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Design and Implementation of Automatic Lubricating System Using PLC

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Abstract- *This paper discuss about implementing the controlling and monitoring of the automatic lubricating system. Lubrication system is indispensable part of almost all industries. Lubrication is the process or technique employed to reduce the wear of one or both surface in close proximity. Lubrication system requires continuous monitoring and inspection at frequent intervals. There are possibilities of errors at measuring and various stages involved with human workers. So a reliable monitoring system is necessary to avoid catastrophic failure, which is achieved by using PLC. This automated system also has features like monitoring and controlling delivery mode and recirculation mode for lubrication by using PLC. The main goal here is to minimize the risk of human life and ensure highest safety during operation. At the same time this project will assure increases the quality and increases its efficiency and easy to maintenance. The proposed system is relatively cost effective, efficient and more reliable in terms of automation.*

Keywords: PLC; Automation; Lubricating System; Reliability.

1. INTRODUCTION

In earlier days all the industries were not automated while monitoring and controlling of the processes are depends on manual system which leads improper lubrication method and using incorrect amount of lubricant. Even nowadays, improper lubrication is prime concerns for industrial sectors and it became very frequent and uncertain also. Improper method and incorrect amount of lubrication being applied to the components are major cause of lubrication-related failures in process equipment. Manual method to lubricate the bearings is lead to 54% failure of the lubrication due to presence of "too much or too less" lubricants. This was causing production of lower quality and also production rate was less. Involvement of human workers at various stages can create possibilities of errors at measuring and controlling.

The target for the automation of lubricating system is to take care of the machineries safety to prevent dangerous conditions occurrence. The risk of human mistakes can be highly reduced, if the process can be handled with the aid of Computer Vision and efficient sensors. The biggest benefit of the automation is that it saves workers and times also by designing a system which can be controlled by main control room. The number of personnel can also be kept small so the plant can be also designed to be run at 1 man shifts. However, it is also used to save energy and materials and to improve quality, accuracy, precision. Automation has been achieved by various means including mechanical, hydraulic, pneumatic, electrical, electronics in integration with computers. The automation of our lubrication system is carried out by using a PLC.

A PLC is a digital computer used for automation of electromechanical process. PLC is designed for various features of itself such as multiple I/O arrangements, immunity to electrical noise, extended temperature ranges, resistance to vibration and impact, memory back-up. Online operation of PLC is used for problem detection and finally it indicates the problem occurring place.

2. RELATED WORKS

For manual lubrication, though maintenance departments are small in many plants, yet there are still the same numbers of productions machines and lubrication point requires. Due to competitive demands, most industries are under increased pressure to be more efficient and improve "uptime". Increased regulations that focus on the environment and safety (lock-out and tag-out requirements) require plant maintenance managers and personnel to follow time-consuming procedures [1-2].

In lubrication equipment and systems Lincoln has more than 100years experience and Lincoln has most unique capability and system solutions to address these essential issues, yet overall problem is not solved [1]. T. Elakkiya and A. Anitta discussed about comparative study of manual lubrication and automatic Lubrication.

They also discussed about different existing method of automatic lubrication can be done with PLC [2]. The most critical and essential part in machining tools is guide way as it guides the tool or work piece along a predetermined path, usually in a straight line or a circle [3]. In 1937, Lincoln Engineering (now known as Lincoln Industrial) introduced the first single-line parallel system for industry in the U.S.A. [4]. F. P. Bowden and D. Tabor designed a Lubrication system by Thin Metallic Films and the Action of Bearing Metals. An investigation has been made of the role of thin metallic close proximity, reducing the friction and wear between metal surfaces, on Mar 1943 [5]. Gao Huiliang on June 2004 discussed offline sampling or online oil measuring and monitoring system using by both single sensor and multiple sensors. Machine lubrication contains abundant information on the equipment operation. Though nowadays, most measuring methods are based on offline sampling or on online measuring with a single sensor [6]. On 2010, the multiple scale double variable technique was discussed by H.G. Elrod.

