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Automation of Waste Segregation System using PLC

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ABSTRACT: **With the growing population rate, the amount of waste being produced is also increasing at a very faster rate. It is also posing a very serious problem at the municipal level to manage the wastes being dumped everywhere as landfill waste. So, it is very crucial to have some system to manage waste automatically which is currently not there. Prime Minister Modi's mission of Swaccha Bharat Abhiyan can also be successfully implemented by the proposed system. The paper proposes a novel method where the provision is given to separate out wet and dry waste into respective bins by the sensing of different sensors incorporated along the conveyor belt on which initially crushed waste is moving. Pieces of glass, paper, metallic materials, and wet waste are separated out from proposed work. Using the segregated wet waste as the organic manure for growth of plants and recycling of most of the dry components like paper, glass, plastic increases the economic value of the waste to its best. We are using programmable logic controller (PLC) as main component and proposed system is simulated using INDRA WORKS Engineering, which is firmware of BOSCH REXROTH PLC's.**

Keywords: Waste segregation, PLC, Hydraulic cylinder, conveyor belt, Moisture sensor.

I. INTRODUCTION

Throwing waste into a bin is a good thing. However, it is not where the process of managing waste ends, but where it actually begins. Segregation is the process of separating biodegradable waste from non biodegradable waste for proper disposal and recycling and is the first step of waste management. It is often recommended to have two separate dustbins in the house to keep wet waste from mixing up with its dry counterpart. Improper segregation may cause mixing in landfills, in turn leading to toxic release in the ground and eventual contamination of ground water. Methane gas is likely to be released in such circumstances, which is one of the most harmful greenhouse gases. Proper segregation leads to proper recycling. Most of the waste can be reused and recycled. Various laws, regulations and other actions at the government level are implemented to cope up with hazardous waste generation and management. Literature survey says that the basic method followed usually involves rag pickers who collect and dispose most of the urban solid waste. However, it seems to be time consuming and also segregating waste with their bare hands might cause cuts and bruises due to glassy objects. Infections may also lead to severe illnesses. In addition to a high prevalence of bites of rodents, dogs and other vermin [1], this system is still at large scale in most parts of the India. Segregation system using RFID is also used where the RFID is considered to be attached to each type of material during manufacturing only to resolve the problem of sorting during the disposal stage of the product [2]. But, the problem arises because of use of RFID scanners in harsh and non-suitable areas, added cost the companies must be ready to bear so that tags are attached to each output product. The other method is making use of microcontroller for segregation. Even this poses some serious problems like more time consumption, not suitable in all types of environments and unable to segregate medical waste, sanitary waste and e-waste properly failing to obey certain rules and regulations imposed by the government in their segregation.

So to overcome the drawbacks from all these methods PLC based system is proposed due to inherent advantages like modular design, provision to make required short-term adjustments without having a large impact on the whole system, flexibility, cost, less wiring etc. The proposed work presents automatic system using PLC where IR, moisture, photo-electric, inductive and capacitive sensors are interconnected with PLC in such a manner so that they function in a proper sequence to detect the materials moving continuously on the conveyor belt. Hydraulic cylinder will push the waste to different collecting bins which are placed exactly opposite to sensor position so as collect the wastes which can be further used as organic powder or recycled.

The rest of the paper is organized as follows: Section 2 presents the block diagram of automatic waste segregating system. Section 3 explains the various components used. Working of automated system is depicted in section 4 through the help of flow chart and ladder diagram. Finally, section 5 presents the conclusion and future scope.

II. AUTOMATED WASTE SEGREGATION SYSTEM

In this section, we describe the block diagram of the system. Fig 1. shows the proposed block diagram based on which the interfacing of various inputs and outputs is done with the PLC.

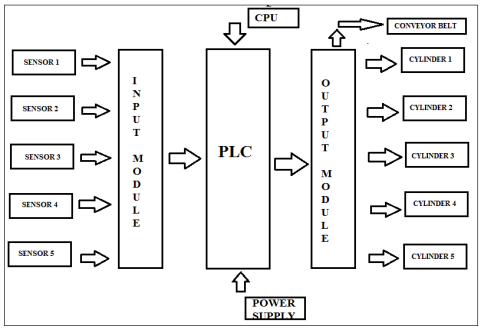

Fig. 1. Proposed network model.

