INTELLIGENT MONITORING AND CONTROL OF GRAIN BAGS STORAGE USING PROGRAMMABLE LOGIC CONTROLLER

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Abstract— India is one of the largest grain producers in the world. It produces 200 million MT (Metric tons) of wheat and rice annually. Seventy-five percent of total grain loss occurs at the farm level. Proper monitoring of grain storage is essential to reduce grain loss. The present system involves human effort in most of the activities which reduces work efficiency and increases time consumption. These difficulties can be avoided by our proposed project. In this project, the controlling and monitoring of the grain storage area is fully automated using PLC and SCADA. The main objective of the proposed project is to control and maintain the temperature in storage area by using thermistor and fed to the PLC for controlling which prevents the formation of microorganisms and spoilage of grains. The height of the bags is measured and directs the different sizes of bags to their respective storage places. The SCADA system acquires the required data and monitors the overall process.

Keywords—Control; Monitoring; PLC; SCADA

1. INTRODUCTION

Agriculture is one of the primary occupations in developed and developing countries. India is the largest producer of grains in the world and hence storage of grains is vital. The grains cultivated in the field is harvested and stored in a storage area like cement buildings. If it is stored for longer periods, the grains get spoiled due to the formation of micro-organisms like fungus, pests and insects. If the humidity inside the storage area increases then it leads to the formation of micro-organisms which ultimately leads to the spoilage of grains.

Thus in our proposed project we are going to maintain the temperature of the storage area where grain bags are stored, so that spoilage of grains can be prevented to a greater extent.

The loading and unloading of the grain bags is also automated using conveyor belt. The purpose of using Programmable Logic Controller is to automate and take control of these operations in the most efficient way and to monitor the overall process using Supervisory Control And Data Acquisition System.

Automation in building began long before recorded time, with the help of microprocessors. The use of dedicated software for safety and control applications began with the technological advancement in the field of PLC. With the advent of newer technologies, situations have turned around a lot and the need to view the live Process in a system, within a control has become essential.

With the development of SCADA (Supervisory Control And Data Acquisition) the task of monitoring and controlling the entire process and confining it to a restricted control has become possible. SCADA is software package, which incorporates various facilities such as Alarm popup, History files, Graphical representations, Animations etc. The technological advancements over the last decades have led to the combined use of PLC with SCADA. With this technology the important modules like tank level, external light, three phase changeover etc are controlled using PLC and the real time monitoring of these modules are made using SCADA. One of the most important advantages of using PLC over microprocessor is that PLC has more number of input/output facilities than microprocessor and some other advantages are easy programming language, easily reprogrammable, longer lifetime etc.

Previously monitoring and control of Grain storage is done by using Programmable Logic Controller and Supervisory Control And Data Acquisition System, but they have used Load cell for measuring the grain bags and directing them according to their sizes [1]. The main disadvantage is mounting of the load cell is difficult and it is a tedious process to calibrate it. Thus in our project we used IR sensors to measure the height of the grain bags and direct them according to their height there is no need of calibration and it is very easy to mount it. When monitoring and control of the grain storage is done by using Microcontroller [2]. The drawbacks of using Micro-controller is programming in micro-controller is difficult only skilled people can do it. Changing of the program for modification and up gradation is difficult[5].

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Hence in our project we are using Programmable Logic Controller and Supervisory Control And Data Acquisition System for monitoring and control of the grain storage. PLC programming is much easier when compared to microcontroller programming and modification of the program can be done easily.

2. STORAGE OF GRAIN BAGS

Storage of Grain bags occupies a vital role in the economies of developed and developing countries. Proper monitoring of grain storage is essential to reduce grain loss. The present system involves human effort in most of the activities which reduces work efficiency and increases time consumption. These difficulties can be avoided by our proposed project.

In this project, the controlling and monitoring of the grain storage area is fully automated using PLC and SCADA. The main objective of the proposed project is to control and maintain the temperature in storage area which prevents the formation of microorganisms and spoilage of grains, to measure the height of the grain bags using a pair of IR sensors placed beside the conveyor belt and to direct the different sizes of bags to their respective storage places.