A multiple scale double variable technique is used on lubrication related problems for the first time. The present analysis applies to one face roughness having striation wavelengths sufficiently long for the applicability of Reynolds equation [7]. Daniel Gropper, Ling Wang, Terry J. Harvey discussed a hydro dynamic lubrication technique. The paper describes a theoretical analysis of the effects of surface roughness in a finite width bearing [8]. A especial lubricating system which is ensured normal operation and prolong service life of the large machinery was discussed by Su [9].

3. METHODOLOGY

Different types of sensors are used in automatic lubrication systems. In our automatic lubricating system PLC is used instead of microcontroller. For temperature sensing thermocouple (TC-K type) is used and for relay switching Electromechanical Relay (RM2S) is used. Different PLCs are available in market. For our project, PLC SIEMENS LOGO! 230RC and for programming (i.e. Ladder Diagram) LOGO! Soft Comfort is used.

In the proposed system PLC is powered by SMPS. Physical variables from sensors are inputs of plc. From programming and collected value from sensors, PLC operates the system by switching while switching is completed by relay. By switching PLC takes actions such as mode selection (Delivery or Recirculation), Heater ON/OFF, pumps and motor ON/OFF. Problem detection or diagnosis can be done by online operation, so diagnosis is easier.

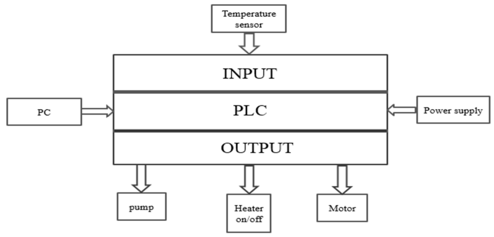

Fig. 1: Block diagram of automatic lubricating system

4. SYSTEM CONSTRCUTION & OPERATION

The following equipment's are used in this project:

- PLC SIEMENS LOGO! 230RC
- LOGO! PC CABLE & USB to RS232 converter cable.
- Analog input module AM2
- Digital input module DM8 (230R)
- Electromechanical Relay (RM2S)
- Power supply (24 volts)
- Oil heater
- Pumps
- DC Motor
- Universal Transmitter (PR 4116)
- Oil Reservoir
- Selection Switch
- Connector
- Thermocouple (TC-K type)

4.1 PLC

A Programmable Logic Controller (PLC) is an industrial digital computer which has been 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. They were first developed in the automobile industry to provide flexible, ruggedized and easily programmable controllers to replace hard-wired relays and timers. Since then they have been widely adopted as high-reliability automation controllers suitable for harsh environments. 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. The components of a PLC can be divided into three core areas. Those are

- The Central Processing unit (CPU)
- The Power Supply unit
- The input/output (I/O) section

CPU module is called brain of the whole PLC. The CPU has different operating modes. Basic components of CPU are a microprocessor, memory chip and other integrated circuits to control logic, monitoring and communications. Continual scanning of a program is basic function of a PLC. Testing input status, Programming execution, Checking and Correction of output status are scanning three basic steps of scanning process.

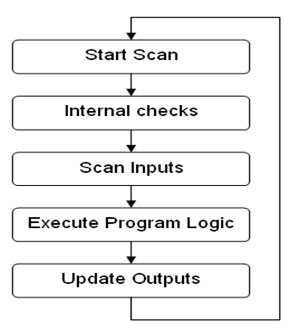

Fig. 2: CPU operating cycle

The operation of our system can be divided into four major stages.

i. Refilling of lubricant
ii. Recirculation mode
iii. Delivery mode
iv. Emergency mode

Where, 1st stage ensure refilling of lubricant in reservoir properly, 2nd stage keep temperature of lubricant at a predetermined range to ensure to go delivery mode anytime. Delivery mode is use for lubricating on machineries by 1st or 2nd pump cycle. And emergency mode is designed for abnormal conditions**.**

5. FLOW CHART

Fig. 3 shows flow chart of our Automatic lubricating system.

