International Journal of
Emerging Research in Management &Technology
ISSN: 2278-9359 (Volume-4, Issue-6)

Research Article

June 2015

Bearing Component Pairing and Assembly Machine Electronic Up-Gradation with Siemens S7 300 PLC, HMI

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Abstract—

Ball bearing consists of inner ring, outer ring and balls of specified size filled between these two rings. The decision of size of balls depending on inner ring diameter and outer ring diameter is made using the controller i.e. PLC. The measurement of diameters of rings is done using LVDT. The corresponding ball size is determined and specified number of balls is filled between inner and outer ring by predefined machine cycle. The status of process is shown on HMI screens. In manual mode of machine the sequential activities can be controlled through HMI or directly through PC (Online control).

Keywords— Ball bearing, HMC, LVDT, PLC, HMI

I. INTRODUCTION

In industrial applications, Horizontal machining centre (HMC) machine is used for different assemblies. One of the applications of HMC machine is Ball-bearing component pairing assembly. The ball bearing is a type of rolling element bearing that uses balls to maintain the separation between the bearing races. Ball bearings are used in different mechanical assemblies e.g. Tires of vehicles.

The ball bearing components (inner rings and outer rings) are manufactured by grinding machines. Each grinding machine produces rings of specified dimensions. In spite of taking all care, some rings differ from specified dimension. So while filling balls between inner and outer rings, decision of ball size is required to be taken in accordance with rings' dimensions. Therefore HMC machine is provided with measurement unit for dimensions of rings.

Two LVDTs are associated with HMC. One measures dimension of inner ring while other measures dimension of outer ring. These signals were fed to industrial PC in order to take decisions regarding to the size of ball to be filled between these two rings. But now, up-gradation of this PC with latest version of software has become unaffordable. Hence there is need to find out a solution which will fulfil the requirements same as that of industrial PC. Aim of this project is to make system cost effective by designing LVDT's signal conditioning unit. This project will have PLC interfaced with signal conditioning block and HMI for remote supervision. The output from PLC is further supplied to HMI and the mechanical arms of HMC machine. Monitoring and movements of the arms will be carried out on the basis of output parameters obtained from PLC readings.

The controller objective is to collect the data of various measurements of the bearings and ball sizes from the LVDT and signal conditioning block respectively. The signals from LVDT are in the range of few mV AC, hence there is requirement of designing a signal conditioning unit.

II. LITERATURE SURVEY

For understanding detail existing system, we visited the company with internal guide. We had discussion with external guide about the existing system and problems associated with it. The problem being an engineering stuff there were many ways to solve it.

We were supposed to find an optimum solution. We discussed the probable solutions with our guide and also referred some journals and conference papers regarding work in industrial automation domain. After considering solutions given by some authors we came up with the most suitable application specific solution.

Once the flow of work is fixed, we focused on the methodologies to achieve the target. For that we studied various sensors from different suppliers considering their cost, efficiency and working. Finally we concluded the literature survey by appropriate selection of LVDT, proximity sensors and other components required for signal conditioning circuit.

In order to acquire knowledge about programming of PLC i.e. developing ladder diagrams, creating SCADA and HMI we have undergone PLC, SCADA training.

III. PROPOSED SYSTEM DESIGN

A. Block diagram

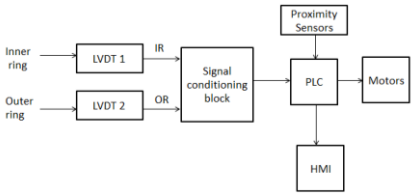


Fig.1.Block diagram

B. Elements of block diagram

1. LVDT
2. Signal conditioning block
3. PLC
4. HMI
5. Sensors and motors

C. Block Diagram Explanation

LVDT takes measurement of inner and outer sizes of rings. LVDT converts these measurements into electrical form, and then they are further given to the signal conditioning unit. The output from PLC is further supplied to HMI and the mechanical arms of HMC machine. Monitoring and movements of the arms will be carried out on the basis of output parameters obtained from PLC readings. The monitoring is specifically done for the only two parameters of HMC machine, Ball sizes and inner-outer ring measurements.

Where,

IR = Inner Ring, OR= Outer Ring

Our project deals with providing signal conditioning block and to solve the problem of ball feeder pipe (mentioned above) by providing sensors.

