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Key way Milling Machine Automation Using PLC and HMI

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ABSTRACT: The one of the most important application area for automation technology is manufacturing industries. Because of this technology there is an increased advancement in industries which results in precise control of manufacturing process and significant cost savings. Milling is one such type of manufacturing process which plays a vital role in engineering works. Milling process removes material from the work piece by advancing tool into work piece. Key way milling machine is a special type of machine especially for milling the key ways on axles of trucks and other heavy load carrying vehicles. After the complete study on key way milling machine, it was found that machine operating with obsolete PLC has capacity limit and can no longer add new controls. Using latest PLC and HMI, the machine can be automated to increase the flexibility of system with smooth control of process. Together with this inclusion of milling on the other side of machine reduces the manual power and increases production. Thus, key way milling machine is automated with latest PLC control with HMI for design and implementation to produce a finished product.

KEYWORDS: Keyway, Milling, Programmable Logic Controller (PLC), Human Machine Interface (HMI), Control panel.

I.INTRODUCTION

As the technology improved, it brought a change in each and every sector including the manufacturing industries. Manufacturing industries certainly needs to upgrade to compete globally, but without any effective method it is not possible to compete with its emerging market peers. Automation is the one such technology which gives a big push to industries. There are many tools available for automation, PLC and HMI are used for the automation of key way milling machine.Programmable logic controller (PLC) is an industrial digital computer which is used in almost all industrial application solution right from small machine to large manufacturing plants. PLCs are programmed in such a way that it handles the complicated logic operation and easily changes the logic state. Human-Machine Interface (HMI) is formerly known as Man-Machine interface which is capable of handling human machine interaction. PLC together with HMI makes the system convenient and reliable.

Keys and keyways are mainly used for coupling the various machine elements. For a key to function, the rotating machine element and shaft must have a keyways, which is a slot and pocket into which the key fits. In vehicles, the axle is fixed to the wheels, with the wheels rotating around the axle. But wheels are cannot connect directly to axles, in order to attach the wheels to axle keyways are made on both axle shaft and hub of the wheel. This keyed joints ensures the connection and enable the axles to transmit the driving torque to the wheel.In existingsystem, the Key way milling machine is operated based on the obsolete PLC control system.Declining parts availability and lack of technical support will eventually cause a catastrophic unplanned downtime event. Identification of trouble in system caused by a failure is critical which leads to difficulty in troubleshooting.Because of only one side key way milling is available, to make the Key ways on other side of work piece operator has to change the position of work piece which is time consuming. All these difficulties are resolved by the inclusion of one more milling station on the other side of existing system and upgrading the machine to a modern PLC platform with introducing HMI to control lines.To upgrade the machine, control panel and operating panels for the key way milling machine is designed, developed and implemented.

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II. CONTROLLING OF KEY WAY MILLING MACHINE USING PLC AND HMI

Figure 1 shows the key way milling machine. The block diagram of the controlling system of the machine is as shown in Figure 2. It shows the interconnection between PLC, HMI and various input-output devices such as push buttons, selector switches, limit switches, solenoids and motors. Push buttons are for star and stop operation. Selector switches are used to select different circuit conditions. Limit switches automatically monitors and indicates whether the movement limits of a particular device have been exceeded. Based on the inputs PLC give the output to solenoids and motors. Solenoid is for forward, reverse and rapid movement of milling head. HMI is for the communication of the machine with outside world. HMI helps to display the ongoing operation.PLC controls all the output devices as per the program and get the desired controlled processes.

This implemented automation scheme will help to meet the desired requirement.As the system is completely automatedwith latest PLC control and HMI, initial setup time is considerably very less. It is easier to troubleshoot the problems with the use of visual alarms and diagnostics data on HMI. Breakdown time of system is reduced which results in less maintenance cost and also reduces production time. It is possible to track the complete shift wise production of the system. Inclusion of one more milling station on right hand side of machine enables the two way milling results in increase in the production of the system and reduces the manual work. This proposed system is safer and operator friendly.

