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PLC Controlled Automatic Nut Tightening Machine

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ABSTRACT

This paper presents automation of the nut tightening controls by a PLC. In this project Bosch Rexroth PLC is been used. With this PLC based approach the whole process can be automated only the loading and unloading the part remains manual. The process lead time is reduced and is completed in 13 seconds according to the trials conducted. The tightening procedure is accurate according to the specific torque thus preventing any damage of the component. For tightening system Bosch Rexroth fastener is used.

Keywords : PLC , Tightening System, Fastener, Torque

I. INTRODUCTION

Automation is the use of various control systems for operating equipment such as machinery, processes in factories, boilers and heat treating ovens, switching on telephone networks, steering and stabilization of ships, aircraft and other applications and vehicles with minimal or reduced human intervention.

The biggest benefit of automation is that it saves labor, however, it is also used to save energy and materials and to improve quality, accuracy and precision. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronic devices and computers, usually in combination. Complicated systems, such as modern factories, airplanes and ships typically use all these combined techniques.

In the project the whole process is controlled through PLC A programmable logic controller (PLC), or programmable controller is an industrial digital computer which has been ruggedized and adapted for the control of manufacturing processes, such as assembly lines, or robotic devices, or any activity that requires high reliability control and ease of programming and process fault diagnosis.

In feed pump assembly line, screw plug is tightened manually using a pneumatic nut runner. Parts are over-checked for Tightening Torque manually using Torque wrench. Inconsistency was observed in the Tightening torques achieved due to manual process also resulting in Copper washer damages which led to Customer complaints for leakage in HP zone.

The main aim is to develop an automatic screwing machine using Bosch Rexroth electric fastener for screw plug tightening on feed pump housing. This system also includes a torque feedback system.

II. SYSTEM DESCRIPTION

A. Component Description

Feed pump component with two screw plugs. Each screw plug has a specified tightening torque level according to which the respective screws must be tightened. One screw plug with torque level 40+20nm another screw plug with torque level 80+20nm.

B. Machine description

The whole machine is designed in such a way that it is compact and cost efficient. The component loading is at the height of 1080mm and floor area occupied is 1000X80mm.

The components are placed in specific locations according to the design.

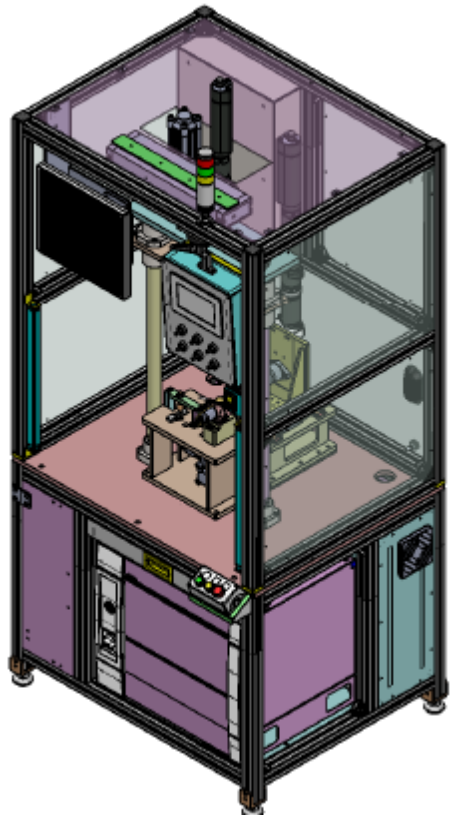

Figure 1: Machine Structure

The main machine body basically consists of the following components:

1) Tightening System

The tightening system used in this project is the Bosch Rexroth tightening system 350 which offers complete solution, from hand-held tightening systems to fully-automatic tightening stations which can be seamlessly integrated into production lines. In the setup two nut runners are used one for the horizontal direction and another for the vertical direction nut tightening with the vertical nut runner torque as 100nm and the horizontal nut runner torque as 50nm.

The fasteners were tested manually and feasibility trials were conducted for 15 pumps. As the result the all the torque values achieved was almost constant for all the 15 pumps. The sealing was found to be effective and the copper washers were not damaged during screwing this was checked by dismantling.

The electrical fasteners are moved using the pneumatic cylinders. The vertical nut runner has the vertical nut runner spindle up/down cylinder, and the horizontal nut runner has the forward/reverse cylinder. These cylinder are operated at the operation pressure of 4-5 bar.

2) Safety Curtain System and Alarm System

The Safety Curtain system is for the safety purpose of the work station operator. The SCHMERSAL Safety light curtains are utilized, these are the optoelectric safety devices which are used as entry, danger point or danger zone guards. These curtains are placed at the entry point where the component is loaded on to the fixture. If there is any interruption or forced entry when the process is taking place, it can be both manual and automatic mode the whole process halts thus protecting the operator from any danger or accidents. The outputs of these safety system is given to the PLC controls.

The alarm system is for indicating any start or stop of process or any errors during the process. This system is integrated with the PLC Controls. Both sound(buzzer) and lamp indicating are included in the system.

3) PLC and HMI System

The PLC used is the Bosch Rexroth IndraControl L25. It scalable hardware platform and has standardized communication interfaces. HMI utilized is IndraControl V with 7 inch display.

The communication mode is the profinet cable. The control panel mainly consists the IndraControl L25 PLC, Sb365 system box is required to support the control and power electronics of the nut runner system, it comprises of VM350 power supply module, SE352 control unit, LTS350D servo amplifiers for tightening spindles, KE350 communication unit responsible for internal and external system communication.