IV. HARDWARE IMPLEMENTATION

A. Proximity Sensors

Proximity sensors detect the presence or absence of object without any physical contact. There are four types of proximity sensors:

a) Inductive b) Capacitive c) Photoelectric d) Ultrasonic

Photoelectric proximity is generally preferred for long range target detection. Ultrasonic is also used for long range detection of targets with difficult surface properties (color/reflectivity) such as for foam, glass, liquid, powder etc. Capacitive proximity is used for close range detection of materials like wood, plastic (non-ferrous). Inductive proximity is used for detection of ferrous material like iron, steel, aluminium etc.

Hence we selected an **inductive type proximity** sensor to detect absence of balls in ball feeder pipe. As these sensors are going to be associated with pipe, we have chosen ring shaped inductive proximity sensor.

1) Features:

a) Inductive proximity sensor gives fast response .
b) It has good resistance to industrial environments
c) It can detect presence/absence of metal upto the range of 3 mm-60mm.

2) Wire configuration

Proximity sensor has 3 types of wires:

Table 1: Wire configuration of proximity sensor

Sr. No.	Color	Significance
1.	Brown	+Ve of PLC
2.	Blue	-Ve of PLC
3.	Black	Input of PLC

Fig 2: Ring type Inductive proximity sensor

B. LVDT (Linear Variable Displacement Transducer):

The LVDT which is used in this project has following features:

a. Measuring range: 1500um
b. Sensitivity: 75mV/V/mm

This means, when LVDT is provided with excitation of 1V, it gives 75mV output for 1mm displacement.

Fig 3: LVDT (Marposs)

C. Signal conditioning block:

The signal conditioning unit is to be developed by following steps. Generally, LVDTs have sensitivity up to 75mV/V/mm. Thus the signals generated by LVDT are too minute of order of few mV AC. To process those signals, we need to have DC equivalent of it. Thus it takes DC conversion. We have used full wave precision rectifier circuit to get DC equivalent.

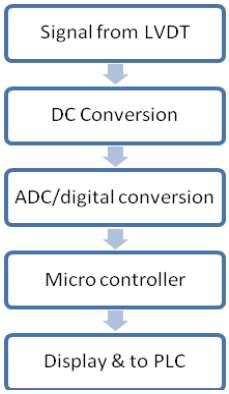


Fig 4: Flow diagram of signal conditioning

In order to use micro-controller, the quantities need to be converted into digital form using ADC. The computational activities and decision making is done by micro-controller. We selected microcontroller with in-built ADC.

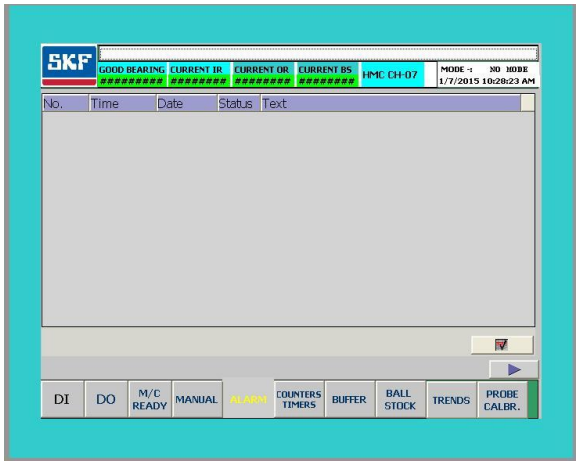
V. SOFTWARE IMPLEMENTATION

A. Software tools required

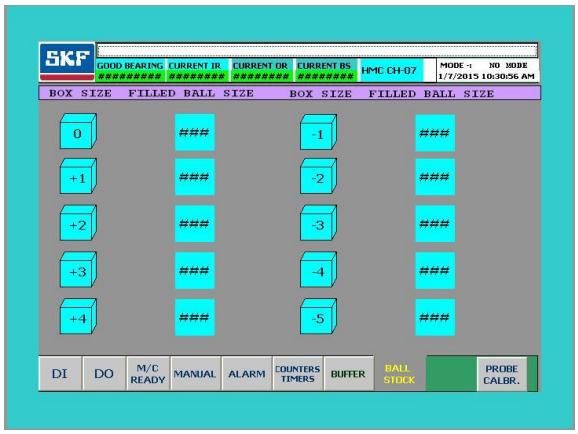
1. Simatic manager (Ladder diagram developement)
2. WinCC (HMI screens developement)
3. Multisim 2012 (signal conditioning circuit simulation)
4. MikroC PRO for AVR (microcontroller prgramming)

