Research and Application of the Control Technology for Flexible Manufacturing System Based on PROFIBUS

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***Abstract*—Traditional military industry can not update the production of weapons and integrate information quickly. Neither can it shorten the production cycle to establish a FMS. In order to solve these problems, this paper attempts to apply fieldbus technology to the Flexible Manufacturing System (FMS) in military production. To put it concretely, the PROFIBUS-DP technology will be adopted to actualize the fast information exchange between field digital control equipments and the control center at the workshop level so as to promote the capacity of production dispatching and control, realize a closed-loop control for the costs and quality of the manufacturing system, and establish a flexible manufacturing system which is highly efficient and easily integrated. The findings of this research can be widely applied to weapon-manufacturing industry for it can lay a foundation for information-based enterprises, accelerate the research and manufacturing of weapons, and improve the manufacturing ability of our defense industries.**

***Keywords*—PROFIBUS –DP,FMS, Manufacturing System**

I. INTRODUCTION

A hierarchical control is often adopted in FMS for military manufacturing, of which the structure is composed of three levels, namely, factory level, workshop level and field level. The monitoring and information integrating system between the latter two levels is the foundation for the automation and FMS of the whole factory[1].

In this research, PROFIBUS-DP technology is adopted as a solution to the communication between the control center at the workshop level and the manufacturing field, that is, a PROFIBUS-DP[2] master station and a slave station will be established respectively at the workshop control center and the manufacturing field. A bus bridge is adopted for the slave station with a PROFIBUS interface and a RS-232 serial communication interface. Meanwhile, an aid controller based on SCM is developed with the function of keyboard input, LCD, and RS-232 serial communication, so that it can be connected to the slave station to realize RS-232 serial communication. The field operator can use the aid controller to transmit the state of military production equipments, production tempo, NC programs and so on to the workshop control center through PROFIBUS-DP; on the other hand, the control center will transmit the dispatching commands, production tasks and NC programs to the manufacturing field, so that the operator can perceive these information via the LCD of the aid controller and perform them. Thus the information communication between the workshop control center and the manufacturing field is realized for the completion of military production[3].

II. THE FMS STRUCTURE

A. Traditional automatic control and information integrating system at the field level and workshop level

A flexible manufacturing system often adopts a hierarchical control and is often composed of several levels, each of which is functionally independent from each other. The information is exchanged between each level so as to form a complete system. The hierarchical control system often consists of 3 levels, namely, the factory level, the workshop level and the field level. (See Fig. 1)

The system of this structure is not a reliable one with poor performance on openness and information integration. Nor is it easy to maintain the system[4].

B. The structure of the flexible manufacturing system based on field bus and Ethernet

Field bus refers to the digital, serial and multipoint communication data bus mounted between the field equipments within the manufacturing or processing area and the self-control device inside the control room. The application of the field bus technology promotes the combination of traditional

DCS system and PLC system as well as the appearance, development and application of FCS (Fieldbus Control System).

The automatic control and information integrating system at the field level and workshop level based on fieldbus technology is shown in Fig. 2. The system of this structure has a better performance on openness, interactive operation, interchangeability and information integrating. Meanwhile, the information integrating capacity is promoted at the field level so that the system becomes more reliable and easier to maintain; thereby the system's engineering costs are cut down[5].

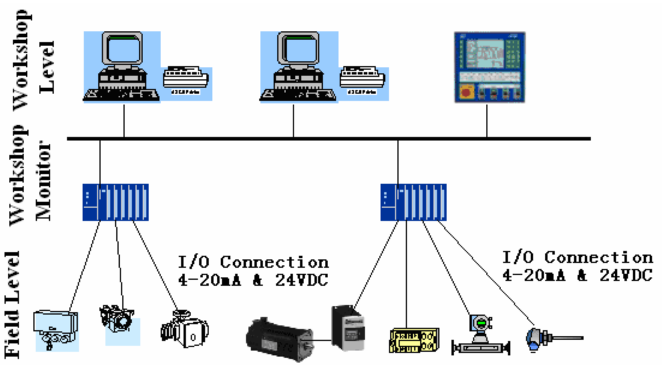

Figure 1. Traditional automatic control and information integrating system at the field level and workshop level

