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FEEDBACK ASSISTED CLOSED LOOP INSPECTION CONTROL SYSTEM

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ABSTRACT:

This paper is intended to focus on the advanced measurement system, developed for accurate measurements of, dimensions of, a valve guide of an engine. Snap gauges, pneumatic comparators, dial gauges, micrometers, etc are traditional instruments used for inspection. These methods may lead in inaccurate job inspection. So, to overcome the drawbacks associated with traditional equipments, one can develop an advanced measurement system using sensors, actuators and control system. The sensing unit of this system consists of two LVDT probes. Control unit is a programmable logic controller (PLC), while actuation unit has electromagnetic relay and a display. Along with this, a mechanical fixture mounted with LVDT probes is used to hold the job to be inspected. A job to be inspected has to be kept on mechanical fixture. Two LVDT probes which are fixed on fixture displaces as per the job profile. These LVDT sensors are integrated with control unit though an amplifier. Control unit is also integrated with display and a relay. Depending upon the signal received from LVDT, control unit decides which data has to be displayed and whether a relay is energized or not. The relay has control over the machine cycle. If the job under inspection has dimensions out of acceptance range, then the error dimensions are displayed on a display and relay is de-energized so as to turn off the machine cycle. This system can not only inspect the job, but also it can have a control over machine cycle.

KEYWORDS: Gauge, LVDT, Measurement, PLC, Relay.

INTRODUCTION:

It is essential for every manufacturer to control and maintain the quality of their products, in order to satisfy the needs of the customers. This is particularly most important for machined parts which require an accurate dimensional and geometrical control. Once, a machined component is produced, an inspection process is carried out to check whether the part is within specified tolerances or not. The intention of the inspection is to ensure that, the part will meet its functional and performance requirements in their overall assembly. Inspection details measure and evaluate relevant characteristics of product in terms of requirements and specifications derived from a desire to meet expectations about the product levels of quality and performance. Inspection is a non productive activity and it does not add value to the product but, it insures whether the manufactured product is within the characteristics limit or not. Inspection is the means by which good quality of the product is assured and poor quality is detected and rejected. Now a day, the competition among the industries is so high that it's all about their reputation in the market. The firms are keen to keeping their quality of the product high, in order to achieve more customers, profit and reputation too.

This paper, will focus on, one of such inspection system which inspects the component with the help of Programmable Logic Controller (PLC) based closed loop control system. The attempt is to design a kind of inspection system, which will help an operator by displaying measurement results and switching the machine cycle either on or off using a relay. If the inspected component has its dimensions out of the acceptance limit, then relay is de-energized to stop the

CNC machine cycle, to eliminate the errors, which helps the manufacturer to minimize scrap and rework.

1.1 IMPORTANCE AND NEED OF THE TOPIC:

In order to determine the fitness of any machine component, manufacturer always chooses inspection process. To deal with mass production and interchangeability of parts, one has to adopt automation in the inspection process. In the old era, a craftsman was supposed to manufacture a part, inspect and assemble it. If any part in the assembly did not fit properly, craftsman would make the necessary adjustments. But, Now-a-days new production techniques have been developed and parts are produced in the large scale. Due to low cost methods of mass production, the hand fit methods cannot serve the purpose any more. The modern production techniques require different persons for manufacturing, inspection and assembly. As a result, various parts to be assembled come from various manufacturers and assembled at one place. So, it is very essential that, parts must be so inspected that, the satisfactory matting of any pair chosen at random will be possible. Thus, industrial inspection is important to meet the necessity of suitable mating of various components manufactured separately. From a manufacturers' point of view, there should be a balance of blend of quality, reliability and affordable cost. Thus, manufacturers are required to adopt advanced inspection system in order to maintain quality levels at marginal cost.

1.2 PROBLEM STATEMENT:

The conventional inspection system is time consuming and is involved with manual handling which results in increased rejection rate and reduced production efficiency therefore, a key strategy is to provide a mechatronics system.

1.3 THEME OF THE PAPER:

The first section of this paper describes the need, importance and problem statement of the topic. Second section focuses on the literature survey trough review of different research papers, based on the advancement in the inspection system and objective of this paper. Third section is methodology which deals with the proposed system and system components. Last section of this paper deals with the conclusion, future scope and the references used for this research paper.

