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Interfacing LVDT amplifire with PLC for Auto Bore Gauge Measurment

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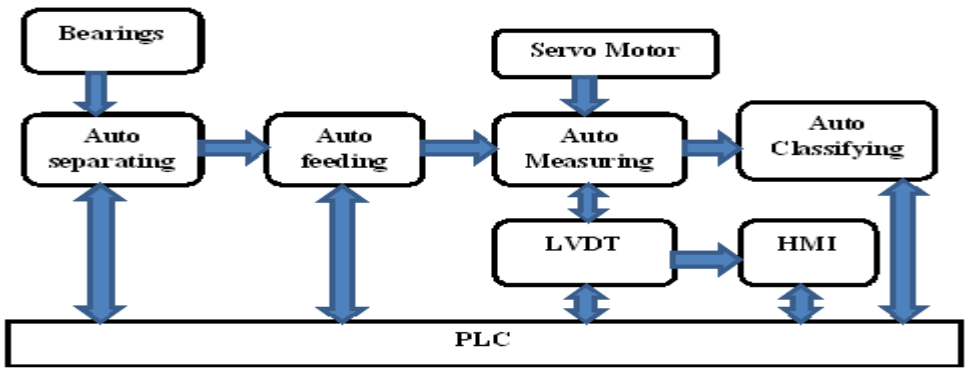
ABSTRACT: The invention ofInterfacing LVDT amplifire with PLC forauto bore gauge measurement and automatic classifying system of bearing is consisted of auto-separating, auto-feeding, auto-measuring, auto-classifying and statistic-analyzing parts,based on automatically measurement the bore gauge diameter.The auto-feeding part uses the manipulator to feed the bearings to the measuring location. The auto measuring part is consisted of inner race diameter bore gauge, zero location detector and V shape localizer and measuringdisplacement.The electrical control unit comprise of a HMI control unit, operator panel and sensors to servo motor pushing by the cylinder against given situation during measuring operations done using LVDT, operational logic and PLC programming. The auto-classifying part classifies the bearings that have been measured according to the measuring result of ring is ok or discard /rejected.

KEYWORDS: Ball Bearing, HMC, LVDT, SERVO MOTOR,PLC, HMI.

I. INTRODUCTION

One of the object of the present invention is to use a programmable logic controller (PLC) to calculate automatically the taper value, the difference between two diameter, of bore based on the measurement and set points. After analyzing the definition of bearing inner bore, researched the four elements of the measurement process including the measured object, measurement units methods and precision consisting of auto-positioning error, auto-targeting error.The metrology departments in the factory technical supervision still manually measure the bearings, estimate the error by eyes, record and calculate the data by hand [3]. To achieve these goals one of the possible solution is to implement the current system using PLC'S which would make the current system in the present invention the device comprises an automatic bore gauge that is used PLC to determine the taper value on bore of ball bearing inner race after the internal diameter of the race is ground to dose dimensions. This project will have sensors to servo motorpushing by cylinder against LVDT interfaced PLC for measuring bore gauge and HMI remote for remote supervision.

II. RELATED WORK



Figure(1) DIAGRAM OF WORKING PROCESS

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The entire system is consisted of auto-separating, auto-feeding, auto-measuring, auto-classifying and statistic-analyzing parts of LVDT .Its working process is shown on fig 1.
To make the bore gauge auto-measuring and classifying system of bearing work automatically, it is essential to have these functions:auto-separating,auto -feeding,auto-measuring and quality judgment [3]. First, diameter gauge should be calibrated to ensure its precision.Second, bearings are separated on the carrying belt orderly.Third, a manipulator which has two V-shaped gaps will hold the bearings to the measuring location and push then gauge will move down & will get self aligned in the ring measured bearing to the belt. After the bearing arrived to the measuring location, system would verify zero location to get the initial value first.When measuring,the cylinder drives zero location detector pushing bearing to the V shape localizer installed on the measuring rack, then PLC not only controls pneumatic parts, but also keeps the mechanical movements of system automatically and HMI on set the value of bore of bearing measurement and signal sensors to servo motor pushing by cylinder againstLVDT interfacing through PLC will be carried out at two places by cylinder to contact the bearing accurately to get the bore value& the result will be displayed on the HMI.The auto-classifying part classifies the measured bearings according to their set by the values on HMI.

