Gravity Fed Automatic Packaging Machine Using PLC

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***Abstract*— This paper presents a prototype with the use of programmable logic controller in automation industry for packaging process. Rapid development of modern mechanization and automation of packaging technology with each passing day, the quantitative packaging of various items should be accurate and this has a direct impact on the survival and economic benefits. A low cost automated packing machine can be used by small enterprises which would help reduce their cost of plant. This low cost automated machine uses simple pneumatic, mechanical and electrical systems. A mechatronics system, developed for this machine, which takes feedback from sensors and accordingly controls the manipulators has been introduced in this paper. A PLC system is used for this particular machine.**

***Index Terms*— Low Cost Automation, PLC**

I. INTRODUCTION

In modern globalization, many technologists are trying to update a new development based on automation which works very rigidly, high effectively and within short time period. The progressive invention in auto weighing system is becoming an important task especially because of rising demand of products and declining labor availability in industry.

Recent years, in industry the weight of the jobs are checking and then faulty jobs are rejected manually. But now days we can check the weight of the object using the automation (using Load cells) technique and faulty jobs rejected using PLC and accurate jobs pass to further process on the conveyor belt. In industry the production speed should be high because demand of the product is more. But when we check the weight of the object manually then it will take more time for checking the weight and overall speed of the production will decrease. Hence the purpose of this project is to develop a automation technique using PLC.

The Gravity machine is an automatic gravity fed nett weigher which incorporates a load cell, and is used for high speed accurate weight of a wide range of products. The load cell weighing system is isolated from the product feed and weighing pan, to prevent contamination by product dust. Movement of the mechanical parts of the machine (i.e. opening and closing of the feed valve, weigh pan doors, positioning of the feed gate) is by means of pneumatic cylinders whose air supply is controlled by solenoid operated air valves in response to signals from the control unit. The electronic circuit of the control system receives the weigh dependant signal from the load cell and operates the weigher feed and discharge system accordingly.

II. NEED FOR AUTOMATION

Packing involves a number of steps like bag forming, weighing, and sealing the bag. If all these processes are to be done manually, the time required is more. The production rates will be slow. In order to achieve higher production rates use of automated machines is necessary. Automated machines are time savvy which gives the entrepreneurs to gain a competitive edge. The quality of the work is high and is repetitive. Automated machines can help reduce the waste generated hence, leading to proper utilization of the resources. Workers may suffer from fatigue which might lead to improper job quality. Use of an automated machine lessens the labour dependency of the enterprise. The key to achieve all of the above stated advantages while keeping the cost to be minimum is Low Cost Automation.

III. PACKAGING SYTEM PRINCIPLE

The system works on the principle that, a bucket is hanging on load cell .The product will transfer from bunker to product bin and then product will have to shift to the bucket through the flapper arrangement .The quantity of product is 50Kg. The product is fed to the bucket in two ways. During the main feeding a bulk of quantity is fed in to the bucket. During fine

feeding the material flow is reduced and obtains more regulation to have the set value of 50Kg. The fine feed quantity will be target weight – main feed quantity – IFC (in-flight compensation), in- flight quantity material is that quantity of material in air, which will fall in to the bucket after feed cutoff to get filled 50 Kgs weight when the operator hold the bag. The CPU sends commands to close or open the flappers. During the operation proximity sensors are used for sensing the bag, bucket closing etc. After sensing the bag the product will fall into bag; if and only the bag is fully filled to the preset value of 50Kg it is sent for stitching and dispatch. To obtain the fastest possible fill, consistent with good accuracy, a two speed feed arrangement is used to deliver a material from the top hopper into the weigh pan. Initially a fast main feed flow substantially fills the weigh pan, then the flow is reduced to a dribble feed rate in order to achieve an accurate feed cut off. The weigh pan is supported by a load cell assembly which is a device which accurately converts weight into an electrical signal. Upon reaching the required weight, feed is stopped and, provided that, the downstream equipment can accept the weighment, the weigh pan doors are opened and the weighment is discharged.