Figure 1: Keyway Milling Machine

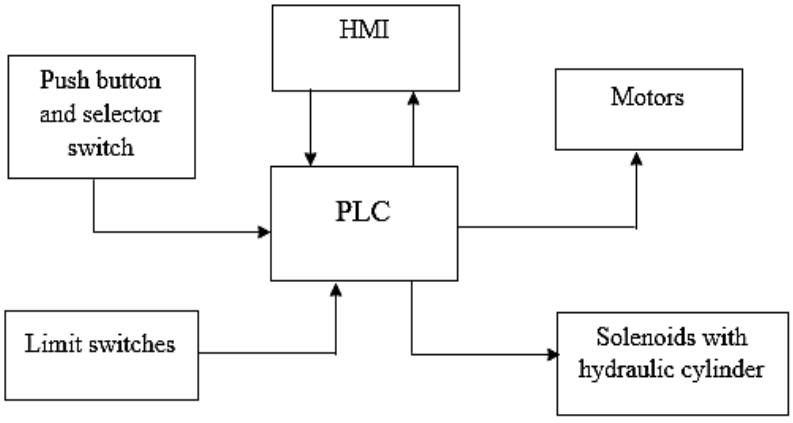

Figure 2: Block diagram of controlling system

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III.OPERATION SEQUENCE OF MACHINE

When the cycle starts, before setting up a job PLC checks for all the limit switches to be in their respective home position, if not operation will come to end. Once operation starts hydraulic motor turns on. Operation on left hand side of machine takes place first in sequence. LH pusher forward pushes work piece to left side of machine. The work piece is clamped tightly to table to secure a work piece and piece is held so it will not spring or vibrate under cut. If LH vertical milling and LH horizontal milling enable is given which turns on the vertical motor and horizontal motor, there by spindle turns on. Coolant motor turns on which ensures the supply of coolant during the complete process. Both vertical and horizontal milling head slide rapid forward. Feed of milling tool will set i.e, drill bit against work piece starts in forward direction. Once the desired shape is obtained feed ends. Milling head slide rapid reverse, feed will reset. Both LH vertical and LH horizontal milling is considered as a LH complete. If milling is not get enable the operation on LH side comes to end. After completion of milling operation on LH side, work piece is declamped from the table then LH pusher reverse pushes the work piece in reverse direction. During operation lubrication motor will be on for 5mins to reduce the friction developed between the parts.Now RH pusher forward pushes the work piece towards the Right hand side of the machine. The work piece is tightly clamped on RH side, when RH vertical and RH horizontal spindle get enable, above sequence of operation during left hand side milling of keyways repeat in right hand side milling of keyway. After the completion of keyway milling operation on RH side, entire cycle is consider as one complete cycle and taken into count. Figure 3 and 4 shows the operation sequence on left hand and right hand side of machine.

