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IMPROVEMENT IN THE DETECTION OF DEFECTIVE COMPONENTS AT ROTA TEST BENCH BY USING A COMBINATION OF PLC AND HMI

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ABSTRACT

ROTA Head Clearance Test Bench is a machine used to check the clearance value of particular elements manufactured on the shop floor. The elements are a combination of a barrel and a plunger fitted together. It is required that the physical dimension of the element is precise and accurate for maximum efficiency. As the elements are batch produced on the shop floor in huge numbers, it is not possible to check each element manually for imperfections. Also, the defects would be too minute to be detected by the human eye. Hence, the ROTA Test Bench is used. It is of two types namely, ROTA Head Clearance and Shaft Clearance. Head Clearance machine is used to check the head of the barrel. Pressurized air is sent thorough the head of the barrel using a pneumatic system. The excess air from the barrel flows through a ROTA tube to the controller which displays the clearance value for that particular element type. The value should be between predefined ranges to be deemed acceptable at the lack of which the component is rejected. Presently, the operators accept or reject the component by verifying the displayed clearance value from a list of component specification manual set near the machine. Hence, this project proposes a system by which a Human Machine Interface would display the complete list of components where the operator can choose the required type. The PLC would then obtain data from the controller to determine of the component can be accepted or rejected. This project is an activity in industrial improvement.

KEYWORDS: ROTA Head Clearance, HMI, PLC, Controller, Elements.

In the industry, where manufacturing and assembling of parts happen on the same factory floor a separate testing unit is essential to ensure the precision and accuracy of the elements. The machine used for this purpose at the BanP Plant of Bosch Rexroth is the ROTA Test Bench. The operation of the machine is such that not more than a few hundred components are tested each day over three different shifts by the operators whereas the numbers of the elements produced in a day are in close to a thousand. These cause a major lag in the assembly line. Hence to increase the efficiency of production an automated solution needed to be implemented. This paper proposes an innovative solution towards that end by interfacing a Human Machine Interface with the PLC of the ROTA machine hence eliminating the need for the manual and the visual testing of the element's clearance. This will also increase the number of elements tested in a day.

METHODOLOGY AND DESIGN

Block Diagram – Present

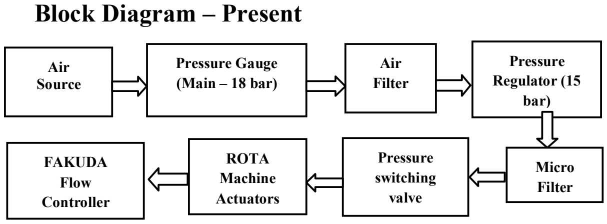

Figure 1: Block Diagram of Existing ROTA Head Clearance Machine

Block Diagram -Proposed

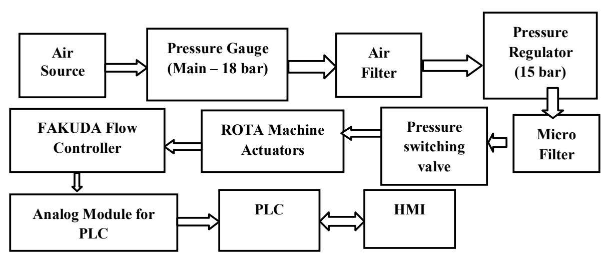

Figure 2: Block Diagram of Proposed ROTA Head Clearance Machine

Construction

a. Programmable Logic Controller

PLC is a programmable Integrated Chip which is used to control and sequence the various actuators present in the automation system. It takes n number of inputs from various sensors and controls the actuators like pneumatic pistons, hydraulic cylinders or robotic arms as according to the input. The PLC is the preferred controller to be used in industrial automation because it is built to withstand the harsh conditions of the industry. In this project, a PLC is used to take the input provided by the flow controller and the HMI.

b. FAKUDA Controller

It is a digital manometer and air leak tester. A range of values can be programmed within in which it would display the value. In this project, the FUKUDA

