International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064

Flex-Ray is Designed for Plastic Injection Molding Machines

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Abstract: ***This innovative application of the Flex-ray technology with the ARM controller is implemented to monitor and control the process of the injection molding machine with the help of host computer. Embedded technology and Flex-ray field bus technology are utilized together for the efficient functioning of injection molding machine. The closed-loop control system, composed of the ARM controller and sensors, realizes the prompt adjustment of the processing parameters, such as temperature, flow, injection pressure and the control of multi-stage injection pressure in the molding process to produce best product in best quality. Flex-ray technology with Artificial Intelligence used in this process to monitor and control the parameters at the high transmission rate.***

Keywords: Flex-Ray Transceiver, injection moulding machine; distributed control system; artificial intelligence.

1. Introduction

At present, the control mode of injection molding machines is mainly stand-alone control, which cannot provide the network control function for injection molding machines. The maintenance and the management for the machines are also limited to on-site management level. This kind of operation and management mode is not only unable to meet the requirements of automation and scale production, but also it is harm to the operator's health because they are long time working in the environments that is full of machine noise and plastic smell. In order to solve the problems mentioned above, the best way is to develop a kind of flexible, effective and practical control system of injection molding machine and establish the automation production line. In regard to this, a new distributed intelligent control system based on ARM and FLEX-RAY field bus was presented in this paper. This control system can realize the distributed intelligent control and the on-site monitoring of the injection molding machine. Besides, the hardware composition and software design scheme of this control system are also discussed in this paper. FlexRay is an option for upgrading existing network systems using CAN in the automotive industry as well as other industrial control applications. It could also be used for new applications in industrial automation, where safety and reliability in a work environment is of utmost importance, due to its deterministic approach to communication of the messages. This is helped by the use of a two channel topology where each channel is able to work independently, but the two channels can also be used to communicate the same information and as such has built in redundancy. The FlexRay protocol has been designed to carry information at a rate of 10Mbits/s over each of its two channels while CAN has a data rate of 1Mbit/s [3][8]. This means that an equivalent data rate of 20Mbits/s can be achieved which is twenty times that of a CAN based system. The high bit rate of FlexRay systems makes it suitable as the basis of a network backbone even where CAN is already in use. A Fieldbus network has a data rate of around 31.5Kbits/s. When the data rate is compared to that of FlexRay there emerges a view that FlexRay, if used with an existing CAN system, could take on a similar role of the HSE communication role used in Foundation Fieldbus.

2. System Architecture Design

The ARM-based distributed intelligent control system mainly consists of the host computer, FLEX-RAY fieldbus, ARM controller as the slave computer and other accessories, as shown in Fig.1. The control center of the system, host computer, together with FLEX-RAY fieldbus, connects all ARM controllers scattered in different working locations, realizing the distributed intelligent control for the injection molding machines. The main functions of the host computer include the initialization of the network, the communication management between the ARM controllers, file transfer, the status monitoring of the machines, product information statistics, the remote maintenance of the systems and the software upgrades. The ARM controller, as the middle bridge, can provide the remote control for the host computer and can carry on the local control for the machine, such as the setting and modifying the processing parameters, detecting, displaying and controlling the status parameters such as the injection pressure, the flow, the temperature and so on.

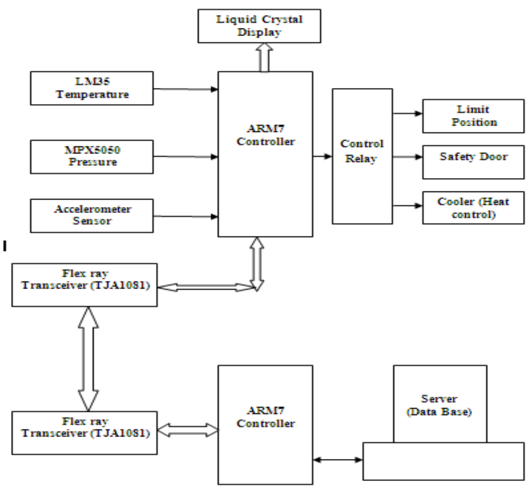


Figure 1: Block diagram

3. Network Topology

The Flex-Ray protocol defines a two channel network, channel A and channel B. A node can be attached to one or both of these channels. If a node is attached to a single channel it does not matter if it is channel A or channel B. The Flex-Ray protocol allows for various bus topologies. These can be a point to point connection, passive star, linear passive bus, active star network, cascaded active stars, hybrid topologies and dual channel topologies. The FlexRay protocol will support hybrid topologies as long as the limits of each topology which makes up the hybrid topology(i.e. the star and bus topologies) are not exceeded shows the possible connections in a dual channel configuration.