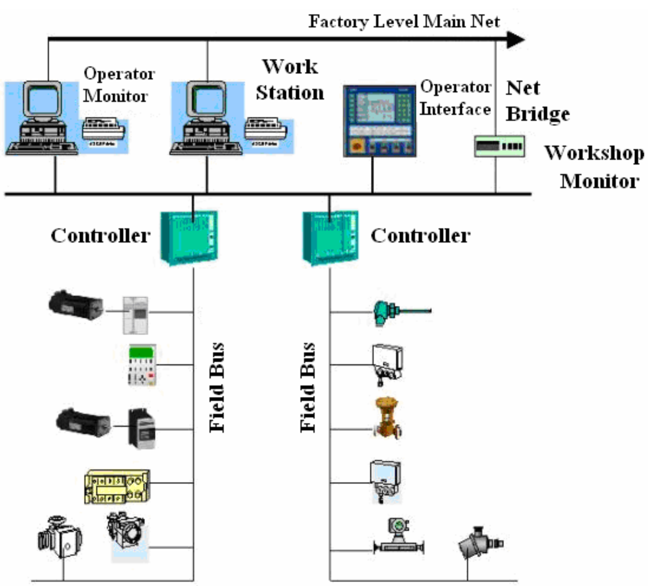

Figure 2. The structure of the flexible manufacturing system based on field bus and Ethernet

III. HARDWARE DESIGN FOR MILITARY PRODUCTION SYSTEM

PROFIBUS is the most important and the most widely applied international fieldbus standard, which includes three main types, namely, PROFIBUS-DP, PROFIBUS-PA and PROFIBUS-FMS. This research adopts PROFIBUS-DP technology. [6]

A. Globall design for the field control of flexible manufacturing system

The system adopts the theory and technology of man-machine coordinating flexible manufacturing system[7,8]. Its overall design is shown in Fig.3.

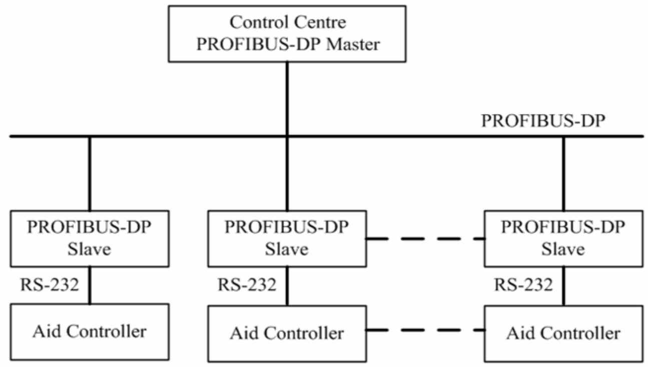

Figure 3. Globall design of man-machine coordinating FMS field control

According to this structure, the PROFIBUS master station and slave station are established respectively at the workshop control center and the manufacturing field, and the field operator will utilize the aid controller to exchange information with the control center via Profibus-DP[9].

B. The detailed design for FMS field control of military production

Modern military enterprises require a close connection between policy-making, administration, planning, dispatching, failure diagnosis, and field control and so on of the enterprise so as to handle the information comprehensively. The information network system of the enterprise is established on the basis of fieldbus and Ethernet, the latter of which connects the factory control level[10]. See Fig. 4 for the structure.

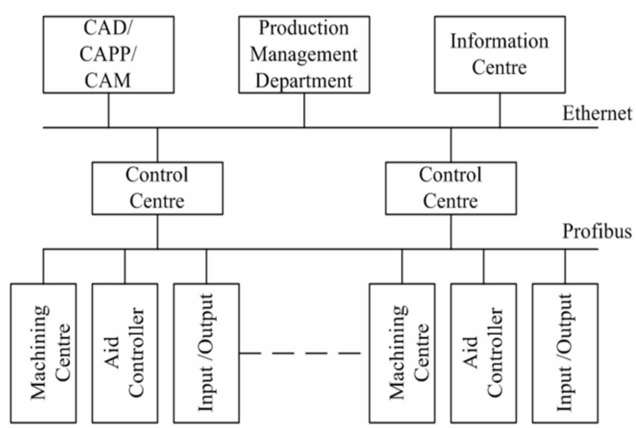

Figure 4. The structure of FMS based on fieldbus and Ethernet

C. The hardware structure of the system

The system hardware is composed of a master station and a slave station, the former of which consists of PC and CP5611 net card[11], while the latter of which is connected to the master station via bus bridge and to the aid controller via serial port[12]. See Fig. 5. for the structure

