

Automation in Biomethanation Plant Using PLC and SCADA

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Abstract

Biomethanation is a feasible method to generate the biogas from organic waste like food waste, human waste, night soil waste, cow dung etc. The night soil waste and animal waste has bad odor in nature and it produces some infection to operators, so we implement the automation in biomethanation plant. This plant has four major processes like waste collection and mixing, digestion, gas collection and gas distribution. These above processes are controlled by manually, hence it produces some problems and errors, to overcome this problem, and we proposed an automatic control system for biomethanation plant. In this system the overall process are controlled by programmable logic controller and field instruments. And also these processes are controlled and monitored by SCADA using wonderware intouch software.

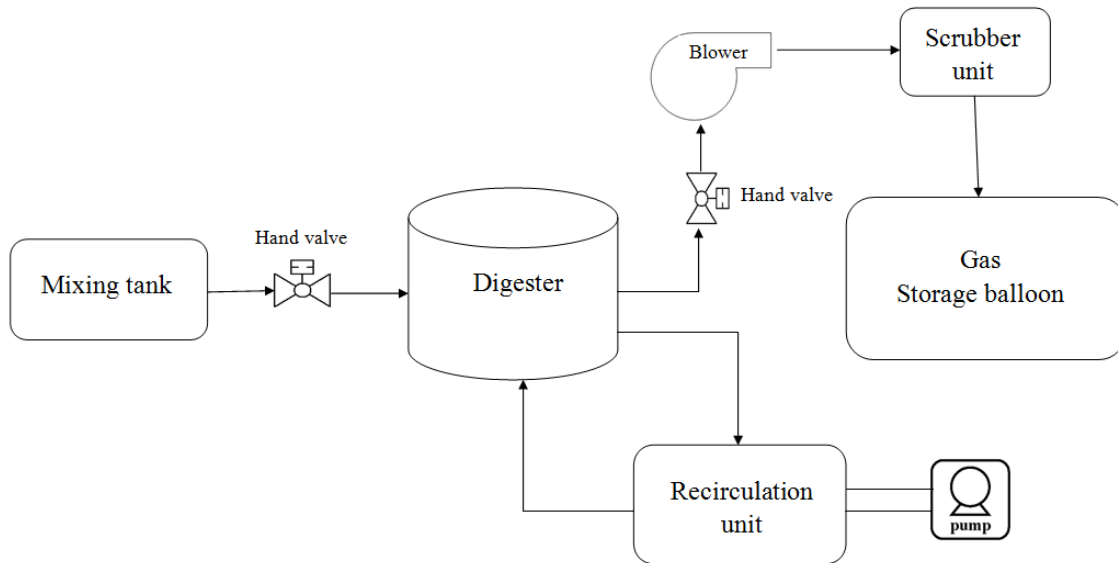
Keywords: *Biomethanation, biogas, automation, programmable logic controller, SCADA*

1. Introduction

Biomethanation is the conversion of organic matter in waste products into methane by the action of microbes in the absence of air is known as anaerobic digestion. Anaerobic digestion is a process in which microorganism decays the biodegradable materials without the presence of oxygen. By this process, bioenergy can be produced from the organic wastes and can be used for Industries, household purposes as an alternate. Most of the fermentation process happens in Industries for food and drink products and home fermentation uses anaerobic digestion [1]. This process of digestion starts with bacterial hydrolysis of input substances. Inorganic soluble polymers such as carbohydrates are decomposed into soluble matters which are accessible by other bacteria. Sugars and amino acids are transformed into carbon dioxide, hydrogen, ammonia, and organic acids by Acidogenic bacteria. This bacterium converts the resulting organic acids into acetic acid with addition of ammonia, hydrogen, and carbon dioxide. Finally, the products are transformed into methane and carbon dioxide by methanogens. In anaerobic waste treatments, a major role play by the methanogenic arched populations [2]. It is used as part in the process of treatment of biodegradable waste and sewage sludge. Anaerobic digestion lowers the landfill gas emission to the atmosphere. Anaerobic digestion acts as the part of integrated waste management system and used as the source of renewable energy. These digesters also fed with energy crops such as maize. This process produces biogas consist of methane, carbon dioxide and some other contaminated gases [3]. This biogas can be used as fuel in all gas engines. Biogas production is one of the most economic ways from organic waste.