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controller is used to display the value of excess air from the barrel which is displayed in terms of cc. The air is passed to the controller from the clamping cylinder by using a ROTA tube. This controller is to be connected to an analog module which would be interfaced with the PLC.

c. Analog Module

Analog input modules facilitate connection of the controller to the analog signals of a process. They are suitable for connecting analog sensors such as voltage and current sensors, thermocouples, resistors and resistance thermometers as well as analog actuators. The use of analog input/output modules provides the user with the following advantages. Since almost any combination of modules is possible, the number of inputs/outputs can be matched to suit the task in hand. Superfluous investments no longer exist. A variety of input/output ranges and high resolution facilitate connection of a multitude of analog sensors and actuators

d. Human Machine Interface

The Human Machine Interface (HMI) includes the electronics required to signal and control the state of industrial automation equipment. These interface products can range from a basic LED status indicator to a 20-inch TFT panel with touch screen interface. HMI applications require mechanical robustness and resistance to water, dust, moisture, a wide range of temperatures, and, in some environments, secure communication. The HMI used in this project is Rexroth VCP02. There are various versions of HMI ranging from version 02 to 25. However, for this application, version 05 is sufficient.

REVIEW OF LITERATURE

As machines get larger and scientific applications advance, it is more and more imperative to fully utilize high performance computing (HPC) capability. The complexity and changing landscape of parallel computers may lead to users being unable or unsure how to achieve optimal performance from their applications and fully utilize their HPC resources [1]. Integration, flexibility and intellectualized are trends for current manufacturing system. The flexibility and intellectualized of process structure and process control in product manufacturing are getting more and more important and complex [1] [5]. In many industrial applications the plant characteristic can typically be described by nonlinear differential equations. Thus we are dealing with nonlinear systems. There exist many modern methods in control theory for the control of nonlinear systems. Programmable logic controllers (PLCs) have been used for many decades for standard control in industrial and factory environments. Over the years, PLCs have become computational efficient and powerful, and a robust platform with applications beyond the standard control and factory automation. Due to the new advanced PLC's features and computational power, they are ideal platforms for exploring advanced modelling and control methods [2] [3]. Pneumatic systems are highly complex nonlinear systems. So, pressure p, density and flow velocity c are coupled. Also temperature and other environmental influences affecting this thermodynamic state vary [3]. Hence to derive maximum utility out of the said pneumatic testing machine an automated method is required which would take into account the physical dimensions of the element being tested and also increase the efficiency of the overall production process of which the element testing is a vital part. Advances in the areas of computer interfaces, intelligent systems, smart appliances, and robotics, combined with new applications have resulted in the introduction of such systems. This embodies human-computer interactions, human-machine interactions which are achieved by a Human Machine Interface [4].

TOOLS OF DATA COLLECTION

To collect data for the literature survey, the complete working of the ROTA Head clearance machine was studied. This was done to ensure the creation of an optimal solution which would enable the machine to function more efficiently and also reduce the pressure on the operators. The Test bench comprises of a fabricated base on which fixture is mounted. In this test bench elements i.e. plunger/barrel assemblies, can be tested. DRAGGER pressure regulator with dial indicator is provided to set the specified test pressure for Head clearance checking. For the testing, pure and dry air at specified test pressure of 10 bars or 15 bar depending upon the type of component is passed through the elements by manually operating the pneumatic valve. The leakage air is led to the FUKUDA METER for measurement through a ROTA tube. The clearance value is displayed on the controller's segmented display. This value should be within the specified limits defined for this particular type of component the validity of which is verified by the operator who cross-checks the displayed value with the values given in the manual. The drawback with the present system is that it is time consuming to check the values for the component from the manual everytime a component is tested. It is impossible for the operator to remember the clearance values for all 800 components. Also, there is the possibility of human error. To overcome all these problems a new method had to be implements to automatically check the clearance value of the component. There were three ways in which this could be achieved.

- To completely check the value using a software program.
- To use a specified controller to check the value
- To use a combination of PLC and HMI to check the value.