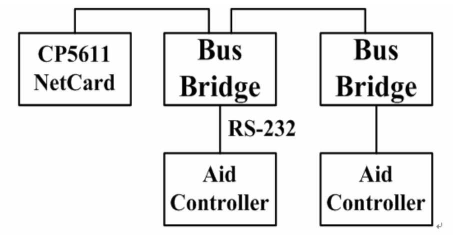

Figure 5. The System Hardware

The slave station has a Profibus interface and a RS-232 interface. The former communicates with the master station while the latter with the aid controller, so that data exchange between the manufacturing field and the control center is realized. See Fig. 6 for the details[13].

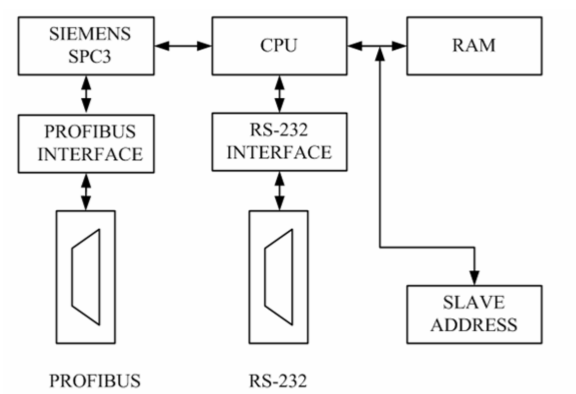

Figure 6. DP-Slave Structur

D. The design of the aid controller

The aid controller helps to make decisions in the man-machine coordinating FMS. It can perform functions such as data transfer, tasks management, and state query and so on. See Fig.7 for details.

AT89C55WD SCM system is adopted in the design of hardware, which has a keyboard, LCD and a RS-232 serial communication interface[18-20].

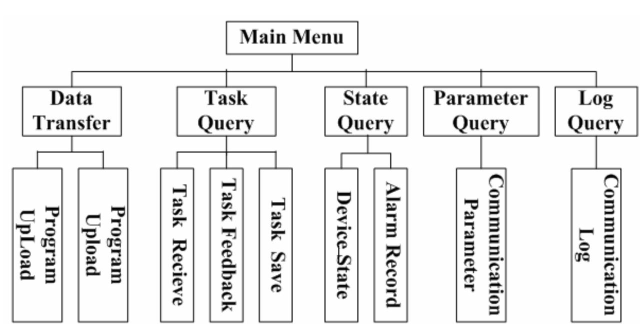

Figure 7. The Aid Controller Function Frame

IV. THE SOFTWARE DESIGN FOR THE MILITARY PRODUCTION SYSTEM

The software design of this production system consists of three parts, that is, the design of PROFIBUS-DP master and slave stations, the design of man-machine interface, and the design of the control programs for the aid controller and the programs for the communication between aid controllers and the Profibus[14-16].

A. The design of the Profibus-DP master and slave[17]

Siemens COM Profibus is adopted for the configuration and parameter-setting of the system and all the stations. The address of the master station is set as "1". See Fig. 8 for the details.