2. Existing System Description

2.1. Process Flow Diagram for Existing System



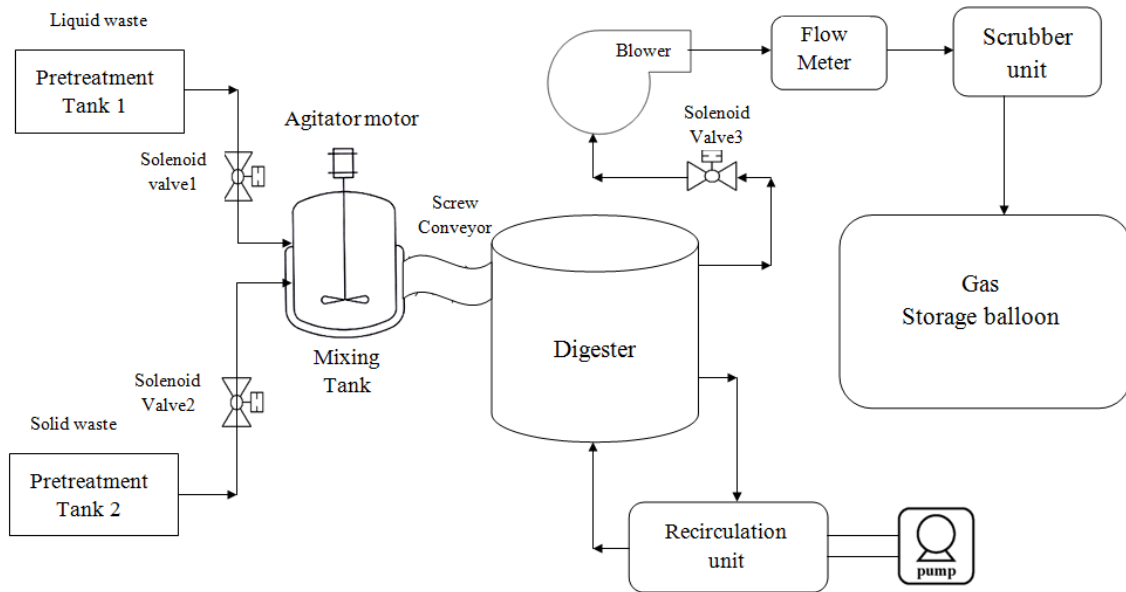
Biomethanation has five main units. They are mixing unit, digestion unit, recirculation unit, scrubbing unit, finally storage unit. In these five units, different types of process take place. In mixing unit all types of feed like cow dung, food waste and human waste are mixed manually by using water and then mixed feed send to digester by using valve. It's a manually controlled valve. Digester is a concrete bed plate placed on the ground level. It is a fully closed unit. After mixing the feed, it transferred from mixing tank into digester [4]. The digester is a continuously working reactor in which fermentation feed is mixed finely to create a fully homogeneous medium. The mixing process in digester is achieved by recirculation unit. It has one pump which is used to re circulate water throughout the digester. This process is used to increase the biogas production in a short period of time. After this, gas will produce in the digester then it will transfer to gas storage bag. The produced gas has some impurities for that we have to remove the impurities by using scrubber unit; it is used to separate the biogas into methane, after removal of unwanted gas the biogas stored into storage bag [5]. These are the process takes place in the biomethanation plant, are controlled by manually.

3. Problem Description

The existing biomethanation plant was fully controlled by manual operation. In this process some difficulties occurs like the waste gives some bad odor so we can't do by manual in feeding and mixing and another difficulty lies in gas flow and gas level monitoring. During manual operation we can't analyze how much of gas produced in particular time period in biomethanation plant. For the above reasons we change the manual operation into automatic operation.