B. HMI design

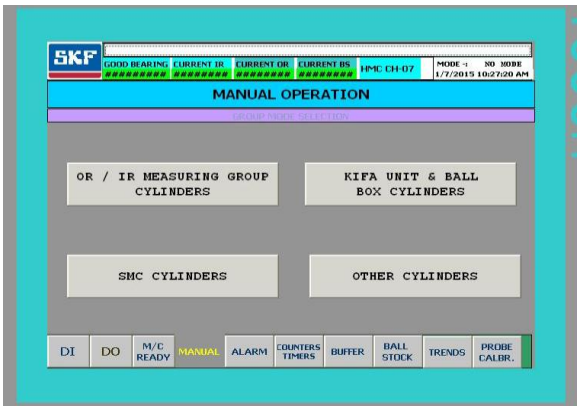
Alarm screen



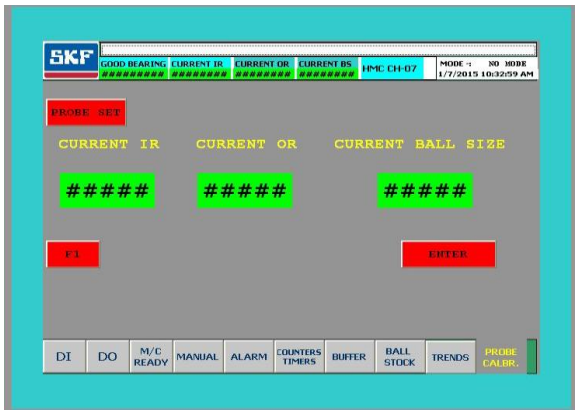
Ball stock screen



Manual operation screen

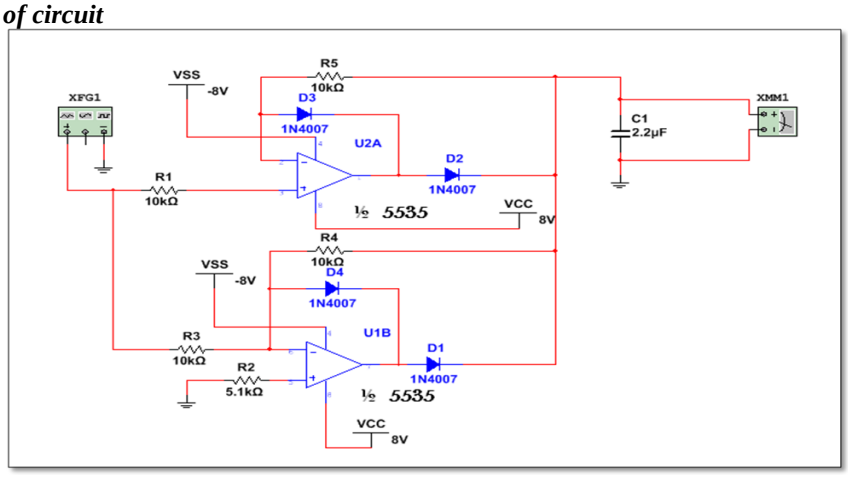


Measurement Screen



VI. RESULTS

A. Software tesing of circuit



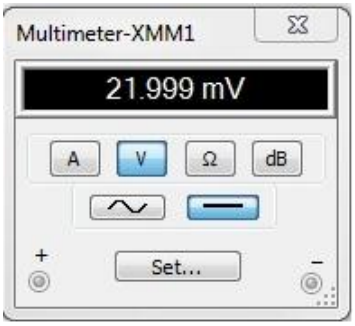


Fig 5:Simulation of signal conditioning circuit

B. Result Table

Table 2: 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

Table 3: LVDT testing

Input from LVDT AC (mVpp)	**DC output obtained (mV)**
40	9
50	13
60	17
70	22

Table 4: Ball size determination

DC output obtained (mV)	**Determined Ball size**
5	2
10	3
30	4
50	5
70	6

VI. FUTURE SCOPE

In this project we have worked on signal conditioning unit to make system cost effective and on proximity sensors for reducing down time of HMC machine.

There is still scope for improvement in machine cycle so that the cycle time is reduced and productivity of machine increases. Some assembly activities can be overlapped to fasten the production of bearings

.

VII. CONCLUSION

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. Thus this project contributes in giving a less expensive signal conditioning unit. Sensing the presence or absence of metallic balls in ball-feeder pipe and correspondingly activation of ball-feeder motors, reduces down time of machine. Thus the loss incurred by company due to down time of machine is reduced.

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