The main parameter that is essential for proper storage of grains is temperature which is taken as input parameter to be controlled using PLC and is measured using a temperature sensor. The SCADA system acquires the required data and monitors the overall process.

3. OBJECTIVES

The main objective of the proposed project is to control and maintain the temperature in storage area which prevents the formation of micro-organisms which leads to spoilage of grains. To measure the height using IR sensors placed besides the conveyor belt and to direct the different sizes of bags to their respective storage places based on their height using IR sensor. To automate the loading and unloading process of grains using conveyor belt. To monitor the overall process using SCADA system.

4. TEMPERATURE CONTROL LOOP

In the process of grain storage, temperature and humidity are the two main factors that affect the grain quality. Insect, mite, fungal and mycotoxin development are controlled by temperature. At temperatures found in grain stores, biological activity of insects, mites, fungi and grain itself, doubles for every 10°C rise in temperature. Traditional methods of on-farm storage generally rely on controlling the moisture content, and to a certain extent the temperature, of the grain going into storage. Without proper conditioning facilities it is unwise to attempt to store the grain for longer than 5-8 weeks. To accurately control process temperature without extensive operator involvement, a temperature control system relies upon a controller, which accepts a temperature sensor such as a thermocouple or RTD as input. It compares the actual temperature to the desired control temperature, or set point, and provides an output to a control element. The controller is one part of the entire control system, and the whole system should be analyzed in selecting the proper controller. The following items should be considered when selecting a controller: Type of input sensor (thermistor) and temperature range.

Type of output required (electromechanical relay, Digital output), Control algorithm needed (Based on high and low limits), Number and type of outputs (heat, cool, limit). Then for heating control, the output is on when the temperature is below the set point, and off above set point. Since the temperature crosses the set point to change the output state, the process temperature will be cycling continually, going from below set point to above, and back below. In cases where this cycling occurs rapidly, and to prevent damage to contactors and valves, an on-off differential, or “hysteresis,” is added to the controller operations. This differential requires that the temperature exceed set point by a certain amount before the output will turn off or on again. On-off differential prevents the output from “chattering” or making fast, continual switches if the cycling above and below the set point occurs very rapidly.

The temperature inside the storage area is measured using temperature sensor, thermistor. The output of the sensor is given to the PLC and is compared with the set point value which is specified by the user. The values are compared and the error is calculated. The digital output from the controller is converted into TPO (Time Proportional Output). The heater coil is switched ON and OFF at the required rate and the heating is controlled to reach the set point. If the temperature exceeds set point, the heater coil temperature is reduced to control overheating. A blower is used to suck the air from outside and this air is heated by the heater in order to maintain the temperature in the storage area.

![Temperature control loop](image)

5. MEASUREMENT OF HEIGHT OF GRAIN BAGS

The height of the grain bags is measured using a pair of IR sensors. If one of the IR sensor detects a bag then it is 50kg grain bag, if two IR sensors detects the bag then it is 100kg grain bag. Thus we can separate the grain bags according to their height.

6. PROGRAMMABLE LOGIC CONTROLLER

A Programmable Logic Controller is a specialized computer used to control machines and processes. It uses a programmable memory to store instructions and execute specific functions that include on/off control, timing,
counting, sequencing, arithmetic, and data handling[3][4]. Basically, the PLC is an assembly of solid-state digital logic elements designed to make logical decisions and provides outputs. Initially the PLC was used to replace relay logic, but its ever-increasing range of functions means that it is found in many and more complex applications over several advantages over a conventional relay type of control. Relays have to be hardwired to perform a specific function. The programmable controller has eliminated much of the hardwiring associated with conventional relay control circuits. A Programmable Logic Controller (PLC) is an industrial grade computer that is capable of being programmed to perform control functions. The programmable controller has eliminated much of the hardwiring associated with conventional relay control circuits. A Programming Device is used to enter the desired program into the memory of the processor. The program can be entered using relay ladder logic, which is one of the most popular programming languages. Instead of words, ladder logic programming language uses graphic symbols that show their intended outcome. A program in ladder logic is similar to a schematic for a relay control circuit. It is a special language written to make it easy for people familiar with relay logic control to program the PLC.