4. Proposed System Description

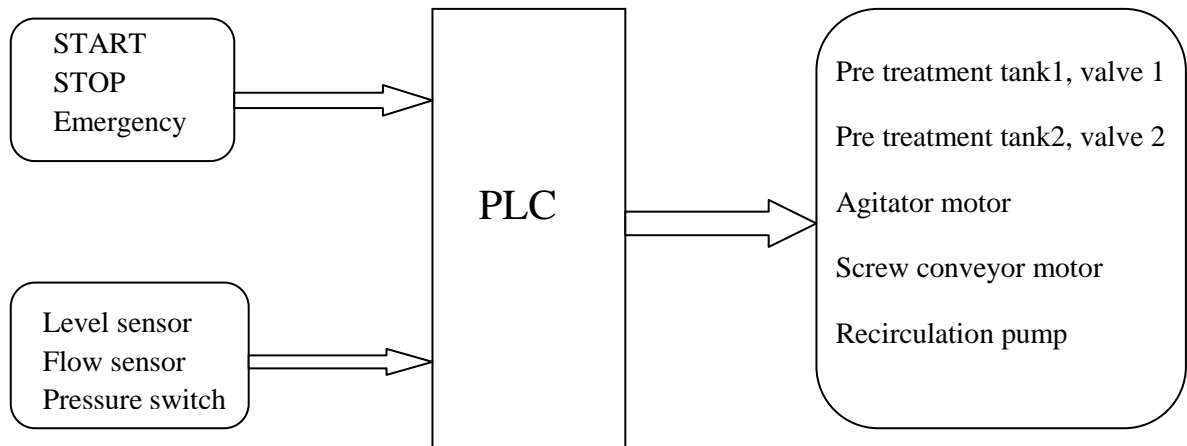
4.1. Process Flow Diagram for Proposed System



In proposed system, all process is controlled by automatic. It has six units. They are pre treatment unit, mixing unit, digestion unit, recirculation unit, scrubbing unit and storage unit. Pretreatment unit is used to remove the non biodegradable materials that are not affected by digestion and take up unnecessary space and it providing a uniform small particular size feed stock for efficient digestion [6]. After the pre treatment process the feed transfer from pre treatment tank into mixing tank. In mixing tank all types of feed mixed together by using agitators which is actuated by electric motor. After preset timing, the agitator gets off and the feed stock will transfer from mixing tank to digester through screw conveyor. If feed reaches low level, the screw conveyor will cut off. After that the recirculation pump will get on. Water will circulate inside of the digester. It is used to improve the contact between the micro organisms and feed. It also prevents the formation of scum and the development of temperature gradients within the digester. After that gas production will get starts. If gas reaches preset pressure, the pressure switch give input to plc then the blower gets on and the biogas transfer from digester to storage bag by using blower because biogas has not the flowing capability. Before this process, biogas will pass through the scrubber which is used to remove CO₂, H₂S, and moisture and then methane gas is stored in the storage bag. It has one flow meter which is used to measure the gas flow of biogas and we calculate the biogas consumption. In manual operation it is not possible. These operations and process are controlled by using programmable logic controller, field instruments like sensors, valve, motor etc.

4.2. Hardware Description

A. Block Diagram of System



B. Block Diagram Description

The system consists of two pretreatment tank valve, agitator motor, level sensor, screw conveyor motor, recirculation pump motor, pressure switch, flow sensor, blower motor, scrubber motor, PLC. Pre treatment valve is used to transfer feed from pretreatment tank to mixing tank. Agitator motor is used to mixing the feed properly. Level sensor is used to check the level of mixing tank. Screw conveyor is used to transfer the feed from mixing tank to digester. Recirculation pump is used to circulate the water throughout the digester. Pressure switch is used to measure gas level in digester. If the gas pressure reaches the present value then it will actuate the blower to transfer the gas from digester to storage tank. Flow sensor is used to measure the gas flow of biogas and it also measure the consumption gas. Scrubber motor is used to re circulate the water from raw water tank into scrubber. It will separate the biogas into methane.

C. Programmable Logic Controller

It is an industrial computer which accepts input signals from field instruments like start/stop push button level sensor, flow sensor pressure switch and it controls the output instruments like valves, motors, pumps etc [7].

4.3. Software Description

Programmable logic controller (or) PLC is an intelligent system which was introduced in the automation and control industry for replacing relay logic because relay has lots of drawbacks. Nowadays better I/O handling capabilities and more programming elements has been added along with good improvement in communications. In this proposed system, we used Rexroth Bosch PLC, software is indralogic. The Indralogic L20 of Rexroth is a compact plc used designed for logic operation and control inputs and outputs. It is the 16 bit processor with 16 inputs and 16 outputs in digital, 2 inputs and 2 outputs in analog [8].

