Data Flow of Flexible Assembly Line Control Systems

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Abstract. The data flow processing is an important part of flexible assembly line control system. First, the system frame of the assembly system is described in detail in the paper, then, the designs of the cell computer data flow and processing functions are expatiated, the paper is focused on the sequence for telegram, product change, pallet control, rework between the cell computer and SoftPLC in IPC. The research has provided a practical, well-established data flow to improve the reliability, flexibility and effectiveness of assembly line control systems.

Introduction

Industrial assembly systems are required to adapt to products and production program changes while increasing automation and reutilization. The assembly systems is faced with the challenge of moving towards more mass customization and personalized production[1], a lot of development work has been done and is continuing, the goal is to design more flexible assembly systems for handling smaller lot sizes and a wider variety of products. In these cases, the flexible assembly control systems need to be increased in order to accommodate the products aspect [2,3]. The paper is focused on data flow in the assembly systems. The purpose is to describe the basics for the programming of the assembly system. To understand the data flow, the reading or writing of the parts data in connection with the cell computers, a general representation of the data flow is given.

System Frame

The assemble control system (Figure 1) is consist of a few IPC and a Master Cell Computer (MCC). The soft PLC software runs in the Industrial Personal Computer (IPC). The machine in assembly line is called as the station. The data exchange between SoftPLC in IPC and MCC. With the IPC Gateway, the data of the soft PLC is received from and sent to MCC [4].

Commonly, a few machines on the assembly line are controlled by a Soft PLC running in cell computers. The cell computers and the Master Cell Computer (MCC) consist of the whole control system. Every machine is called a station and is named. The flexible assembly control systems are designed based on Ethernet, Profibus and other Fieldbus. The master product database is central to control system and located on MCC. This computer is integrated within the manufacturing department's network. With locally installed product editor software, other computers can access the master product database via the network.

Database technology is applied to management system data, product code is the unique identification of the product. The system data are required from the control units of the production lines. These data are supplied by MCC that control and monitor the lines, and are filed in a database within the cell computers.

The data for the selected product identity (ID) are exported to the appropriate subordinate cell computer. Data transfer to the appropriate cell computer is conducted automatically. The data of test and parameter, which are sent to subordinate cell computers by the MCC, are used control the soft PLC to how to run, the data of working state and test result in the control units are sent to the master database in a MCC again.
Booster lines have load/unload stations therefore it is necessary to store the information if the result to cell computer is sent.

The part need to rework, the function block (FB) to reset the tracking information and to get the release info to rework a part is designed, for this function it is necessary to fill a list in the cell computer.

When the product had changed, the new different product ID is selected, the appropriate product data on a line-oriented basis in the database that is located on the MCC, will be downloaded to the stations, the new product is manufactured in the assembly lines. It is very easy and flexible that the lines are controlled and monitored. The communication between MCC and the stations is one of the key technique[5,6].

Cell Computer Data Flow

With the complexity of the current assembly system, the MCC is in connection with several decentralized assembly cells computer. In order to improve the flexibility and expansibility of the control system, the communication among them is finished with a few type telegram. Commonly there are two kinds of telegram CTS (MCC To Station) telegram and STC(Station To MCC) telegram at least[7].

Telegram for IPC -> Cell Computer

STC: Station to Cell, Status information and requests to the cell computer.
RESULT: Result telegram
MDA: The machine data acquisition as MDA provides diverse parameters for analysis and evaluation of machine productivity. MDA includes Production time, Downtime, Disturbance period, Setup time, Material shortage period, Current cycle time, Minimal cycle time, Maximum cycle time, malfunction times, standstill times, Number of OK, NOK(not OK) parts produced and Number of machine disruptions and so on.

Telegram for Cell Computer -> IPC

CTS: Cell to Station, Status information and requests to the IPC.
SETUP: Minimum, maximum values and parameters for a certain product number.
PALLET CONTROL: Target sequences for all machines sent to all stations.

Telegram Sequences
To request product data, the IPC sends a STC to the cell computer. A distinction is made between: A. Request for New Product Data (NEW) (Figure 2)
1. A STC with NEW PRODUCT DATA Product number and Production index is sent to the cell computer.
2. The cell computer replies with CTS in which the Pause action is included.
3. The cell computer replies with CTS with the SETUP action.
4. The cell computer then sends CTS in which the Setup action is included (AUTOSETUP).
5. The PLC requests the product data with an STC with the CURRENT PRODUCT DATA action.
6. The cell computer replies with a SETUP telegram which contains the new product data.

