by which this module function is implemented:

(1) Go through the flow chart. When entering the module interface, one can read the field content of process flow chart file in the product information table through the data access layer and then use the binary serializer to deserialize the data before obtaining the object set of List <IPaintItem>, which includes all of the process nodes and connecting line segments in the flow chart. After that, one traverses the set and calls the DrawSelf method on each object to draw all of them in the form interface;
(2) Draw process nodes. Users can add a process simply by dragging and dropping the process icon from the left toolbar to the appropriate position in the form interface. This function is mainly realized through the DragDrop event of the form. When the user releases the mouse, the node object at the cursor position is established and added to the process flow chart set;

(3) Set up the process basic information. The MouseDoubleClick event triggers a dialog box when the user double-clicks the process node, allowing the user to enter details such as the process number, the process name, and the assigned team. After setting, the process node can display the process number, process name, and associated colors in accordance with the various allocated teams;
(4) Draw connecting line segments between process nodes. The connection relationship is established by drawing a connecting line between process nodes. According to the actual needs, there are two types of connecting lines: straight line and broken line;
(5) Move the process node. The operation node be moved. Users can drag the process node to reposition it when editing the process flow chart. The link between process nodes will automatically and instantly change as the user moves;
(6) Delete the object. The system will determine which object the user has chosen by comparing the click coordinates with the coordinate range of each object. When the delete function is chosen, the specified object is deleted by invoking the Remove method of the set;
(7) Copy/paste process nodes. The ability to copy and paste process nodes is especially useful for process flow chart that contains some same or similar process nodes, which can aid technicians in quickly and effectively drawing the necessary process flow. The realization method is as follows: Initially, the user opens the process flow chart of similar products, selects the process nodes to be copied, and then adds them to the copying list one by one. Next, the user opens the target process flow chart and uses the paste feature to draw the process nodes in the copy list into the flow chart one by one, and at the same time, the associated process data will be automatically copied;
(8) Save the process flow chart. The user verifies the integrity of the flow chart before storing it. The user is asked to complete the process's basic information if it is not already filled out. The flow chart's List <IPaintItem> object set is binary serialized and stored in the database's product information table if the integrity check is successful.

The visual design module of the process flow chart fulfills all functions and can successfully draw, edit, and save the product process flow based on the design of the technical scheme mentioned above. After drawing the process flow chart in the production management system of the workshop, the input and management of all kinds of information for each process can be completed on the flow chart, including the following: craftsman inputs process card information, workshop director setts time limit, team leader assigns operators, etc.

4.2. Process Card Management

Typically, a craftsman will create a process card specifically based on the product's structure and technical specifications. This process card is then issued to the workshop personnel as a technical instruction document. A product corresponds to a complete process flow, which usually includes multiple processes. Each process corresponds to a process card, which includes multiple steps. Due to the high volume of product orders, each process and its steps may correspond to multiple operators.

In the production management system, the machining process card is no longer the traditional paper card but a rich-media form of data integration carrier. The information of each process card can be compiled once the flow chart has been built by the craftsman. The specific procedure is to double-click any process node on the flow chart in order to open the process card interface and navigate to the process card management module. After logging into the process card management module, the user can enter the fundamental details of the process, the step list, the contents of the corresponding description for each step (video, pictures, notes, etc.), the inspection standards of each step, and the bad history of the process. The main interface of this module is shown in Figure 7.