A. SCADA

SCADA (supervisory control and data acquisition) is a unify monitoring system used to control a complete system in industries such as thermal power plant, glass production plant, nuclear power plant. SCADA system collects the information from plant and transfers the information to plant and display the information using HMI [9]. This system is very simple to operate and easy to monitor and supervise the plant. In this system WONDERWARE INTOUCH HMI software are used to control and monitor the plant because, it is user friendly, easy to handle, simple to make a graphics, easy to configure the system and easily interface to any system. The SCADA design for automated biomethanation plant is shown in fig.1. It is mainly used to monitor and control the overall process. This system monitors some parameters like gas flow, gas pressure, tank level, and valve position. And also it controls the overall system like start/stop by local and remote.

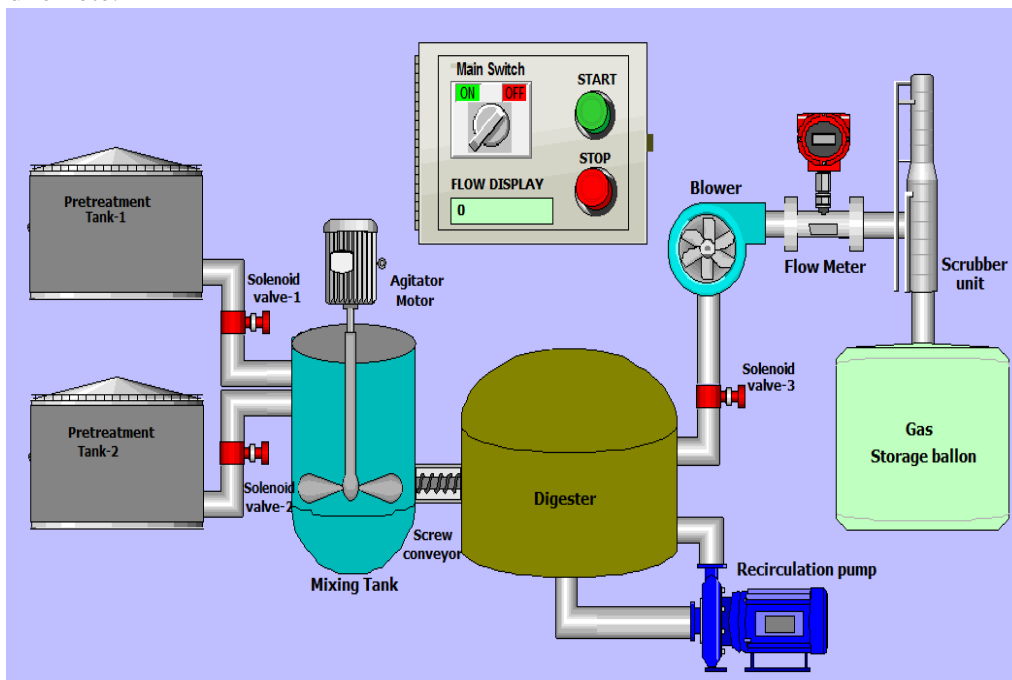


Figure 1. SCADA Graphics for Biomethanation Plant