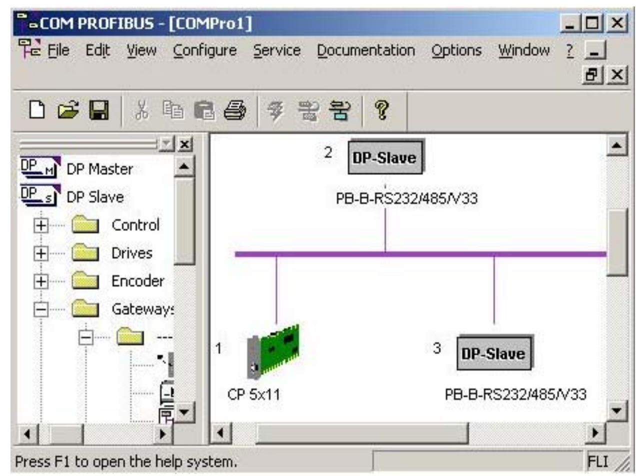

Figure 8. DP-Master and DP-Slave Configuration

B. The design of man-machine interfac

Siemens Wincc is adopted as the control program for this system. The software can provide required operating, monitoring, control and alarm display, real-time trend curves, diachronic trend curves and report printing and so on.

The design of the control program for the Profibus master includes establishing items, adding Profibus-DP drivers and set up variable tags.

The design of control display can utilize the picture objects attached to the graphics designer in Wincc. The dynamic property of graphics variable will be connected to the variable tag so as to show the running state of the controlled objects directly.

The configuration of COM Profibus can be connected to Wincc via "Setting PG-PC Interface". But the processing variable set by Wincc must match the I/O address set by COM Profibus. See Fig. 9 for details[21].

C. The design of the control program for the aid controller

The control program includes the master program and multiple subprograms.

The master program runs to ensure the system to be electrified and reset, and establish communication with the control center and the aid controller so as to complete the information exchange. See fig.10 for its program frame.

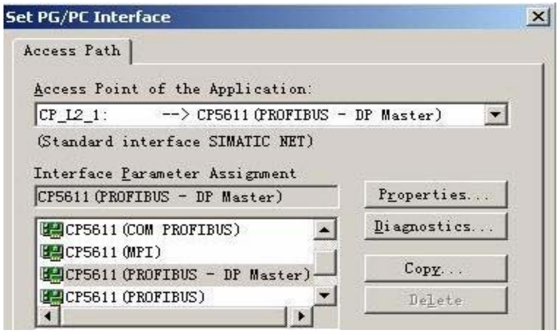

Figure 9. Set PG-PC Interface

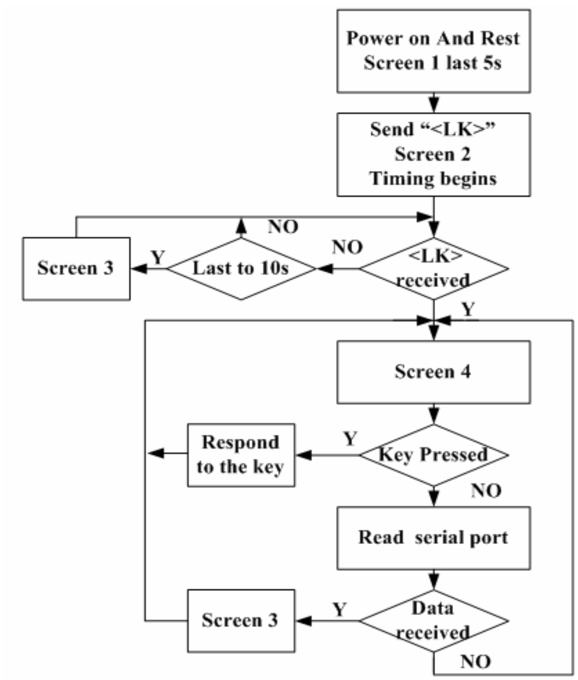

Figure 10. The frame of the master program

The subprograms should complete the following tasks such as program uploading and downloading, task reception, query and report, parameter query, log query, information display of equipments' state, alarm log display, and failure report, etc. Here the detailed flow diagram is omitted.

A communication protocol should first be established between the aid controller and Profibus. The aid controller then send out a demanding signal after the system is started to connect to Profibus for data exchange. See Fig.11 for the detailed flow chart.

V. SYSTEM DEBUGGING

System debugging consists of two parts—single debugging for the aid controllers and man-machine interface debugging.