IV. BLOCK DIAGRAM

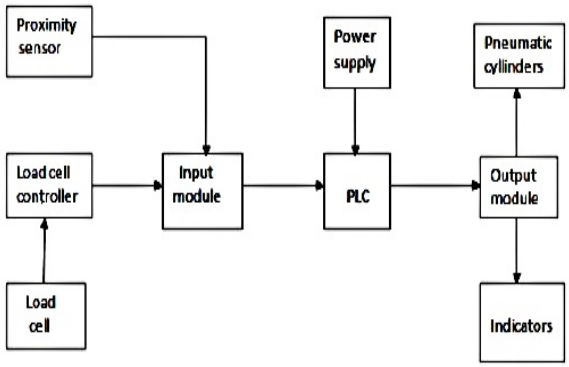

Fig 1 Block diagram of the System

A. PROXIMITY SENSOR

It is used for detecting the object which is moving on the conveyor belt. And proxy sensor send signal to the PLC to ready for object is coming. Inductive proxy sensors detect metallic objects which is moving on the conveyor belt. The operating principle of the proximity sensor is based on a coil and high frequency oscillator that produced a field in the sensing surface. Due to presence of metal in the operating area it causes a change in the oscillation amplitude. This change in amplitude is detected by a threshold circuit, which changes the output of the proxy sensor. The operating distance of the sensor depends on the size of coil as well as the shape of target, size and material.

B. LOAD CELL

Load cell is used to measure the weight .of the job which is moving on the conveyor belt. A load cell is nothing but a transducer which is used to create an electrical signal. The magnitude of this signal is directly proportional to the force being measured. The various types of load cells including hydraulic load cells, both the pneumatic load cells and strain gauge load cells are available in market. Load cell output is send to Load cell controller.

A load cell is a transducer that is used to convert a force into an electrical signal. This conversion is indirect and happens in two stages. Through a mechanical arrangement, the force being sensed deforms a strain gauge. The strain gauge measures the deformation (strain) as an electrical signal, because the strain changes the effective electrical resistance of the wire. A load cell usually consists of four strain gauges in a Wheatstone bridge configuration. Load cells of one strain gauge (Quarter Bridge) or two strain gauges (half bridge) are also available. The electrical signal output is typically in the order of a few millivolts and requires amplification by an instrumentation amplifier before it can be used. The output of the transducer can be scaled to calculate the force applied to the transducer. The various types of load cells that exist include Hydraulic load cells, Pneumatic load cells and Strain gauge load cells

C. PLC

PLC is the heart of our project. Load cell controller is connected to the input module and output module of PLC is connected to pneumatic cylinder and indicators. The fixed range of weight is put into the PLC and then it will check the coming job is in range or not if the job is not in the range of weight then it is rejected by pneumatic cylinders and accurate jobs are passing on the conveyor for the further process. A PLC or programmable logic controller is a digital computer used for the automation of typically industrial processes, such as control of machinery on the factory assembly lines, light fixtures or

amusement rides. PLC's are used in most of the industries and machines.

D. CONVEYOR BELT

Conveyors are very durable and also reliable components used in automation and distribution and warehousing. It is used with combination with computer controlled pallet handling equipment this allows for more efficient retail, wholesale, manufacturing distribution. Conveyor belts are largely used in industry because it saves largely manpower and transfer volume from one location to another location, allowing companies to receive or ship higher volumes with small storage space and with low labor expenses. The conveyor belts having made by rubber is used to convey the items whose having irregular bottom surface ,having small items may be fall in between rollers (e.g. a sushi conveyor bar), or bags of product that can be sag between rollers. Belt conveyors are generally similar in construction consisting of a metal frame with rollers at the end of a flat metal bed. The belt is looped around both of the rollers and when one of the rollers is powered (by an electrical motor) the belting slides across the solid metal frame bed, moving the product. In case of heavy applications the beds are pulling to the belts having the support .due to the rollers they allow the friction generated by the belt. Belt conveyors can now be manufactured with curved sections which use tapered rollers and curved belting to convey products around a corner.

V. WORKING METHODOLOGY

To complete the assigned task, it is required to choose a PLC software which is readily available. For this, the PLC software called Rexroth IndraWorks by Rexroth, Bosch group has been used. To program the PLC, several programming languages such as Function Block Diagram, Ladder Diagram, Sequential Flow Chart, Structural Flow Chart, Instruction List, and Continuous Function Chart are available. Among these, Ladder Diagram with Function Block Diagram was used for this task. Inputs and outputs of the defined process were analyzed and a relation between these inputs and outputs were established which were used to develop control strategies. These control strategies has been converted to Ladder Logic. Block diagrams can also be used to relate one or more inputs and outputs, and also, it allows the use of analog inputs in the logic.

The developed program can be executed and tested online with the help of "Simulation Mode" feature provided within the IndraWorks PLC.

Fig 2. Rexroth Indra Works PLC kit

The Indra Works Control is a modular and scalable control. It combines the benefits of a compact small control with a standardized I/O system on the basis of terminal technology. It is a hardware platform that can be used for PLC applications. It provides onboard interfaces, e. g. high-speed inputs and outputs (8 each) and communication interfaces, such as Ethernet, PROFIBUS and RS232. The locally available I/O units can be extended by the Rexroth Inline I/O system, just by simply mounting the components side by side.