B. Request for Current Product Data (NEWL) (Figure 3)
During a PLC new start or HMI, the product number is sent to the cell computer with an STC. The cell computer replies with a SETUP telegram which contains the new product data.

Special Characteristics of the Loading Station Prepare product change Sequence (Figure 4)
1. A CTS with the Prepare Product Change action is received and the contained product number is written to a buffer.
2. The product number is copied from the buffer of the STC and STC is sent after setting special bit flag (ACTION_NEWPRODUCTDATA).
3. The cell computer replies with CTS with the SETUP action.
4. The PLC sends an STC with CURRENT PRODUCT DATA, Product number, Production index.
5. The computer sends a setup telegram with the new product data.

Result[8]
With Result, the tests and actual values associated with the product number are sent to the production index and the time stamps of the parts to the computer. With a loading station, the Result does not contain time stamps. The time stamps are transferred with the reply (CTS) of the cell computer. In the next step (Moby write), the time stamps are written to the pallet. The cell computer checks the RESULT for:
- Mismatch of limits and parameters.
- With a LUM, the actual value must be within the min and max limits.
- Result, the parts processed in the correct sequence.
- Are the time stamp, the product number, the production index known to the cell computer.
- When a test was not successful, the cell computer returns NOK.

Special Characteristics of Loading Station[9]
On the loading station, the time stamp is 0 in the RESULT. If the cell computer receives a result from a loading station, it generates a time stamp and sends it with the CTS to the loading station. In the loading station, the new time stamp is directly written.
**Part Moved from Pallet**

When a part is taken from a pallet, the PLC sends an STC with the corresponding action. The cell computer enters this information in the database and replies with a CTS.

**Status Messages**

Status messages of the IPC are transmitted with an STC. The status messages include: Trouble, Tool change, Material is low.

**Sequence of Product Change[10]**

When the product data form between the remote cell computer and local station have different product numbers, a product change exists. The station now has to request the new product data from the cell computer.

1. The station works with product A; a pallet with product B enters the station
2. the product number is written to the Moby station Data Block(DB)
3. A difference between the Moby DB and the product data DB is detected, Detection of Product Change

Originally, the function block detected a product number difference only the product data form between the remote cell computer and local station.

**Rework**

When a rework product is processed on a line, no parts are placed on the loading stations. However, the cell computer must receive a result. Since the loading station cannot be deselected in pallet control, physical loading is switched off via a parameter.

The communication between MCC and IPC involves a lot of complex process, the response process of STC from IPC is briefly introduced(Figure 5).

**Conclusion**

The frame of the Booster Assembly System is shown as an example in the paper, the designs of the cell computer data flow and processing functions is expatiated. The sequence for telegram, product change, pallet control and rework is illustrated in details. The research has provided a practical, well-established data flow to improve the reliability, flexibility and effectiveness of assembly line control systems.
Figure 5. Response Process of STC.

References

[1] Baldwin, C., Hippel, E. von, 2011. Modeling a Paradigm Shift: From Producer Innovation to User and Open Collaborative Innovation. Organization Science 22 (6), 1399–1417.

[2] Mehrabi MG, Ulsoy A G,Koren Y, Trends and perspectives in flexible and reconfigurable manufacturing systems, Journal of Intelligent Manufacturing, 2002, pp. 13-135.

[3] XieNan, Li Aiping, Xu Liyun, Reconfigurable manufacturing system and their key techniques, Journal of Tongji University:Natural Science, 2005, 33(11):1513.

[4] Zoz & Partner GmbH, Karlsruhe, Gateway, Zoz & Partner GmbH, Karlsruhe, 1999, unpublished.

[5] Song Zhifeng, Chen Yitao. Design of Flexible Assembly Control Systems Based on data medium Moby-I[J]. ICECE 2010, 736-739 (2010).

[6] Song Zhifeng, Chen Yitao. Design of Flexible Assembly Control Systems Based on Ethernet. ICIMA 2010, 50-53 (2010).

[7] R. Gans, EIS, Produktionssteuerung und WT-Kontrolle, CONTI TEVES, 2009, unpublished.

[8] Information on http://www.conti-online.com.

[9] R.Gans, EIS, Maschinendatenerfassung, CONTI TEVES, 2009, unpublished.

[10] CONTI TEVES, Telegrammstrukturen, Zoz & Partner GmbH, Karlsruhe 2002, unpublished.