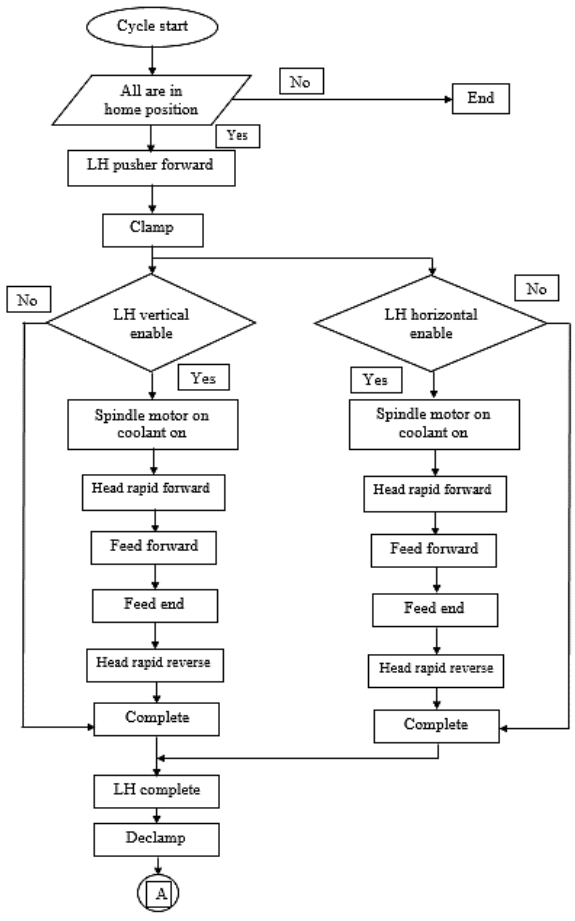

Figure 3: Flowchart of the machine operation on LH side of machine

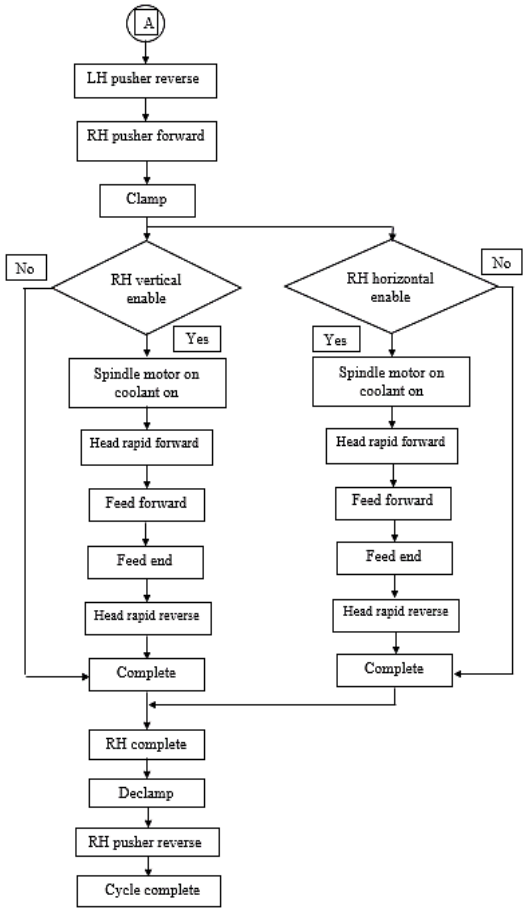

Figure 4: Flowchart of the machine operation on RH side of machine

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IV.IMPLEMENTATION STEPS

Figure 5 shows the step by step procedure followed to develop the control panel and operating panels for key way milling machine.

- **Data Collection -** Based on the studied information of the system, required components for the design and development of control panel are chosen. This includes the selection of PLC, HMI and other I/O components.
- **Control system design and development -** It includes designing the layout drawing of panels for general arrangement of control panel, internal arrangement and power wiring. In accordance with the drawings electrical components are assembled with in the control panel.
- **Control program for PLC and HMI -** Using software like GX Developer for PLC and GT Designer for HMI, programming is done using PC. Ladder diagram is used to write the PLC program which converts the electrical circuit into a s executable logic using NO, NC contacts, master control relays, timers, counters, coils, etc.,.
- **Testing and Modification -**After design and developing thecontrol system, the panel is being tested in the view of desired automation of the machine and if the design was not success, the modifications would be done and finally the required automated operation of the machine was obtained.

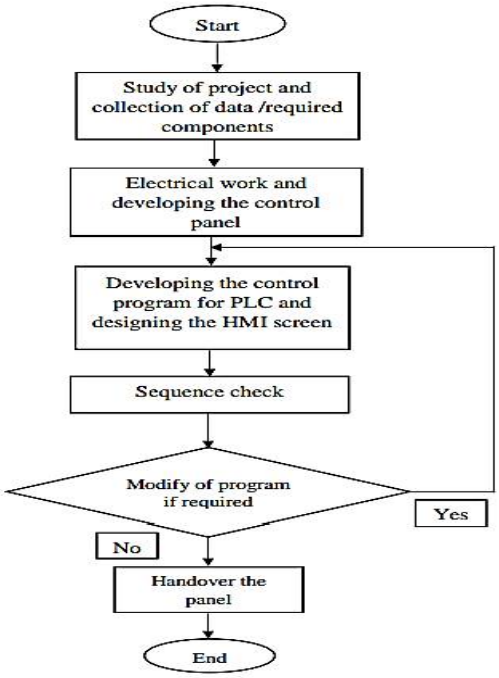

Figure 5: Implementation flowchart

V. DEVELOPED CONTROL PANEL FOR KEYWAY MILLING MACHINE

Control panel manufactured for the Key way milling machine mainly consists of Programmable Logic Controller (PLC), Human Machine Interface (HMI), relay boards, etc. These components are wired and connected to the Key way milling machine.The panel cut-out is done according the layout diagram and the components are assembled in the panel. Wiring is done as per the power distribution diagram. Figure 6 shows the snap shot of control panel designed for automating the key way milling machine.