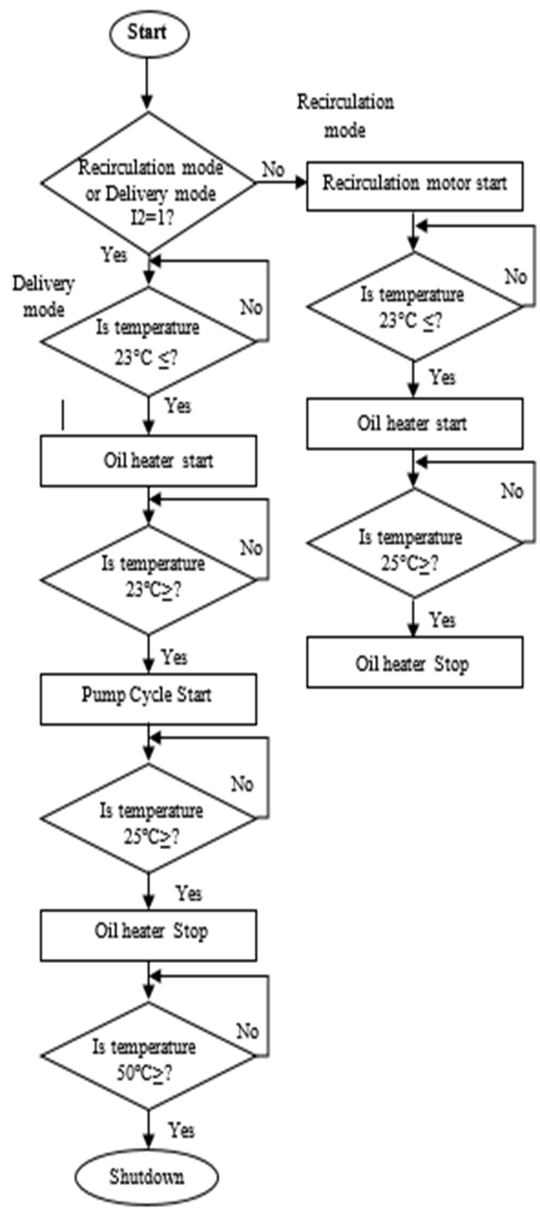

Fig. 3: Flow chart of our Automatic lubrication system.

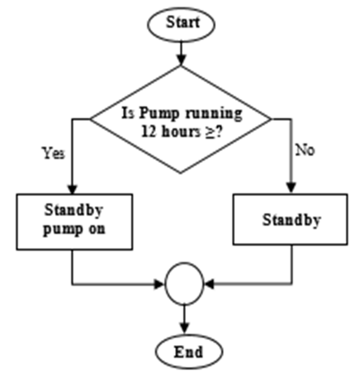

Fig. 4 Flow chart of pump cycle

6. SYSTEM IMPLEMENTATION

Fig. 5 shows the implementation of automatic lubrication the system.

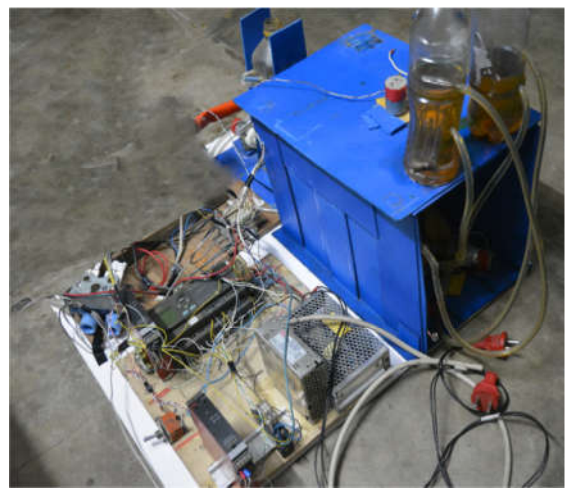

Fig. 5: Implementation of automatic lubricating system

7. RESULT ANALYSIS

Initially, when system is starting and if selection switch i2=0 Recirculation mode is on and heater Q4 and recirculation motor Q3 is running because if temperature is below 23°C heater is switched ON. Fig. 6 shows simulation of above condition.