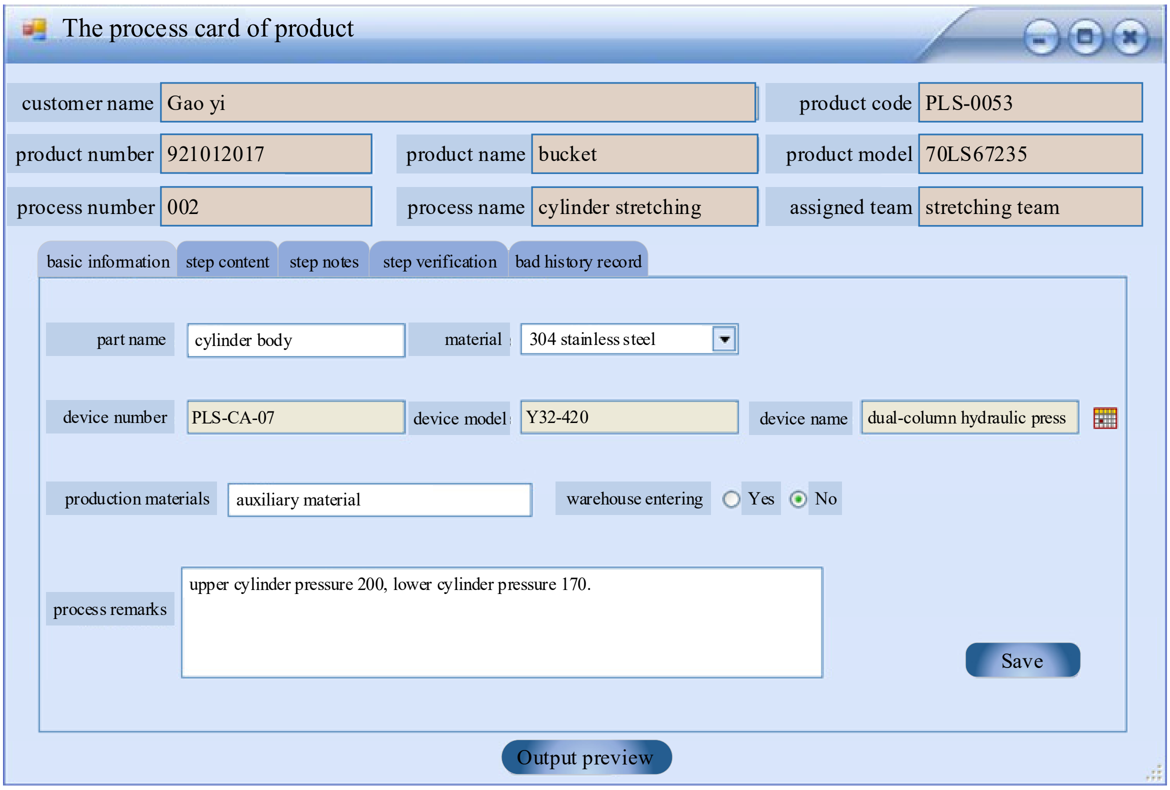

Figure 7. Process card module.

The RDLC report from C#.NET is a powerful, highly adaptable report technology. After designing the interface layout and the data field arrangement for the process card using the RDLC report and binding the data source, the process card in the PDF, Word, Excel, and other document formats can be quickly created.

4.3. Process Flow Chart Release

Products can enter the process release module for official release if they have been compiled with process flow and related information. Process completeness inspection and process version number compilation are two of the module's features. Among them, process completeness inspection is a crucial link that can verify the accuracy and integrity of process data for items that have been released. In Figure 8, the inspection procedure is displayed.

The detailed inspection flow is as follows:

Step 1: Read the process flow diagram;
Step 2: Start to traverse all process nodes in the process flow chart, and let $i = 1$;
Step 3: Start to check the ith process node;
Step 4: For the process node, inspect its fundamental details, its step list, the bad history, the contents of the corresponding description, and the inspection standards of each step sequentially;
Step 5: Have all process nodes been checked? If so, print the check list, as the list describes whether there is some information missed and reminds the user of the lack details; otherwise, let $i = i + 1$, and jump to step 3 for the subsequent node.

After the product process flow is released, the production procedure that uses the process flow will produce a duplicate of the version of the process flow to operate independently. In this way, the production procedure that carries out the initial version of the product process flow can continue to operate after the process flow is adjusted, and a new version is released.