In the first method, the creation of the software program necessitates outsourcing the cost of which would be around Rs. 4, 00,000/- In the second method, the use of controller would significantly reduce cost, however, the controller's memory is limited to the storage of 50 programs. As the no of components to be checked is 800 it is not possible to use the controller. In the third method, the combination of PLC and HMI cost is much less compared to the first method and can also easily store 800 different programs. Hence this method is to be implemented.

DATA ANALYSIS AND INTERPRETATION

Table 1: Sample elements and required testing details

Element (NO.)	Head Clearance		Angle (deg.)
	Min (cc/min)	Max (cc/min)	
1418301001	30	150	180
2418303002	30	150	217
3408455008	50	150	119
9412038419	80	250	80
F002B10104	10	90	322

Table 2: Clearance Value and corresponding voltage

FAKUDA Controller Reading	Voltage (V)	O/P from Analog Module
0	0	0
200	0.111	325
500	0.277	660
700	0.388	980
800	0.444	1110
1000	0.555	1575
1200	0.666	1865
1400	0.777	2000
1500	0.833	2250
1700	0.944	2800
1800	1	3000

FLOW CHART OF PROPOSED SYSTEM

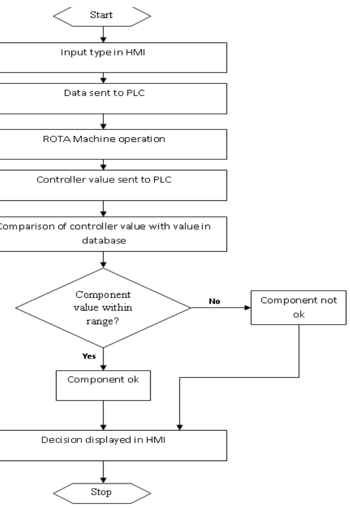

Figure 3: Flow Chart of the proposed system

HARDWARE AND SOFTWARE

Firmware

A programmable logic controller (PLC) is a digital computer used for automation of electromechanical processes, such as control of machinery on factory assembly lines, control of amusement rides, or control of lighting fixtures. PLCs are designed for multiple arrangements of digital and analog inputs and outputs, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed-up or non-volatile memory. A PLC is an example of a "hard" real-time system since output results must be produced in response to input conditions within a limited time, otherwise unintended operation will result.

IndraControl L10 of Bosch Rexroth

The new IndraLogic XLC (extended Logic Control) PLC system implements the latest PLC technology to provide substantial advantages for the intelligent automation of production tools and systems.

IndraWorks software offers a full integration of all necessary tools and a noticeable reduction in the engineering process chain. Object-oriented language extensions in programming enhance the quality of user programs through simplified modularization and accelerate the generation of machine variants.

Scaling and open design of the IndraControl device families are the basis for flexible and application-oriented solutions in central or distributed control topologies. The universal, open real-time communications system sercos III is the high-performance, high-functioning backbone among the system peripherals.

Application-oriented task setting of the high-performance Motion-Logic runtime system permit both rapid I/O signal processing and highly dynamic motion control tasks. Consistent system information and transparent diagnoses throughout the system minimize downtimes and provide a tangible increase in productivity for a wide range of applications and processes.

INNOVATION IN PROJECT

The innovation in this project would be the addition of a HMI programmed with a database containing the specifications of all the 800 different elements from which the operator would simply have to select the type of component to be checked. The controller which is to be interfaced with the PLC would feed the value of clearance to the PLC. The PLC would the compare the values and display OK or rejected on the HMI screen.

EXPECTED SIGNIFICANCE

- Easier to select the component if displayed on HMI.
- Less chance of human error.
- The operator doesn’t have to memorize the clearance values
- The operation of the machine will not depend on selected operators who are familiar with the clearance values. The operators available at that particular shift can be used.
- More components can be checked through the day as compared to before.

CONCLUSION

- This innovation can be implemented on all the testing machines on the shop floor.
- Only the specifications of the elements checked on various machines need to be changed on the database to implement it.
- It saves time for the operator and enables different people to operate on various shifts thus reducing stress on certain operators.

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