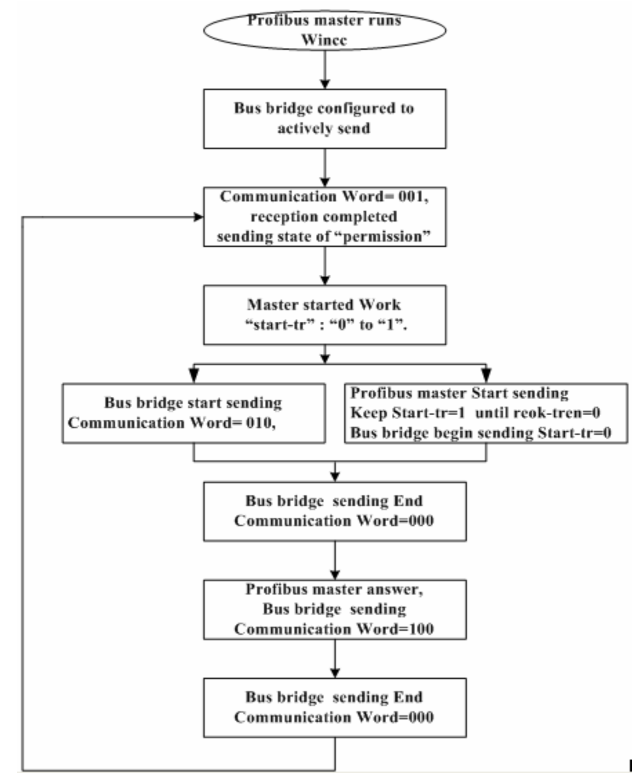

Figure 11. The flow chart of signal exchange between the aid controller and Profibus

A. *Single debugging for the aid controllers*

The aid controller debugging is carried out on its three parts respectively according to the following sequence-LCD program, keyboard inputting program and RS-232 serial port communication program. The programs will be written into the Flash memory of AT89C55 SCM with the programmer.

B. *Debugging for man-machine interface*

Wincc begins to run after hardware are connected, the interface of which is shown in Fig.12.

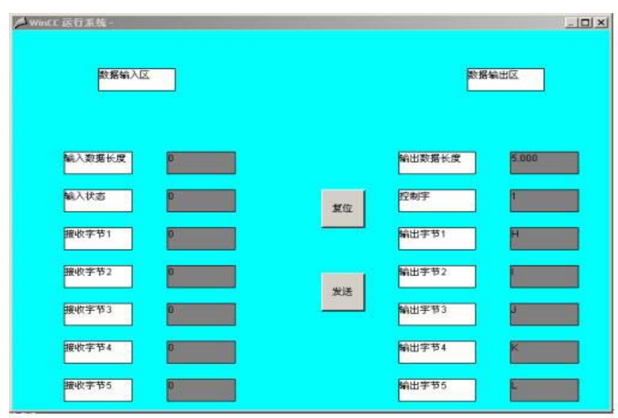

Figure 12. WinCC Operate Interface

Data area will be highlighted if the system runs normally, when the red indicator for communication on the bus bridge goes out, which means the Profibus master and slave has been connected and data exchange has begun.

Click the "send" button to send out the data within the "data output" area, when the TXD green indicator on the bus bridge will flash. If the green indicator does not flash, data are not sent out, or the other side does not receive the data which has been sent out. Now click the "reset" button to continue to send out data.

If the RXD green indicator on the bus bridge flashes, the data sent by field equipments have been received and they will be displayed within the "data input" area. However, if the RXD green indicator does not flash, it means that no data is received.

If Wincc does not run normally, the data area will turn grey, and the red communication indicator on the bus bridge will switch on. That means there is a Profibus communication failure, so that the cable connection and the system configuration should be checked.

VI. CONCLUSION

The findings of this research can be applied to the man-machine coordinating FMS for military products. In this research, Profibus technology is adopted to integrate production data from the bottom equipments into the workshop level with the help of independently developed aid controller, which has succeeded in finding a solution to the communication problems between the manufacturing field and the workshop control center and realizing the information integration of the FMS.

The research findings can not only be applied to military production, but also to the FMS of automatic machine manufacturing of civil products. If the findings are applied, the production capacity and efficiency as well as the competitive power of manufacturing industry will be greatly improved. It can be said that the wide application of the findings indicates a promising future for flexible manufacturing industry. At the same time, it can also bring in enormous social and economic benefits.

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