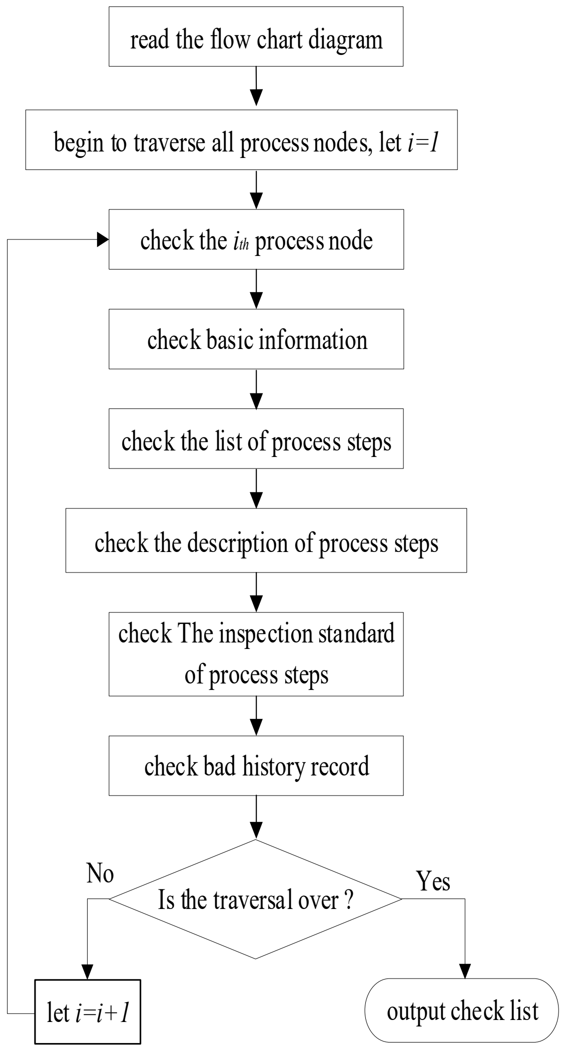

Figure 8. The inspection procedure of process completeness.

4.4. Process Control Based on Process Flow Chart

The operator in the workshop must adhere to the defined process flow to carry out the production in a timely manner, and this process control function can be accomplished with the use of a process flow chart.

In the process flow chart, each process node has three attributes: its own process number, its downstream process number, and its status (not started, in progress, or finished). For process P_i, the process cannot be executed until no previous process or all previous processes have been completed.

The following steps are used to determine if a process with previous processes may be carried out, as shown in Figure 9:

Step 1: Define the execution identity $Flag$, and let $Flag = false$;
Step 2: Start to traverse all the objects in the process flow chart, and let $i = 0$;
Step 3: Find the ith flow chart object $Item(i)$; $Item(i)$ is the process node or connecting line segment in the flow chart;
Step 4: Determine if $Item(i)$ is a process node, and if it is not, let $i = i + 1$, and jump to step 3; otherwise, proceed to step 5;
Step 5: Are the states of the previous processes satisfied? If yes, let $i = i + 1$, and jump to step 3; otherwise, let $Flag = false$, and end the traversal;
Step 6: Is the execution identity $Flag$ false? If it is, the process is allowed; otherwise, it is forbidden.