According to above mentioned figure, there are three main systems involved. One is the input module to which the wet waste detecting, object detecting, metal, plastic, glass and paper detecting sensors are interfaced. Along the conveyor belt these all are appropriately arranged with the respective hydraulic cylinders below them and the collecting bins in-front. High speed blowing fan is also used to blow away the dust particles and other light weight materials into a collector placed exactly opposite to it.

Second one which is the heart of whole system is PLC which processes the signals from input modules and performs actions according to the logic diagram written for it. The last is the output module interfaced with the output giving devices. In our case, conveyor belt which starts running as soon as the IR sensor is actuated and cylinders which will expand to act as a flap to push waste into bin.

III. COMPONENTS USED

The main components used in the proposed system are discussed below:

A. Crusher

All the waste is first put into a crusher to reduce the size of some bigger materials. The crushed waste is then dumped to a funnel like structure which helps in systematic movement of materials over the conveyor belt.Please note that it is not connected to the PLC and operated independently.

B. Programmable Logic Controller (PLC)

Bosch Rexroth PLC works as the core of the project. It has control over all other elements used. The main function of it is to acquire the signals from the input and perform certain actions as the output. Fig 2. shows the Indracontrol L10 PLC with onboard input and output modules.

Fig. 2. Onboard input/output modules of PLC.

The software used for programming this Bosch Rexroth PLC of L10 series is Indra Works Engineering. The ladder logic developed is dumped on to the PLC from PC by Ethernet cable.

C. Sensors

In order to detect few of the materials in the waste considered to either re-use them or to re-cycle, various sensors are used.

(a) IR sensor. The main motto of this sensor is used to detect the presence of any object on the conveyor belt by emitting the infrared radiations. When the object is detected, it will signal the PLC to start the conveyor if the start button is made on already. Fig 3. shows the working principle of IR sensor.

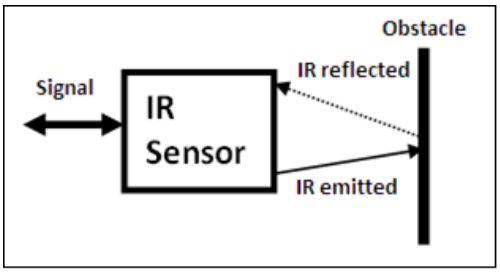

Fig. 3. Working of IR sensor.

(b) *Moisture sensor.* This sensor is used basically to separate the organic waste (wet) from dry waste. Therefore, it is placed at the beginning of the conveyor belt. It measures the change in electrical impedance. When the water vapour is absorbed, the ionic functional groups get dissociated and the electrical conductivity will increase due to conductive polymer.

Fig. 4. Moisture sensors.

(c) *Metal detection sensor.* Inductive proximity sensors operate on the principle that the inductance of a coil and the power losses in the coil vary as a metallic (or conductive) object is passed near to it. Thus, is used to sense the metallic wastes and is insensitive to non-metallic wastes.

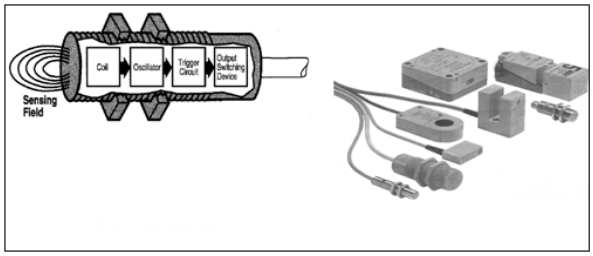

Fig. 5. Inductive sensor.

(d) *Plastic detection sensor:*
Use is made of photoelectric sensor Built-in Amplifier for Detecting Clear, Plastic Bottles. Different sized bottles upto 2-l can be sorted.

(e) *Proximity Capacitive sensor to detect glass and paper:*
The principle of operation of the sensor is that an internal oscillator will not oscillate until a target material is moved close to the sensor face. The target material varies the capacitance of a capacitor in the face of the sensor that is part of the oscillator circuit.

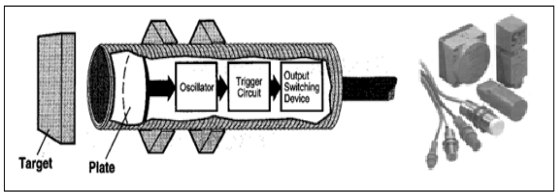

Fig. 6. Capacitive proximity sensor.