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- **SMPS:** Autonics made 24VDC, 10A. It gives supply to the PLC. Input is from step down transformer.
- **PLC:** FX5U CPU module 40input, 40output. 64K programmable capacity. Contains the main program, input is from push buttons, limit switches and gives required output signals to particular component.
- **MCB:** 2Pole, 10A. It is placed for the protection of transformer, input to MCB is from the mains and output is to transformer.
- **MPCB:** 3Pole, MPCB, for motor protection and line protection. Input to MPCB is from mains and output is to motor.
- **8 channel relay board:** These relay boards are placed for protection of circuit components. The output from the PLC goes to motors and solenoids through this relay board.
- **Contactors:** Power contactor. The motors in the key way milling machine are connected to panel through contactors. Input to contactors is from relay, output is to motors.
- **Transformer:** Steps down the voltage from 440V to 230V and 110V. Input is from the 2pole, 10A MCB and the output is given to SMPS.
- **Terminals:** The inputs from milling machine to PLC i.e., limit switches are connected through terminals. It acts like mediator between the field and the control panel.

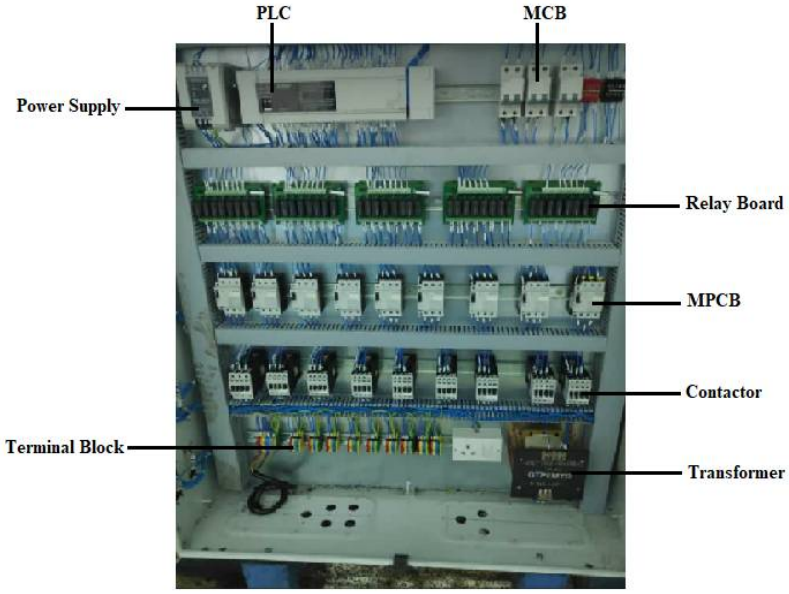

Figure 6: Control panel for key way milling machine

The 3-phase, 440VAC supply is given to the control panel by turning on the rotary switch (RS). From switch power flows to MPCB and transformer, from MPCB power flow to contactors then to motors in key way milling machine. The 1KVA step down transformer step downs the supply voltage 440VAC to 230VAC and 110VAC as a dual output voltages. 230VAC is converted to 24VDC using switch mode power supply (SMPS), 24VDC is given to PLC. 110V AC is used to relay common terminals.

VI.DEVELOPED OPERATING PANELS FOR KEYWAY MILLING MACHINE

Figure 7 and 8 shows the developed operating panel for right hand side (RH) and left hand side (LH) of the keyway milling machine. It consists of push buttons, selector switch, HMI, emergency stop switch. Push buttons are provided to turn motors on or off, forward & reverse movement of milling head and cycle start. Selector switch for choosing coolant and selection of Auto/Manual mode is also provided. Mitsubishi HMI of 7.0 inches, (800*480) pixels, 9MB ROM is used.