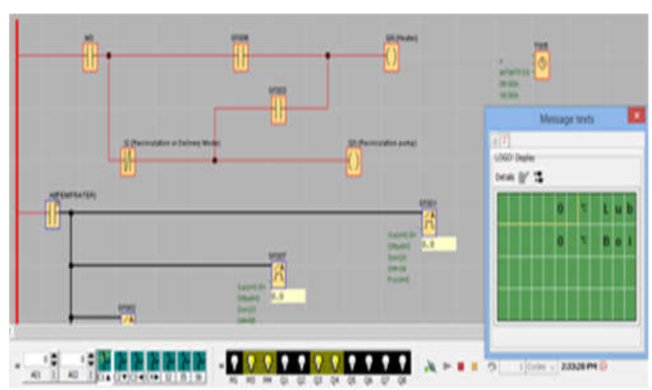

Fig. 6: Simulation of recirculation mode at initial condition

When temperature reach 25°C heater Q4 is switched OFF but motor Q3 is switched ON, because on recirculation mode motor is running instead of pumps. Heater will again switched ON if temperatures of system fall below 23°C. Fig. 7 shows the simulation of system when selection switch,i2=1 delivery mode is ON and temperature is below 23°C,on this condition pump Q1 is not switching ON because temperature is below 23°C. On delivery mode Pumps will not operate below 23°C.

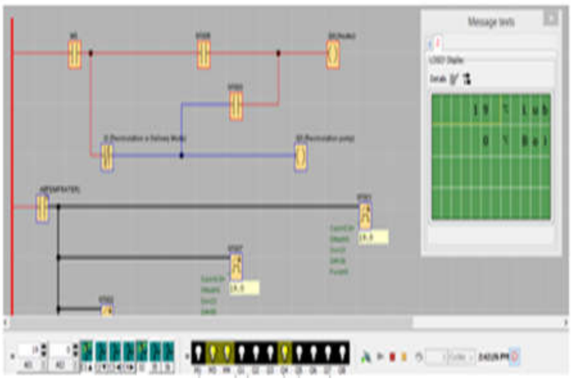

Fig. 7: Simulation of 1st pump cycle, on delivery mode at 19°C temperature

Fig. 8 shows the simulation of condition when selection switch, i2=1 delivery mode is ON and temperature is above 23°C. On this condition pump Q1 is switched ON.

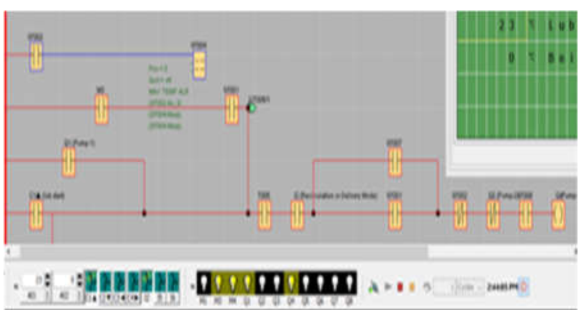

Fig. 8 Simulation of 1st pumps cycle of delivery mode at 23°C temperature.

Fig. 9 shows simulation of second pump cycle, when system is on delivery mode and after 12 hours pump Q2 is switched ON if temperature is above 23°C and if temperature is reach 25 °C or above heater is switched OFF.