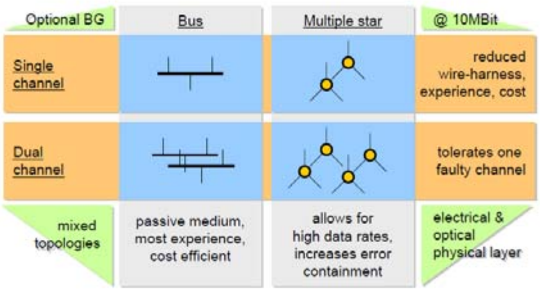


Figure 2: Flex-ray topology

4. Flex-Ray Hardware

Each node has a communication controller, a host, a power supply unit and two bus drivers, one for each channel. Fig 3 [8] shows the logical connections of each element. The host handles the applications of the system while the FlexRay protocol is handled by the communications controller. The bus driver is used to read and write data to the physical medium over which the data is transmitted. In sleep mode it also has the ability to start the wakeup procedure if it detects a wakeup symbol. The communications controller will mainly handle the framing of data and the checking of received data to ensure it was uncorrupted before passing it to the host. The host and communications controller share information such as control information and payload data from the host, while the communication controller relays status information and data received. The host interface to the bus driver allows it to change the operation of the bus driver as well as read status and error flags.

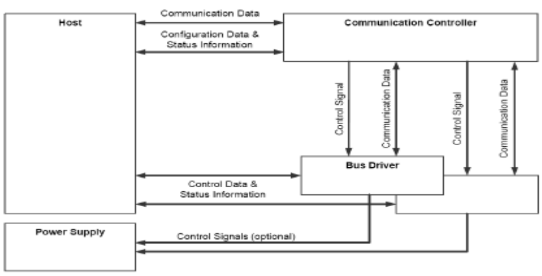


Figure 3: Flex-ray protocol

4.1 TDMA

In a TDMA system the communication cycle is broken down into smaller time segments referred to as slots. The duration of the slots in the static segment are the same. The slots are assigned to a given communication node so that in every communication cycle only that node can transmit at that time. It should be noted that Flex-Ray does provide a cycle multiplexing system so that information can be sent out every odd cycle for example. This allows another message to be sent in that slot during the even communications cycles and again this message would also be set to that slot in that multiple of the communication cycles. Also a node may get more than one slot per segment depending on the setup of the system and the need to send different messages. This approach to message arbitration leads to a very deterministic networking scheme making it very suitable for monitoring and safety systems applications.

4.2 Static Segment

The static segment is broken down into smaller sections called static slots. Every static slot is of the same duration. During transmission each slot is assigned to a specific message and only that message can transmit during that slot time.

4.3 Dynamic Segment

The Dynamic segment is an optional section of the communication cycle. It is broken down into smaller sections known as minislots. If a node wishes to communicate it must wait until its minislot comes around. If no transmission occurs after a given period the minislot counter is incremented and the node with the next message/frame id may begin transmission of data. The data to be sent will only be sent if there is enough time left in the dynamic segment. In this way the dynamic segment is priority driven with the message with the lowest ID having the highest priority, just like CAN.

4.4 Symbol Window

A symbol is used to signal a need to wake up a cluster amongst other things. This depends on the symbol sent and the status of the controller at the time. Within the symbol window a single symbol may be sent. If there is more than one symbol to be sent then a higher level protocol must determine which symbol gets priority as the Flex-Ray protocol provides no arbitration for the symbol window.

4.5 Network Idle Time

The network idle time is used to calculate clock adjustments and correct the node's view of the global time. It also performs communication specific tasks and uses up the remaining time of the communication cycle.