A. Conveyor belt and fan
A continuously moving conveyor belt is used to which the different object detecting sensors are attached. The materials move over this and are put into respective bins after the sensing mechanism is over with the help of hydraulic cylinders. High speed fan is also used in the midway or at last to blow out dust and other particles.

B. Hydualic cylinders
Spring return type single acting cylinder is used in which cylinder is pressurized from only one side due to high force being exerted by fluid during both the extension as well as the retraction process.

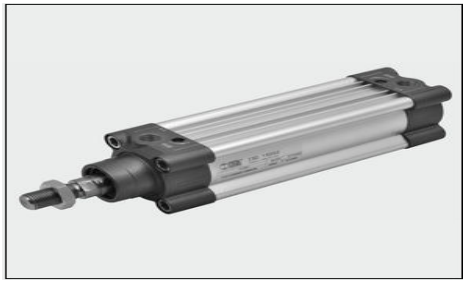

Fig. 7. Hydraulic cylinder.

IV. WORKING AND SIMULATION

This section describes briefly the working of the system with the help of flow chart. Ladder diagrams showing the simulation results are also discussed. Fig. 6. shows the flow chart for the working of the proposed work.

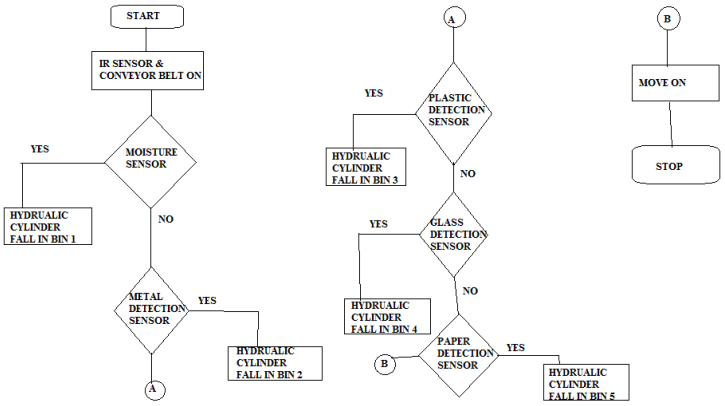

Fig. 8. Flow chart.

The process begins with the waste collection and dumping all this into a crusher which is operated separately from the designed system. Later, crushed waste is made to fall on to a large funnel like structure. At the output of this stage, the waste starts moving on to the long conveyor belt installed. Initially, conveyor starts moving only when the IR sensor is sensed. Further, upon sensing of individual sensors attached at different locations along the belt, the conveyor belt halts for about 5s and then respective hydraulic cylinders are energized and waste material is pushed to respective bin. Note that at a time only one sensor can sense. Fan will help in collecting the small dust particles and other minute things into a chamber fixed exactly opposite to it.

The ladder diagram written to execute this logic is as shown in fig 8.

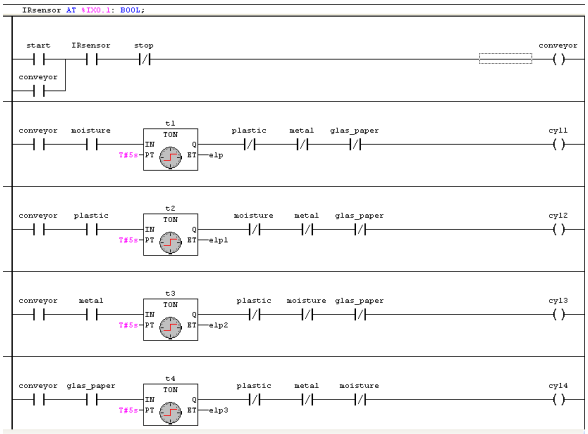

Fig. 9. Ladder diagram.

V. CONCLUSIONS AND FUTURE SCOPE

In this paper, we proposed an automatic waste segregating system using the PLC. The system separates out the wet and dry waste along with few dry components detection and separation. This system can be implemented at the municipal level or in some small scale industries to segregate out the metallic, plastic, glass and paper wastes more efficiently at an affordable cost. Use of PLC has added advantages like reduction in manpower with improved accuracy and speed of waste management, also avoiding the risk of working at hazardous places. In Future, the work can be implemented by making use of a robotic arm to pick and place certain materials which can be re-used. Also, limit sensors can be placed at the top of each of the collecting bins to unload them when they are full.

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