5. Working of Proposed System

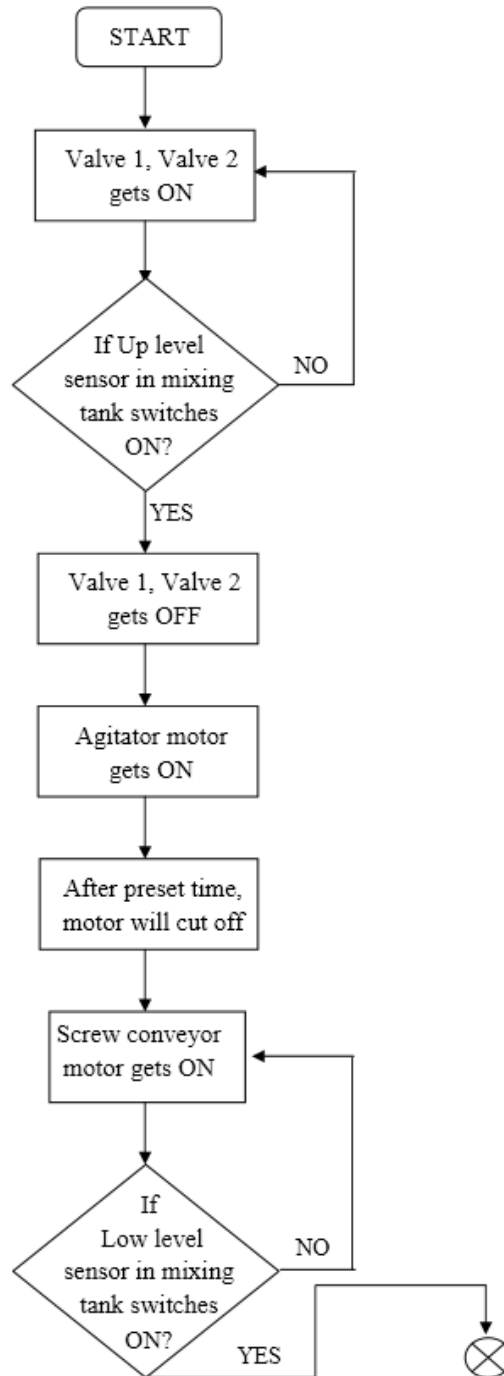
5.1. Sequence of Operation

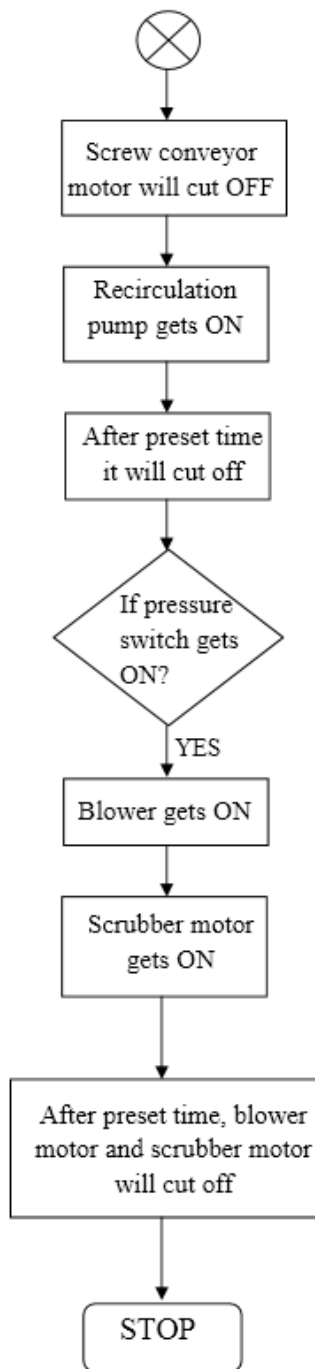
The following steps are working algorithm of automated biomethanation plant:

1. Press the start push button to start the process.
2. Pretreatment tank solenoid valve1 and solenoid valve2 gets open (waste material transfer from pretreatment tank to mixing tank)
3. If top level sensor in mixing tank (agitator) detects the waste material, then solenoid valve1 and solenoid valve2 will cut off.
4. Simultaneously agitator motor gets on (to mix and grind the solid waste and liquid waste).
5. After some preset time the agitator motor will cut off.
6. Simultaneously screw conveyor motor gets on (to transfer the waste material from agitator to digester).
7. If both top level and bottom level sensor in mixing tank de senses. Then screw conveyor will cut off.
8. Simultaneously recirculation pump gets on (to mix the waste materials in digester for improve digestion)