5. Frame Format

The frame of a Flex-Ray message is broken down into 3 sections: the header, payload and trailer section as seen is Fig 6. When compared to the CAN frame format, both standard format and extended format, it can be seen that the frame format of Flex-Ray is much larger. This is partly due to the extra error checking. The header section contains status information such as status bits indicating if the fame is a null frame, i.e. contains no payload data, or if the frame should be used for clock synchronisation. There are also bits to indicate the length of the payload transmitted and cyclic redundancy check (CRC) bits so the receiver can determine if the header was received correctly. The payload contains the data to be transmitted over the network. The payload may also be used to transmit more frame information as an option and this would be indicated in the header of the frame. The payload length can vary from 0 to 254 bytes. When compared to the 0 to 8 bytes in a CAN frame this is a significant improvement. The trailer section contains a 24 bit CRC that is calculated over the payload and header sections. This is used by the receiving node again to determine if the frame was received without any errors.

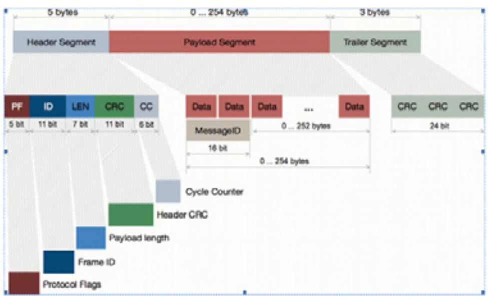


Figure 4: Frame format

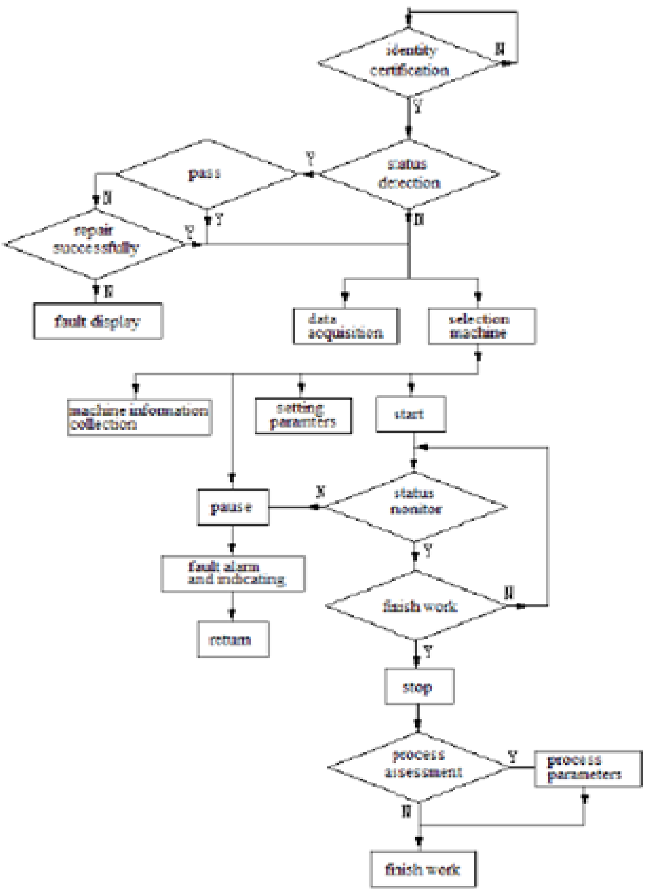
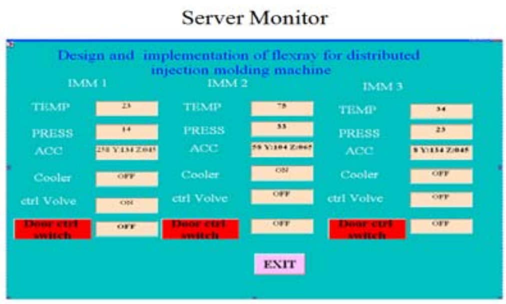


Figure 5: Flow chart of host computer

6. Result analysis



7. Conclusion

In the process of plastic molding, the setting and control of the process parameters of the machines are critical. The experiments have showed that the ARM-based distributed intelligent control system of the injection molding machine can improve the control capability and the management level by optimizing the process parameters, dynamically tracking and controlling the molding process, and establishing and updating the processing knowledge base. Compared with similar products, this control system can decrease the preparation time, increase the yield and qualified rate of the products, reduce the default rate, and enhance the safety performance of the system. The intelligent setting of the process parameters, the prompt and accurate statistics of the process information and the automatic generation of the working reports, all these information provide the theoretical basis for the scientific decision, which has important significance to the development of our country's injection molding industry.

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