Operating elements and interfaces are arranged on the front. The eight-digit display with four operator keys, the Reset button with light-emitting diode, the RS232 interface, and the receptacle for the Compact Flash card are provided to the left of the unit. Further interfaces (Ethernet, PROFIBUS DP) are located in the central section of the unit. The terminals for digital inputs and outputs (eight each) and the voltage supply connectors are arranged to the right of the unit.

VI. CONTROL ALGORITHM

Step 1: Start the process cycle

Step 2: Check if the material to be weighed is stored in a feed hopper which is located over the weigher inlet aperture

Step 3: Check the machine status (these include checking if the pan door is closed and the weighing pan is empty)

Step 4: If Step 3 is true, close the feed valve and open the feed gate
Step 5: Activate main feed if Step 4 is true
Step 6: Open the feed valve such that material is gravity-fed through the feed valve spout into the weigh pan at the main feed (fast) rate
Step7: Weigh the material in the weigh pan using Load Cell
Step 8: If preset value of target is reached, switch over to fine feed
Step 9: Close the feed gate
Step 10: Weigh the material in the weigh pan using Load Cell
Step 11: If preset value of fine feed achieved, cut off the feed by closing the feed valve
Step12: Weigh the material in the weigh pan using Load Cell ("In flight" material assumption also added)
Step 13: Reset the process cycle count: if the final weight is not equal to the preset weight or when the sample count is reached, else increment process cycle count by 1
Step 14: Check for the presence of bag
Step 15: If bag is present, discharge the weighment into the bag
Step 16: Repeat the cycle, go to Step 1

VII. WORKING METHOD OF PLC

Basics of a PLC function are continual scanning of a program. The scanning process involves three basic steps.
Step 1: Testing input status
First the PLC checks each of its input with intention to see which one has status on or off. In other words it checks whether a switch or a sensor etc., is activated or not. The information that the processor thus obtains through this step is stored in memory in order to be used in the following steps.
Step 2: Programming execution
Here a PLC executes a program instruction by instruction based on the program and based on the status of the input has obtained in the preceding step, and appropriate action is taken. The action might be activation of certain outputs and the results can be put off and stored in memory to be retrieved later in the following steps.
Step 3: Checking and Correction of output status
Finally, a PLC checks up output signals and adjust it has needed. Changes are performed based on the input status that had been read during the first step and based on the result of the program execution in step two – following execution of step three PLC returns a beginning of the cycle and continually repeats these steps .
Scanning time = Time for performing step 1+ Time for performing step 2+ Time for performing step 3.
Algorithm can be converted to ladder diagram, shown in figure 3.

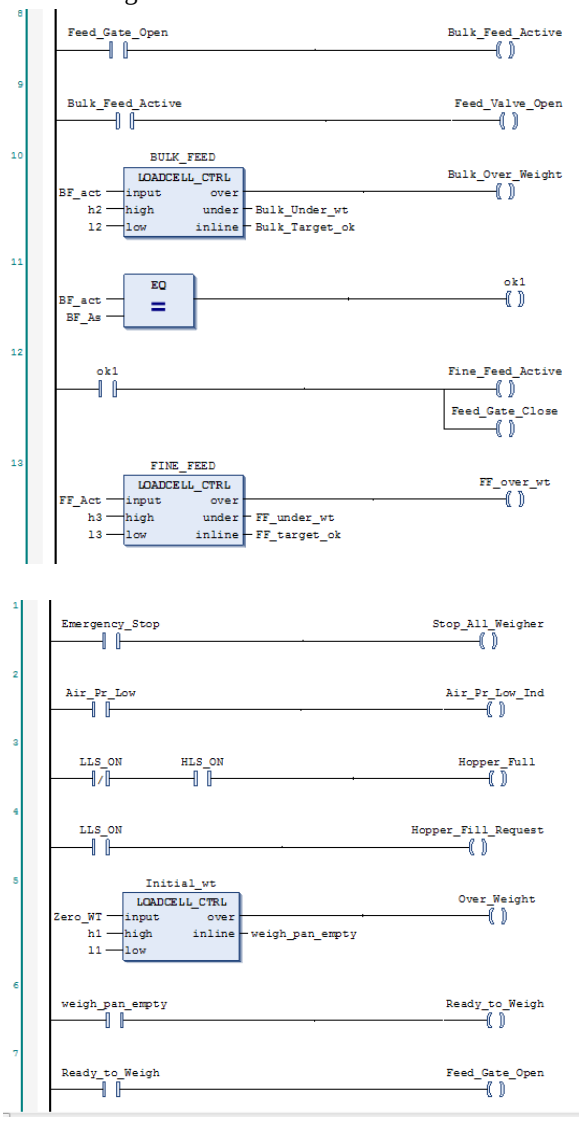

Fig 3. Ladder diagram of the System

PLC programs are typically written in a special application on a personal computer, and then downloaded by a direct-connection cable or over a network to the PLC. The program is stored in the PLC either in battery-backed-up RAM or some other nonvolatile flash memory. Often, a single PLC can be programmed to replace thousands of relays.