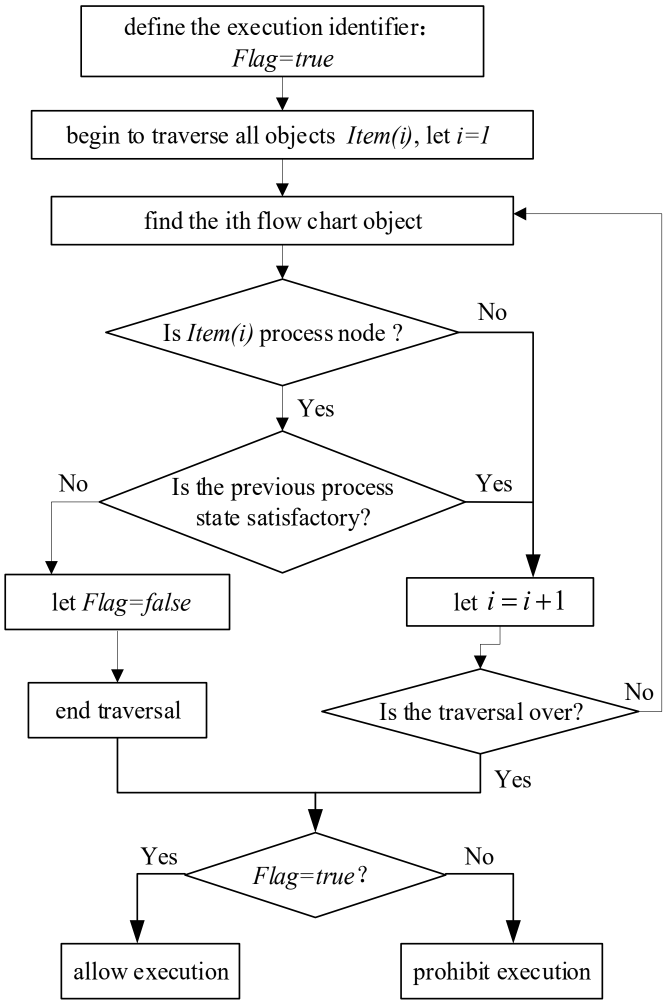

Figure 9. The flow chart for judging process execution status.

4.5. Production Schedule Monitoring Based on Process Flow Chart

The process flow chart can be used to show the execution statuses of the processes in addition to conveying the logical relationships of the process flow, enabling effective monitoring of the production schedule in the workshop. There are three execution statuses of a process: not started, in progress, and finished. Each process node in the flow chart has a different display effect set according to the process's various states. Table 1 lists the rules for setting the display effect of process nodes.

Table 1. The display effect of process nodes.

Execution Status	Display Effect
Not started	Colored background (except gray) (different colors correspond to different teams)
In progress	Flickering background
Finished	Gray background

The implementation procedures of this function are as follows:

Step 1: Traverse each object in the flow chart;

Step 2: Add the process node to the executing node set *PList* if its execution state is in progress; the background will be changed to gray if the process has finished; if the process is not started, leave things alone;

Step 3: Start *Timer* after the traversal is complete, and set the interval to 1 s. In the trigger event, the background image of each node in the set *PList* is alternatively changed to create the flicker effect.

The workshop production schedule monitoring interface is shown in Figure 10.