LITERATURE SURVEY:

The unavoidable inaccuracy of the manufacturing process makes it impossible to obtain a part with rigorous conformity to the specifications. The designer, conscious of this problem, introduces tolerances on each effective dimension of the part, so that it can fulfill its function correctly. Inspection is the process by which a real product is compared with the specifications defined at the design stage. In industry, inspection is usually performed by human controllers, based on a sampling of parts rather than on the total production, because of the reduction in time and cost. However, in certain critical applications such as for the aerospace or medical industries, all of the parts must be inspected because, even the smallest defect is unacceptable and must be identified.

At present, most of the automated inspection systems use contact devices, which require that the part be stationary and carefully placed. In industry, the standard machine for the inspection of parts is the coordinate measuring machine (CMM). LVDT is also a most widely used inductive transducer for translating the linear motion into electrical signal. The dimensional variations in the component being inspected, is used as a measure to produce electrical signal. The dimensional tolerances are expressed as the difference between the high and the low size limits of a tolerance dimension. This represents the interval in which the effective dimension of an element can vary.

Basically, there are two main types of inspection generally performed by machining industries namely finish product inspection and in-line inspection. The main difference between these two inspection practices is that for the finish product inspection, the work is performed at the end of the machining process in a special quality room. On the other hand, for the in-line inspection, the measurement is performed at the production site. The main purpose of performing in-line inspection is to control and maintain high quality of machined part at the early stage of production. In post-process measurement, specific instrument or machines could be used to inspect the work piece. Compared to in-process and in-situ measurement, the post process measurement is a time-consuming procedure and a specific inspection area.

In order to detect deviations from the nominal values or to detect the absence of vital parts or properties, the inspection process should be performed on-line. The main benefit with on-line inspection is that products out of tolerance are detected at an early stage in the manufacturing process. This means that products out of tolerance are prevented from further machining, handling, assembly, etc., resulting in less rework and scrap. In addition, information on deviations from target values may be fed back to the process. Variations in the form, size, position and smoothness of a feature are

some of the errors that can occur in manufactured cylindrical components.

2.1 OBJECTIVE OF THE PAPER:

To provide advanced closed loop inspection system for valve guide of an engine so as to display the measurement results and take necessary action for a faulty component.

METHODOLOGY:

This system consists of PLC as a control system which is integrated with sensing unit and actuation unit.

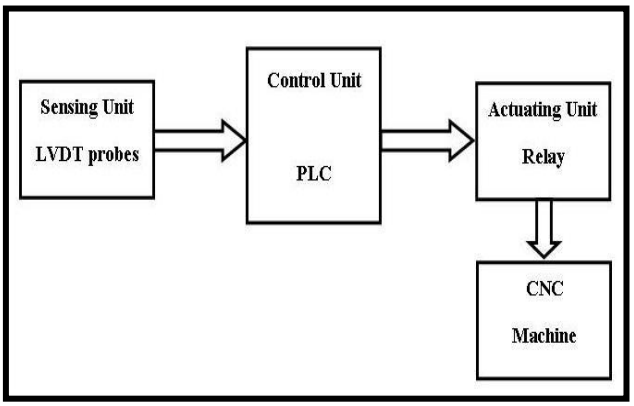

Figure 3.1 Block diagram of inspection system

Sensing unit consists of LVDT probes used to measure the dimensions of engine valve guide. Actuation unit consists of display and an electromagnetic relay which is used to on/off the operation cycle of CNC. Figure 3.1 shows block diagram of inspection system, while figure 3.2 shows the image of engine valve guide which is being inspected.