III. PROPOSED ALGORITHM

A. Design Considerations:

1. From In-feed conveyor only one ring will be passed through singling.
2. Sensor will detect the ring.
3. Ring will be moved to gauging unit by pusher cylinder & will stop against stopper.
4. Ring will get hold by clamping cylinder.
5. Gauge will move down & will get self aligned in the ring, measuring will be carried out at two places & the result will be displayed on the HMI.
6. Gauge will move toits home position.
7. Ring will get un-hold.
8. Pusher cylinder will push the ring to out-feed conveyor.
9. If OK ring will be moved to next station from out-feed conveyor.
10. If Not-ok i.e Bore over size & taper out of limit rejection cylinder will move the ring to scrap box.
11. If Not-ok i.e Bore under-size & taper within limit rejection cylinder will move the ring to rework box.
12. Same cycle will be repeated for next component

B. Description of the Proposed system:

Aim of the proposed algorithm is to, measuring will be carried out at two places. The proposed system is consists of main steps.

Step 1: Calculating Measurement Theory:

The standard measure ($S_{Measure}$) enters the measuring program and is shown at the screen. The standard value used is equal to 69.995mm. The LVDT calibration difference ($\Delta LVDT_{Calibration}$) is obtained after the end of the gauge movement during the calibration and is equal to the "zeroed" standard. The variation ($\Delta LVDT_{Measure}$) is obtained after the end of the gauge movement during the measurement, and is equal to the difference between LVDT measure (obtained during the measurement routine) in relation to the LVDT measure (obtained during the calibration routine).The measurement equation obtained by the transducers to carry out the real measurement ($R_{Measure}$) is shown below:

$$R_{Measure=} S_{Measure}+(\Delta LVDT_{Calibration}-\Delta LVDT_{Measure})$$

Thus, the first step consists of calibratingthe sensors using the ring gauge. The sensors are moved to the inner part of the ring gauge and gaugemovementsare performed. To prevent the measurement of dynamic random changes, zero-correction was carried out before measurements every time. When putting a standard bearing on this system to measure, the error between test results and standard bore gauge of the standard bearing its systemic error, and this part can be corrected.The auto-separating part is at the upper-left corner of the drawing, bearings are transported by carrying belt from production line.

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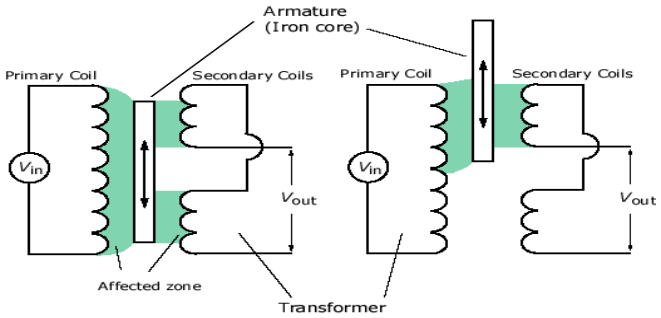

Figure (2):Construction Of LVDT

Step 2: Selection Criteria:

A. Proximity sensor

A proximity sensors are able to detect the presence of nearby objects without any physical contact. A proximity sensor often emits an electromagnetic field or a beam of electromagnetic radiation, and looks for changes in the field or return the signal. The object being sensed is often referred to as the proximity sensor's target. an inductive proximity sensor always requires a metal target. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts. It can detectpresence/absence of metal upto the range of 3 mm-60mm.

B. Servo Motor

Servo motor is special type of motor which is automatically operated to certain limit for a command with help of error sensing feedback to correct the performance. The main reason is that it provide angular precision i.e it will only rotate as much we want and then stop and wait for next signal to take further action.

C. HMI

GOT 1040 HMI can be directly connected to the MITSUBISHI PLC via serial interface resulting in easy and quick installation. It also replaces the conventional push button panel and wiring. MITSUBISHI introduce this series of touch screen terminals for effective communication between operator and machine.

D. Control System

1. PLC based Control System Make: Mitsubishi FX3U-64MT, GOT-1040
2. Proper illumination will be provided at working area. Illumination will get on
3. only during auto cycle. It will remain ON for predetermine time.There will be a part counter which will register the number of accepted components.
4. There will be one No. of Main Control Console housing Power Supply, Power Contactors, Safety Gadgets, PLC, Main Switch, etc. and there will be Operator Pendent ergonomically fitted tosuit the Machine Operator. The Control Console will have two Nos. of fans for Air Cooling and appropriate illumination for maintenance as per standard practice. The operator Pendent consists of Indicators, Push Buttons.
5. The Control System is designed to suit 415v +/- 10%. Suitable safety interlocks are provided for fail safe working of the Machine. Emergency stop switch, three storied beacon light Red, Green & Yellow will be provided System will operate in both Auto & Manual Mode.