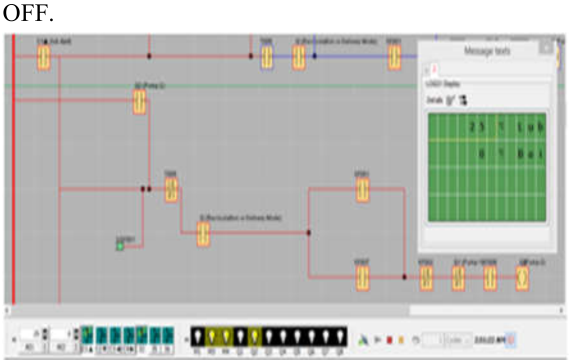

Fig. 9 Simulation of 2nd pumps cycle, on delivery mode at 25°C temperature.

Fig. 10 shows, simulation of system when temperature reaches at 50°C or above the system shut itself down to ensure safety of system.

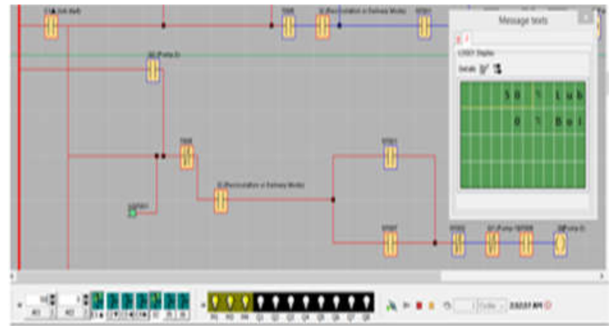

Fig. 10 Simulation of system when temperature at 50°C or above

The implemented automatic lubrication system can be also turning off by setting ON/OFF switch, C2=1. On recirculation mode greases is rotating by motor to prevent from coagulating and to maintain a fixed temperature, so that system can be operate instantly, where traditional system required a time to heat grease or oil to operate.

8. COST ANALYSIS

When considering implementing an automated lubrication system, it is important to know that it could pay for itself within the first year through the cost savings it generates. Production uptime, repairing costs, preventive maintenance costs, safety expenses, environmental compliance costs, lubricant costs and machine replacement costs are all positively impacted.

It's not unusual for process plants like paper, petrochemical or primary metals to replace 1,000 bearings or more per year on the average. Depending on the application and size, each replacement of bearing can cost anywhere from a few dollars to several thousand dollars. An average replacement costs approximately $150 (material cost). It takes approximately three hours for a worker to replace each bearing and per hour labor costs is approximately $30. So, replacement Cost for per bearing is $240. Hence, total annual replacement cost for 1,000 bearings is $240,000. Reducing the number of bearings to be replaced by just 50 percent nets a savings of $120,000/year just on labors and bearing costs. Downtime in the process industries costs from $10,000 to $150,000 or more per hour. Assuming a line production time value of $60,000 per hour, shutting down a strategic line for just three hours to replace a few bearings can be very costly. Consider that $60,000 x 3 hours = $180,000 in lost production.

There is no standard for the cost of implementing a lubrication system. Depending on the application and size our lubrication systems can costs $1,000 (for very small operation) to $10,000 (for large operation). It becomes a fairly simple matter to justify the cost of an automated lubrication system. Obviously, the most important factor is how many bearings or other lubrication points need protection. Then, depending on the scale of the application, other accessories/controls may be required to maintain, monitor and manage the lubrication system.

9. ADVANTAGES

This automatic lubrication system has following advantages:

- Simplicity
- Cost effective
- Easy to maintain
- Easy to control
- Retentive
- Reduces labor cost
- Reduces number of labor
- Centralized
- Reuse of lubricant
- Low power consumption
- Reduced wastage of lubricant
- Reduce risk of bearing failure

10. CONCLUSION

In this project based research work, the automatic lubricating system having the facilities of automation and Online operation to detect problem and to indicate of problem occurring place. The implemented system is very simple because of the convenient way to control and maintain. The system is cost effective also and no manual work is necessary to control it.

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