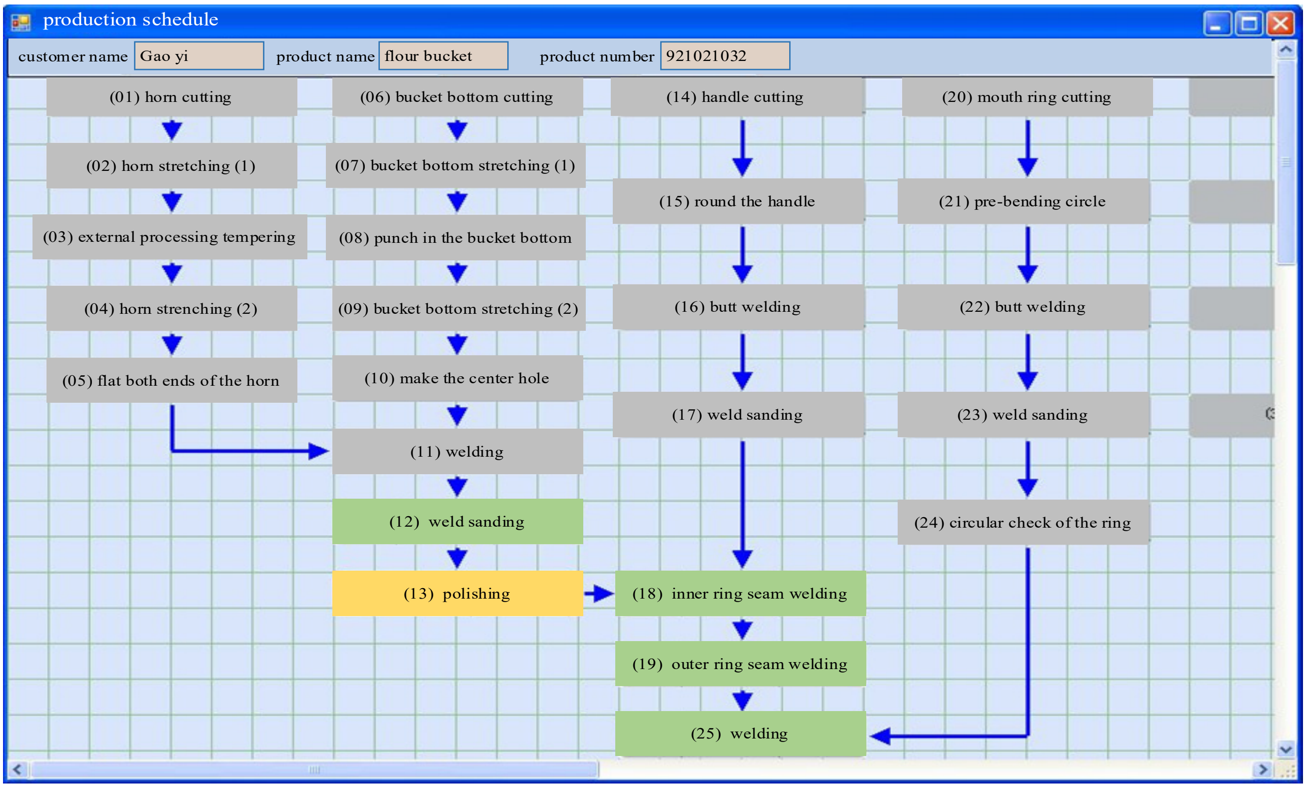

Figure 10. The workshop production schedule monitoring interface.

5. Conclusions

(1) After investigating the visualization technology of the process flow chart in light of the characteristics of the manufacturing process for mechanical products in small-sized businesses, the model of the production process flow chart containing process data and process flow charts was constructed. The database-based process flow chart storage scheme is thus proposed;

(2) The mechanical manufacturing workshop production management system was created using SQL Server as the database, VS2019 as the development environment, and C#.NET as the programming language. The various operations for the production process and associated process data were realized in the system;

(3) The graphical process design, process card data management, and process flow chart release were all finished by the system software created in the study. The judgment method of the process execution status was used to realize the process flow chart process control, and the process execution status display mechanism was applied to visualize the workshop production schedule;

(4) Through the use of the process flow chart visualization technology, the overall structure of the production process and the connection between processes can be graphically displayed, and the system effectively raises the level of information management and work efficiency in the workshop. It also provides the technical foundation for flow-driven production information transfer in the workshop and can serve as a universal standard for the process module in workshop production management systems;

(5) The system developed in the research implements the main functions of workshop production management in small-sized enterprises, but it also has its limitations. First, it is suitable for products with similar production processes. For example, it is currently employed in the machinery manufacturing company in Ningbo, China, which mainly produces various complex structural sheet-metal goods. In terms of product processes, stamping, drawing, welding, polishing, etc., are mostly used. In this way, the process flow chart and corresponding production management of new products can be quickly established by copying and modifying those of the existing products. Second, the system primarily implements production management in small enterprise workshops and lacks other management functions, such as finance and sales. Future research will focus on expanding existing functions or integrating new functions with the enterprise's functional systems. Finally, the system lacks research and application of relevant intelligent methods in the process of production organization, such as the allocation of team members for each process, the intelligent scheduling of workshop production resources, and so on. In the future, we will strengthen the research on intelligent optimization issues related to workshop production management and solve problems such as production task allocation and workshop resource scheduling to further enhance the intelligence level of the workshop production management system.

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