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Figure 7: RH operand

Figure 8: LH operand

VII.SOFTWARE DESCRIPTION

Mitsubishi PLC and HMI module is used for the system. Ladder diagram was used as programming language; the ladder programming has been developed in GX Developer for process control of keyway milling machine. HMI screens are designed using GT Designer. RS-485 communication cable is used to dump the program from PC to the PLC and vice versa. The program is written such that the machine can be run in two mode, i.e. machine can operates in either manual or auto mode as selected by the operator. In manual mode, input is given through push buttons and selector switches. In case of auto mode operation is continuous in accordance with the timer delay provided.

VIII.IMPLEMENTATION RESULTS

Key way milling machine is completely automated using latest PLC & HMI. The machine is automated in such a way that it can run under both auto mode and manual mode. The complete operation is carried out in auto mode. Only during some emergency condition or fault occurs the operation is switched to manual mode. Figure 9 shows the initialization of auto mode of program. By this automation of key way milling machine silent working and smooth cutting of key way is achieved. Inclusion of two way milling increase the production count and reduces the cycle time considerably. Together with all these benefits automation makes the key way milling machine versatile and durable for very long time. Figure 10 and Figure 11 shows left hand and right hand side of key way milling machine.

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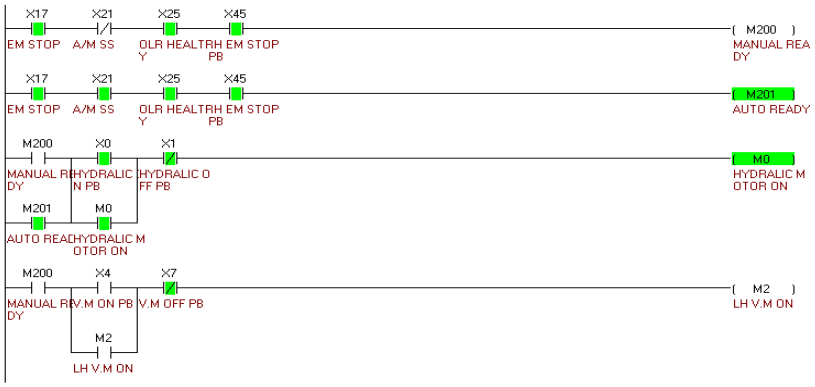

Figure 9: Ladder diagram of Keyway milling machine

Figure 10: Left hand side(LH) side of Machine

Figure 11: Right hand side(RH) side of Machine

Developed HMI screens:

The HMI screen developed for the interface between the user and the machine using GT Designer software.
During the operation of machine main screen(Figure 11) appears on HMI. This main screen shows current mode of operation of machine. It has a visual disply of ongoing process of machine during operation. It also shows cycle time which is a total time taken by the machine for milling the keyways on LH and RH side of work piece is displyed during each cycle. The screen also shows the production count of the machine which helps in production tracking of the machine and it can be easily reset. By selecting the INPUT, OUTPUT and SETTINGS icons on main screen operator can move to respective screens.

When SETTING icon is clicked on Main screen, setting screen appeared is as shown in Figure 12. It shows the lubrication on time on screen. Operator can enable the particular milling from this setting screen by clicking on icons available.

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Figure 11: Main screen

Figure 12: Setting screen

IX.CONCLUSION AND FUTURE WORK

Key way milling machine with obsolete PLC was less reliable, time consuming, requires maintenance and skilled operator. Thus in order to overcome from all these drawbacks and difficulties keyway milling machine is automated using latest PLC control with HMI to enhance the performance of the machine by increasing the productivity and accuracy. Also with the inclusion of two way milling machine, operation requires less labour power with good quality of product. Analysis of critical condition and fault detection becomes quiet easy because this automation tools. The combination of hardware-software approach helps even an unskilled labours to operate the machine quite efficiently. This will fulfil all the requirements of the industry with good levels of accuracy and reliability thereby yielding a more robust system.

The machine can be further implemented by including one more Horizontal spindle (Horizontal 2) on either side of keyway milling machine with existing vertical and horizontal models to increase the number of keyways on axles.

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