IEC 61131-3 currently defines five programming languages for programmable control systems: function block diagram (FBD), ladder diagram (LD), structured text (ST; similar to the Pascal programming language), instruction list (IL; similar to assembly language) and sequential function chart (SFC).These techniques emphasize logical organization of operations.

Ladder logic is a programming language that represents a program by a graphical diagram based on the circuit diagrams of relay logic hardware. It was primarily used to develop software for programmable logic controllers (PLCs) used in industrial control applications. The name is based on the observation that programs in this language resemble ladders, with two vertical rails and a series of horizontal rungs between them.

VIII SIMULATION RESULT

Simulation of a program allows the user to observe an operation through simulation mode without actually performing that operation. Rexroth Indra works has in built simulator. The main advantage of simulation is to test the program procedure, setting the parameters of the control and drive, reproduction of problems(trouble shooting), and validation of error solutions.

The command is available in the context menu of the relevant control and is used to switch on and off the simulation mode of the programming system.

In the simulation mode, the active application can be started and debugged on a "simulated target device". As such a simulated device is always integrated into the programming system; no real target device is needed to test the online behavior of an application. If the command is called from the context menu if an application is selected in the Project Explorer, login is carried out with this selected application even if it is not set as "active application".

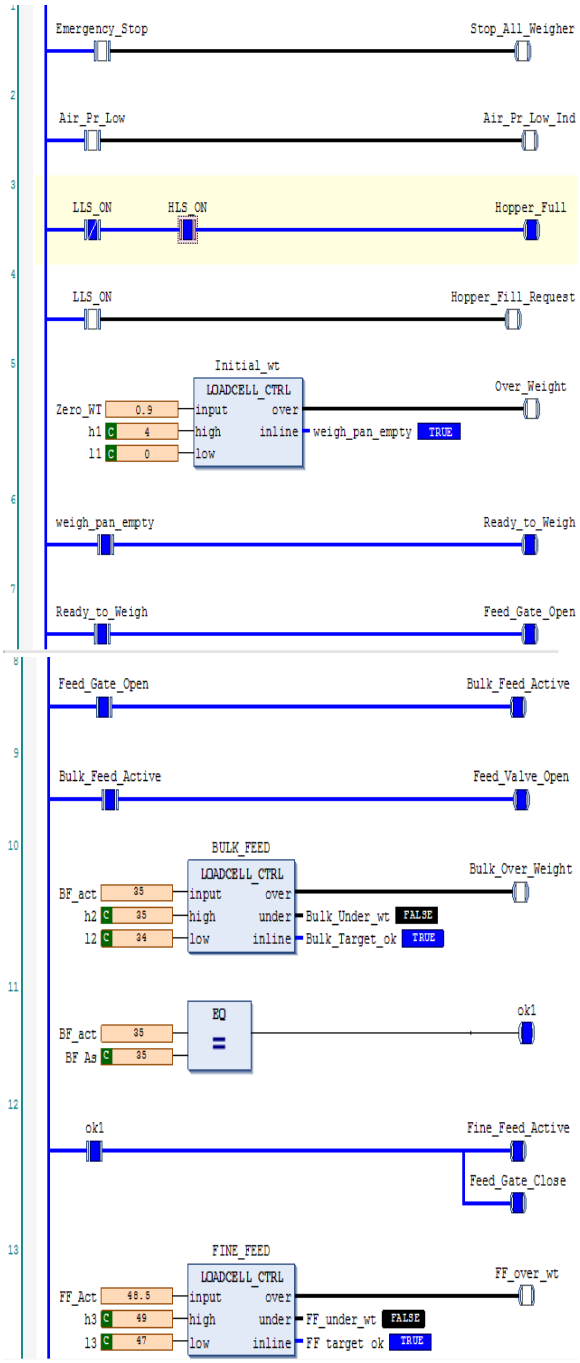

Fig 3. Simulation Result

IX. CONCLUSION

This paper discusses the automatic packing of different sized products based on PLC. Using currently available information and data on flexible automation techniques and mechatronic systems the automation of the machine has been developed. Due to a simple design and the use of low cost reliable

components, the machine is developed in lesser cost as compared to other conventional machines. Simulation result can be used to get the accurate result by detecting and correcting errors in that. Speed of operation can be increased and this whole system requires low cost and less maintenance.

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