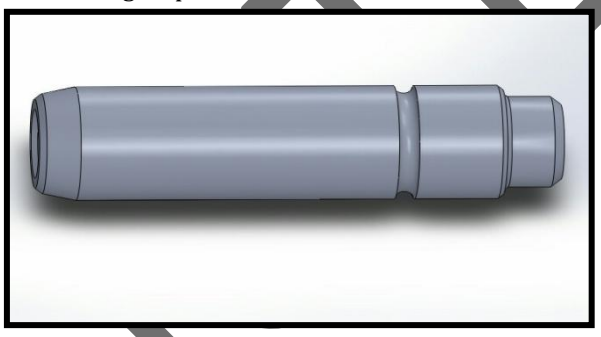

Figure 3.1 Engine Valve guide

For inspection, components are kept on mechanical fixture which is specially designed to support and hold engine valve guide. Two LVDT probes are fixed to mechanical fixture in such a way that, they can measure two different diameters. When probes come in mechanical contact of a component to be inspected, LVDT measures dimensions and produces related electrical signal. This signal from LVDT is sent to control unit through an amplifier. Control unit is a PLC which is programmed by using ladder programming. Programming is provided with accepted limits of tolerances for dimensions and decision for further action. If the component being inspected has dimensions within accepted range, then display shows the dimensions in green color and relay remains energized to keep the CNC machine cycle on. On the other hand, if the component has dimensions out of limits, then display shows the error in dimension with red color and relay de-energizes to stop the CNC machine cycle.

3.2 SYSTEM COMPONENTS:

As represented in the block diagram, this system has mechanical fixture, LVDT probes, SMPS, amplifier, PLC, relay and display.

A. MECHANICAL FIXTURE:

A fixture is a device, which holds and locates a work piece during an inspection. Valve guide is shown in figure 3.2, which is cylindrical in shape. V-block fixture is chosen for this component, which can restrict all six degrees of freedom.

B. LVDT:

Linear Variable Differential Transformer (LVDT) is an electromechanical transducer which converts mechanical displacement into electrical voltage. The LVDT proposed for this inspection system has working stroke of 2mm and sensitivity of 73.75±0.15mV/(Vmm). There are two LVDT used in this system are are integrated with PLC.

C. SMPS:

A switched-mode power supply (SMPS) is an electronic power supply that incorporates a switching regulator to convert electrical power, efficiently. Like other power transformers, SMPS converts voltage and current characteristics and transfers power from a source to destined load. There are two SMPS used in this system and are connected before LVDT.

D. Amplifier:

As output voltage of LVDT is in millivolts, it need to be amplified and converted into volts in order to produce sufficient signal for PLC. To achieve this, an inverting amplifier is used. Amplifier gain is so selected as to produce output voltage in a range of 0-10 volts when probe plunger is displaced by 1 mm.

E. PLC:

A programmable logic controller is a specialized computer used to control machines and processes. It uses a programmable memory to store instructions and specify functions that include on/off control, timing, sequencing, counting, arithmetic and data holding. The

programming method used for PLC is ladder logic. Ladder diagramming is a graphical programming language that uses graphical symbols with the logical instructions, needed to perform control operations. In this particular system, PLC acts as a control unit and it is integrated with LVDT, relays and display unit.

F. RELAY:

Relay is an electromagnetic device which is provided with input electrical power. Relay has two switches viz. normally open and normally closed which are used in the output. In this system relay is controlled by PLC. If the dimensions of inspected component are within accepted limits then relay remains energized or else gets de-energized. Normally open switch of relay is connected in series with CNC machine cycle, which turns on or off according to PLC instruction.

RESULTS AND CONCLUSION:

Figure 4.1 shows the advanced inspection system for inspection of engine valve guide. Valve guides are inspected manually and also be using system. The results are compared, analyzed and concluded as below.

Figure 4.1 Advanced Inspection System

4.1 RESULTS:

It is observed that PLC based inspection system gives better results than that of conventional inspection system. In advance, it also indicates exact size of the component after inspection. Due to the implementation of advanced inspection system, inspection time is reduced up to 55%, as compared to manual inspection method. Below table 4.1, indicates the comparison between manual inspection and PLC based inspection.

Table 4.1:- Results and discussion

Parameter	Manually inspection	PLC based inspection
Inspection Time	20 sec	8 sec
Accuracy	Difficult to maintain	Can be maintained within1 microns
Manual Handling	More	Less

4.2 CONCLUSION:

From the results, it is clear that, the advancement in inspection system has resulted in saving the inspection time, minimizing the manual handling and increasing the accuracy etc. This system is capable of producing accuracy up to 1 micron, which leads to precise inspection. This system involves the interfacing of CNC machine with inspection system, which stops the machining of defective components and increases efficiency.

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