E. Electrical

1. Connected Load is 2 KVA. All electrical & pneumatic control valves and elements will have legend plates and will be easily identifiable and matched with the circuit diagram. All proximity switches will be mounted inrigid individual plates with easy maintenance access. Electrical equipment suitable for 3-phases 415 ±10 %V, 50 ± 3% Hz. Ac supply.
2. Machine will have auto power saving feature, wherein if machine is not in operation for more than 5 minutespower should be switched off , there will be proper labeling on machine for indicating in fault display with detailswill be provided on HMI..
3. Pneumatic Solenoid valves equipped withsurge suppressers for Solenoid coils.

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IV. SIMULATION RESULTS

A. Software Tool Requirement

The proposed algorithm is implemented with GX Developer.GX Developer is the standard programming ladder developersoftware for all FX3U PLC series and combines all functions with the user guidance of Microsoft windows. With this software we can comfortably create PLC programs alternatively in the form of ladder diagrams or instruction lists. GX Developer can be run under MS windows, XP and VISTA.

B. Machine Output

1. Rings found good with respect to all quality parameter will be guided to Interconnection for next operation.
2. Rings with quality deviation of Bore over size & taper out of limit out of limit will be discarded in scrap box.
3. Rings with bore under size & taper within limit need will be directed towards rework BOX.

Table 1 : Proximity sensor testing

Parameters	Output
Metal is detected	Voltage given by sensor is 24 volt
Metal is absent	Voltage given by sensor is 0 volt

As shown in table 1 when metal is detected then Voltage given by sensor is 24 volt. And if metal is absent then Voltage given by sensor is 0 volt.

Table 2 : LVDT testing

Input from LVDT AC (mVpp)	DC output obtained (mV)
40	9
50	13
60	17

As shown in table 2 Ac voltage given to the LVDT in mv. When ac input is 40mv then DC output voltage is 5 mv. When ac input is 50mv then DC output voltage is 10 mv. When ac input is 60mv then DC output voltage is 15 mv.

Table 3 : Measured value in mm

DC output obtained (mV)	Ring gauge	Ring test 1	Ring test 2
5	Ø 69.9962	Ø 69.9479	Ø 70.0432
10	Ø 69.9961	Ø 69.9482	Ø 70.0424
15	Ø 69.9959	Ø 69.9473	Ø 70.0445

As shown in Table3 the rings were calibrated using radial direction. It means that cylindrical measurement error was not considered. Therefore, a position to measure them was determined. This position is the same that was used in the calibration of the sensor device, so that the average calibration value is accurate.

C. **HMI Results**

HMI can be directly interfacing with PLC via serial interface resulting in easy and quick installation. It also replaces the conventional push button panel and wiring. PLC introduce this series of touch screen terminals for effective communication between operator and machine.

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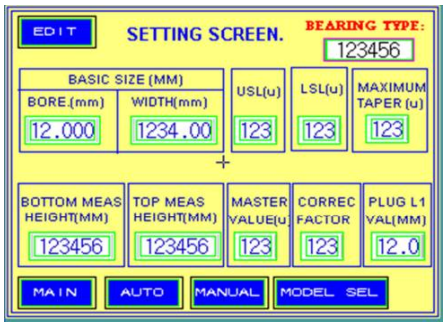
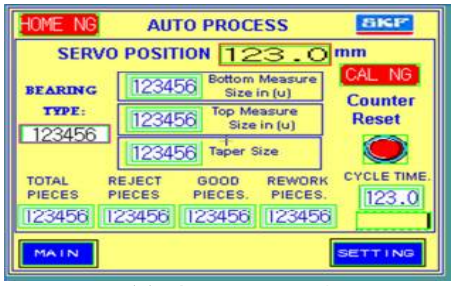


Figure(3): Setting Screen

Setting screenis shows in Fig. 2 included that the manual setting of the bore value and change as per the required for measurement of gauge value. Master value is set as a reference value for measuring the top and bottom diameter of ring.



Figure(4): Auto Process Screen

Our results shows that itcan not only classify the grade but also process the quality statistics analysis on HMI.
The HMI result shown in Fig.4 which is auto process screen based on servo position value and then proceed to check bearing type ,total number of bearing count, taper size, number of rejected as well as good pieces and cycle time.

V. CONCLUSION AND FUTURE WORK

PLC is used in industries for batch processing in order to reduce manual work and error. To make the system intelligent it requires many sensors to be interfaced with the PLC. It realized the high -speed measurement, which only needs 5 second and high precision, which is 0.5um. It can not only classify the grade but also process the quality statistics analysis and then send out the reports of quality, which can meet the requirements of companies. The degree of accuracy of the automated system is higher than the ones provided by conventional instruments,micrometer and comparator bore gauge. This is due to the use of displacement transducers (LVDT) and the measurement resolution.
Measurement time consuming in the proposed system is lower than that of the coordinate-measurement machines because the first does not need to be prepared to measure.
Also, there is chance for improvement in machine cycle so that the cycle time is reduced and productivity of machine increases.

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