The interfacing layout is as shown in the following figure

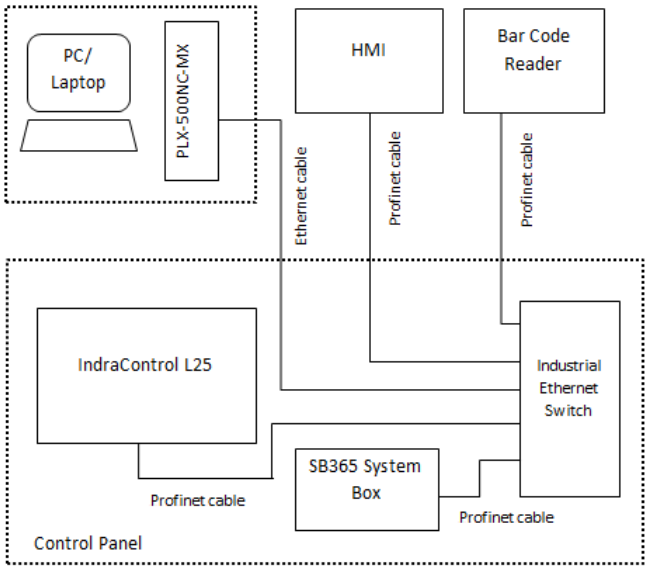

Figure 2 : Interfacing Layout

4) Bar code Reader

Cognex ID readers are used for the barcode reading operation. This helps in maintaining a data log for all the feed pump component. This output is communicated to the PLC using Profinet bus and the details about component is data logged.

The Cognex DataMan 302 fixed mount barcode reader is used, it is the most versatile Cognex fixed-mount barcode reader offering multiple integrated lighting and lens option. Here the codes are in the form of QR codes.

III. WORKING PROCESS

The basic working process is as shown in the flow chart:

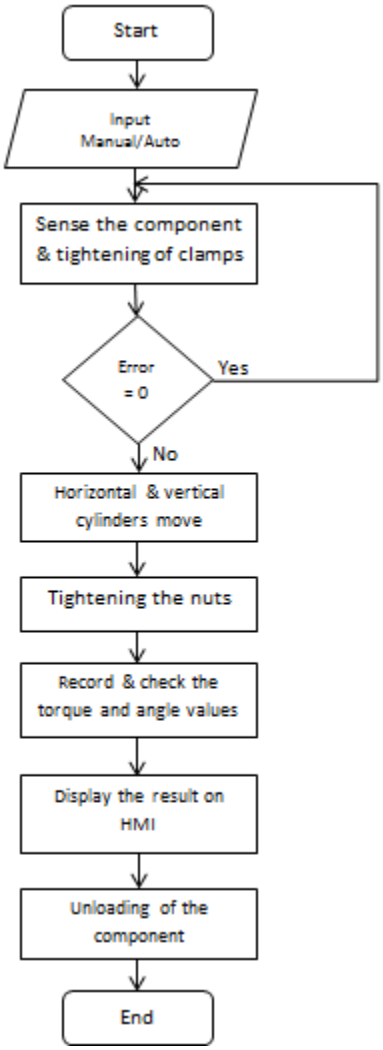

Figure 3: Process flow chart

The feed pump component is loaded on to the clamping fixture by the operator. The proximity sensor senses the presence of the component giving a signal to PLC and the clamps around the component tightens. The operator sets the process in automatic mode or the manual mode. If all the conditions are satisfied the tightening process is initiated. Both horizontal and vertical spindles move forward with the help of the pneumatic cylinder systems provided. The nuts of the component is tightened according to their torque specification, when the tightening is complete the spindles retrieve to their home location.

The torque and angle feedbacks are recorded and the results are displayed on the HMI screen. The results are compared to the specified torque values and pass or fail result is displayed. The ID of the component is recorded using the bar code reader.

After the whole tightened process is completed the clamp loosens up and the operator unloads the

component. Further the component is subjected to the leak testing process where the sealing of the pump is checked.

IV.TESTING AND RESULTS

The trials were conducted on the feed pump. Each cycle was completed in a cycle time of 13 seconds. The 2 trial results are listed in the table below

Sl .No	Spindle	Torque(Nm)	Angle(degree)	Result
1	Spindle 1	90.2	17.05	pass
	Spindle 2	45.2	27.17	pass
2	Spindle 1	90.4	18.13	pass
	Spindle 2	45	16.51	pass

Table: Trials Result

According to the trial the whole operation is completed within 13 seconds which is much less than the manual process. The sealing was checked and was found to be effective. The copper washer was checked and it was damage free. The whole process except the loading and unloading is automated and controlled by PLC thus the rate of error is less and accuracy is increased. The loss due to damaging of the component is almost eliminated.

V. FUTURE DEVELOPMENTS

Since the whole process is automated except the loading and unloading, for future developments loading and unloading part also can be automated by using the robotic arms like KUKA, FANUC etc. This will result in complete automation of the process. The robotic arm can be programmed for the pick and place application for picking the feed pump housing component from the conveyer to the fixture clamp of the tightening machine.

VI. CONCLUSION

This tightening system is a cost efficient hassle free automation saving a lot of manufacturing lead time and cost. The machine is compact and is designed such that it is easy to operate. The whole process is completed in 13 seconds. The 100% over-checking of Tightening Torque in assembly line can be eliminated. Sealing was found to be effective. Copper washers were not damaged during screwing (checked by dismantling). The trials conducted shows us that the results are accurate and the torque specification is achieved. The customers complaints regarding leakage of pump in high pressure zone were solved. The whole process is controlled by the PLC, which is programmed such that operation takes places smoothly without any errors. The safety system is also provided to protect the operator from any harm and danger. Further the process can be completely automated by introducing the robotic arms for the loading and unloading process which is manual at present.

VII. REFERENCES

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