7. SOFTWARE SPECIFICATION
SCADA provides management with real-time data on production operations; implements more efficient control paradigms, improve plant and personnel safety, and reduce costs of operation.

Fig. 2: SCADA diagram for overall process

These benefits are made possible by the use of standard hardware and software in SCADA systems combined with improved communication protocols and increased connectivity to outside networks, including the Internet[3][4].

WONDERWARE INTOUCH provides a flexible, maintainable and secure software platform for SCADA environments. These solutions are built on and integrated with a single, open and scalable software architecture that can connect to virtually any automation system, remote terminal unit (RTU), intelligent electronic device (IED), programmable logic controller (PLC), database, historian or business systems in use today. The open nature of this platform enables users to expand their existing systems without having to buy new hardware or control systems.

8. PROCESS DESCRIPTION
The block diagram consists of various components such as Power supply unit, Conveyor belt, Conveyor motor, IR sensors, Deflector motor, Heating Coil, Blower, Relays, Limit switch, PLC, Storage Area.

Input devices: The input devices connected to the PLC are as follows: IR sensors (4), Thermistor (2), Limit switches (2).

Output devices: The output devices connected to the PLC are as follows: Conveyor Motor, Diverting Motor, Heating coil, Blower.

In presence of grain bag: when the job in sensor senses the presence of bag the conveyor motor starts.

In presence of small grain bag: The lower IR sensor senses or detects it and the diverting motor moves forward and when the upper limit switch gets activated the diverting motor stops.

In presence of large grain bag: Both the upper and lower IR sensors senses it and the diverting motor moves backward and when the lower limit switch gets activated the diverting motor stops.

At the completion of storage: When the grain bag is sensed by the job out sensor the conveyor motor stops after a delay.

Fig. 3: Block diagram
Counter: The number of large grain bags and small grain bags and the total number of grains bags is counted and displayed on the SCADA screen.

Fig.4: Overall process flowchart

The storage bags are unloaded from the vehicle and placed on the conveyor which is sensed by the job in sensor placed at the start point of the conveyor. If the presence of bag is sensed by the job in sensor, then the conveyor motor is turned ON otherwise it is turned OFF to reduce the power consumption. The two different sizes of bags are measured by placing a three IR sensors perpendicular to the conveyor belt. If the first two IR sensors detect the storage bags then it is a small storage bag and if all the three IR sensors detects the storage bag then it is a large storage bag.

Fig.5: Temperature control flowchart

Two temperature limits are used if the measured temperature is below the low limit then the heater and the blower is turned ON and if the measured temperature is above the high limit then both the heater and the blower is turned OFF. Thus the temperature of the storage area is maintained. The number of bags is counted by the counter when it is sensed by the IR sensor. If the storage area is FULL then the Loading process is stopped i.e., the conveyor motor is stopped.

9. CONCLUSION AND FUTURE ENHANCEMENT

This project reduces human effort and also saves time by implementing automation in the field of Agriculture. The loading and unloading of grain bags in the grain storage area is done by the use of a conveyor belt. A pair of IR sensors is placed beside the conveyor belt to measure the height of the grain bags and also to have a count on total number of bags in the storage area. A mechanical separator directs the grain bags to their respective storage places based to their heights. The temperature in the grain storage area is controlled automatically by using Programmable Logic Controller and SCADA software is used for real time monitoring of these processes.

In future, this project can be further enhanced by adding rat detection by using Passive IR sensors and can be avoided by using ultrasonic sound generator. Further theft detection can also be added by using motion detector sensor.

REFERENCES