PLC Programming of an Inline Transfer Machine for the Production of the Core Bush of the Automobile Tyre Valve

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***Abstract*— The Valve Stem is a pneumatic valve that admits pressurised air into the automobile tyre or tube and then closes to prevent leakage of the admitted air, thus keeping the tyre inflated. The Valve stem contains a spring assisted poppet valve called the valve core to perform this function. The bush forms the body of the core and provides complete sealing inside the stem in addition to providing a proper seating to the core inside the valve stem. The bush is produced on an inline transfer machine comprising several workstations that have individual functions. The raw material is progressively machined as it moves from one station to the next on a transfer mechanism, so as to get the finished product i.e. the bush, at the ejection station. The process of manufacturing the bush is carried out by PLC programming. An attempt has been made in this work to control the operations performed by this automated production line for the machining of the bush. The PLC programming is carried out in order to achieve control over every function of the machine, the workstations, poka yoke system and to enable easy fault traceability through the Human Machine Interface (HMI). Safety of the machine and the operator is realised through programming. The replacement of relay based hardwiring by PLC programming makes the control panel much more compact and troubleshooting significantly easier.**

Keywords*— *Valve Core Bush, Inline Transfer Machine, PLC Programming, Poka yoke systems.

I. INTRODUCTION

The automobile tyres are inflated through a pneumatic valve called the valve stem shown in Fig.1. The valve stem consists of a spring assisted poppet valve called the valve core. The core opens to admit air into the tyre or the tube and then closes by means of spring force, to ensure that there is no leakage of air so that the tyre remains inflated. A complete sealing between the inner wall of the valve stem and the core is provided by the core bush which forms the body of the core. [1]

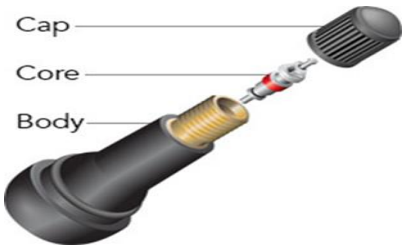

Fig 1: The Valve Stem

In the tyre valve industry the bush is produced on an inline transfer machine composed of several workstations having different functions (Fig.2). These stations consist of spindles to which the machining tools such as drill bits are fixed. The workstations are arranged in a straight line with a convenient pitch. Inline configurations are characterized by multiple workstations arranged in a more or less straight line and a transfer mechanism that feeds the work parts to the stations.[2] In this machine the raw materials are clamped to the work holders and fed to the fixed workstations on a sprocket-chain mechanism that is driven by an indexing cam coupled to the output shaft of a gear reduction motor. A brake induction motor drives the indexing cam through the gear reduction box. The workstations are driven by cams that are mounted on a single camshaft which is driven by the same brake induction motor. The spindles of the workstations are driven by induction motors that are provided for each machining station. The operations performed by the workstations include drilling, facing, chamfering and grooving.

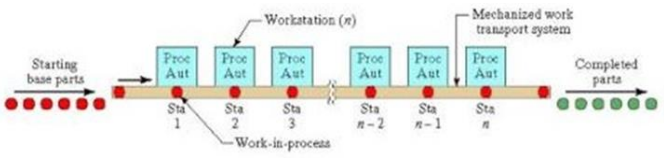

Fig 2: Inline Transfer Mechanism

The electrical control of these operations can be achieved by conventional relay based hard wiring or by using a Programmable Logic Controller (PLC). PLC is a digital computer that is used to automate electro-mechanical processes in industries. A PLC module is shown in Fig.3. In order to achieve a compact control panel, higher efficiency, lesser downtime and easier troubleshooting, PLC is chosen over hardwiring. [3]

Fig.3: PLC Module

PLC Programming has been implemented for various industrial applications such as the production of steel where parameters like temperature, rate of cooling etc. are controlled by the PLC.[4] In addition to this there have been implementations of PLC in models such as that of a soft drink production line.[5] There are also many applications where poka yoke systems are implemented through PLC Programming to increase the efficiencies of processes and to obtain products that are free from defects.[6]

The present work attempts to develop a PLC program to achieve control over individual workstations of the inline configuration machine that produces the valve core bush. The programming ensures safety to the machine and the operator in addition to making fault traceability much easier through the Human Machine Interface (HMI). Poka yoke systems are implemented to check the dimensional accuracy of the machined product.

II. METHODOLOGY

The methodology involved in programming the automated production line that produces the valve core bush is as follows.

- *Listing all the inputs and outputs of the machine.*
- *Identifying the conditions to be satisfied.*
- *Configuring the PLC Hardware.*
- *Writing the ladder logic program on the PLC software based on the application requirements.*
- *Simulating the program and checking for faults in the program.*
- *Downloading the program to the PLC memory.*

The machine is then run in the auto mode, jog mode and single cycle mode as per the conditions of the program, to test whether the program is in agreement with the requirements. The program is fine-tuned if the requirements are not met. The program is then simulated. Before the program is used for mass production, the faults in the machine are identified and eliminated.

III. THE FUNCTIONS PROGRAMMED IN PLC

The following are some of the functions of the machine that are achieved through PLC programming.

1. Auto Mode: This is the mode in which there is mass production of the valve core bush. The mode is programmed such that it is executed only if,

- The Emergency Push Button is released.
- The switch used for selecting different modes, is positioned in the auto mode.
- All doors are closed.
- No emergency faults or poka yoke faults are activated.
- The machine has completed a single cycle, once.

If the above conditions are satisfied the machine can be run in the auto mode. The mode is started by switching on the oil pump. The machine is programmed such that the motors of the workstations switch on only after the oil pumps are turned on. A short time delay is achieved between these two operations using the ON Timer function.

2. Single Cycle Mode: In this mode, the cam shaft is required to complete one full rotation so that all the workstations are in the home position before beginning the auto mode.

3. Jog Mode: This is a mode used to run the machine in small steps, only as long as the pushbutton is pressed. This mode helps to observe the movements of the workstations to find out if there is any mechanical fault.

4. Door: The programming ensures operator safety by enabling the machine to run only when all the doors are closed. To achieve this, the doors are provided with sensors.

5. Faults: The faults that would cause damages to the machine or would result in hazard to the operator are treated on first priority by making the machine stop immediately if those faults occur. Such faults include current overload and excessive resistance in the transport chain. On the other hand, error signals from sensors, poka yoke systems etc. are faults that would only require the machine to stop after homing. The faults are displayed on the HMI screen when they occur.

6. Encoder: An absolute encoder is used to get the position feedback of the cam shaft. This feedback is required to know the initial and final positions of various station cams in terms of cam angle. Gray to Binary conversion is employed in the programming related to the encoder. The cam angles can also be modified on the HMI screen.

7. Counting of parts: The program uses shift register and counter functions to count the total number of parts machined, the number of good parts and the number of defective parts. All these numbers are displayed on the HMI screen.

There are also other functions like machine life display on HMI, control of machine lamps and vibrating feeder bowl that are programmed and controlled using PLC.

IV. CONCLUSIONS

The PLC programming meets the requirements for the production of the valve core bush. It ensures that the machine is operated under safe conditions in addition to implementing Poka yoke systems for elimination of defects. Through programming, control is achieved over each work station and fault traceability is simplified by implementing the HMI.

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