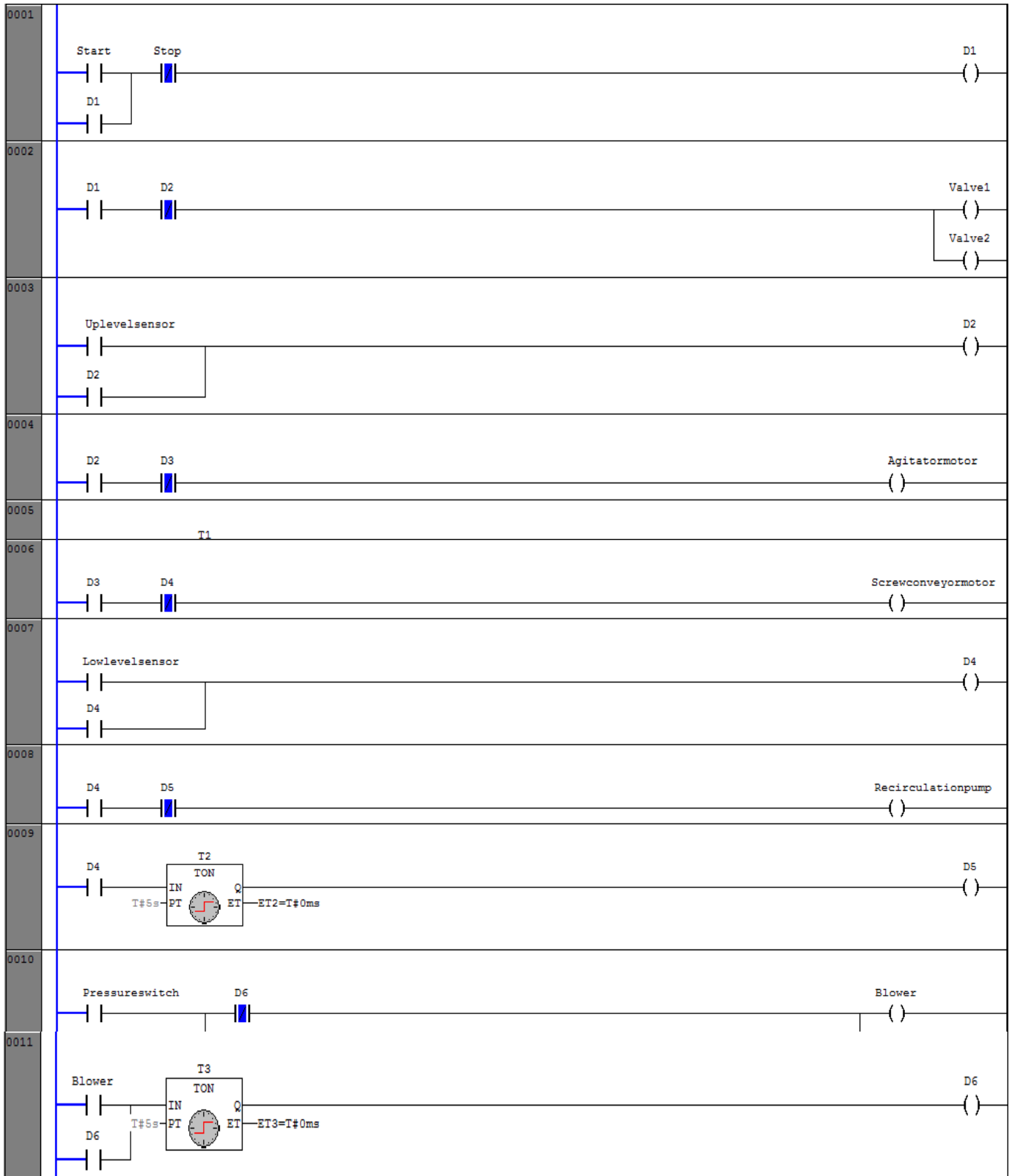
9. After some preset time the recirculation pump will cut off.
10. If pressure reaches the set point in digester, then the blower gets on.
11. Simultaneously scrubber motor gets on.
12. After some preset time the blower motor and scrubber motor will cut off.
13. After these steps the process will repeat when the stop push button is pressed.

5.2. Flow Chart for Proposed System





5.3. PLC Program for Proposed System



6. Advantages of Proposed System

- ❖ It can reduce the process time.
- ❖ It is used to reduce the man power
- ❖ It is used to collect the data from plant
- ❖ It can avoid the human errors
- ❖ It gives good reliability.

7. Conclusion

This paper involves three stages (i) study the existing system of Biomethanation plant, (ii) Identifying problem in existing system, (iii) Finally give the new proposal for automation of this plant. The proposed system is an automated Biomethanation plant, which can perform operations like mixing, transferring feed into digester chamber, re-circulating water in digester for mixing and collect the data from digester like pressure and flow of gas etc. These all operations are achieved by using programmable logic controller and field instruments.

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