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Process Control in Effluent Treatment Plant Using Automation

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ABSTRACT:In this paper, we propose a few automated processes for a partial automation which can be mostly used in residential areas and industries. It is developed using PLC.It has explained the process of ETP in industries. The process include different parameters like flow, level, pH, DC motor, solenoid valves, pump are controlled by using PLC (Allen Bradley Micrologix 1100) and simulated by using software RS Logix . As we know that effluents emitted by industries contains harmful chemicals which could lead to effect on environment and society. So by retreating these effluents could be a blessing in disguise. This process can't be goingthrough using manual process so here we need some automotive tools for that. That is why we make use of PLC (programmable logic controller). PLC is recommended instead of other automation devices because of its versatility, robustness, reprogrammable nature and many other significant features.

KEYWORDS:PLC, ETP, Automation, CV(Control Valve), pH, RS Logix, BOD.

I.INTRODUCTION

Water treatment is, collectively, the industrial-scale processes that make water more acceptable for an end-use, which may be drinking, industry, or medicine. Water treatment is unlike small-scale water sterilization that campers and other people in wilderness areas practice. Water treatment should remove existing water contaminants or so reduce their concentration that their water becomes fit for its desired end-use, which may be safely returning used water to the environment. These processes involved in treating water for drinking purpose may be solids separation using physical processes such as settling and filtration, and chemical processes such as disinfection and coagulation.The treatment of contaminated water can be done with the ETP, which is an effluent treatment plant clean up the industry effluents, polluted water from rivers, lakes, etc. So, they can be recycled for further use. Thus, water is recycled and stored.Automatic systems are being preferred over manual system because they reduce individual's effort. Similarly talking about apartment automation, by use of PLCs everything seems to be more accurate, reliable and more efficient than the existing controllers.

II.EFFLUENT TREATMENT PROCESS

Effluent can be treated in a number of different ways depending on the level of treatment required. These levels are known as preliminary, primary, secondary and tertiary (or advanced). The mechanisms for treatment can be divided into three broad categories: physical, chemical and biological, which all include a number of different processes (Table 1). Many of these processes will be used together in a single treatmentplant Common physical unit operations include among other processes screening, flow equalisation, sedimentation, clarification and aeration.

SCREENING: A screen with openings of uniform size is used to remove large solids such as cloth, which may damage process equipment, reduce the effectiveness of the ETP or contaminate waterways.

FLOW EQUALISATION: There are several different steps in the textile dyeing process and therefore wastewater quality and quantity varies over time. ETPs are usually designed to treat wastewater that has a more or less constant flow and a quality that only fluctuates within a narrow range. The equalization tank overcomes this by collecting and storing the waste, allowing it to mix and become a regular quality before it is pumped to the treatment units at a

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constant rate. To determine the required volume of equalization tank the hourly variation of flow needs to be determined.

SEDIMENTATION AND FILTRATION: The flocs formed in flocculation (see chemical unit processes for a description of flocculation) are large enough to be removed by gravitational settling, also known as sedimentation. This is achieved in a tank referred to as the sedimentation tank, settling tank or clarifier. Sedimentation is also used to remove grit and suspended solids, to produce clarified effluent, and to thicken the sludge produced in biological treatment. Flocculation and sedimentation should remove most of the suspended solids and a portion of the BOD.

AERATION: Aeration is required in biological treatment processes to provide oxygen to the microorganisms that breakdown the organic waste (this is described in more detail in the biological treatment section). Two main methods are used for this, either mechanical agitation of the water so that air from the atmosphere enters the water, or by introducing air into the tank through diffusers.

Table 1 Treatment Process of Effluent Treatment Plant

Treatment Level	Description	Process
Preliminary	Removal of large solids such as rags, sticks, grit and grease that may damage equipment or result in operational problems	Physical
Primary	Removal of floating and settleable materials such as suspended solids and organic matter	Physical and chemical
Secondary	Removal of biodegradable organic matter and suspended solids	Biological and chemical
Tertiary/advanced	Removal of residual suspended solids / dissolved solids	Physical, chemical and biological

CHEMICAL UNIT PROCESSES: Chemical unit processes are always used with physical operations and may also be used with biological treatment processes, although it is possible to have a purely physio-chemical plant with no biological treatment. Chemical processes use the addition of chemicals to the wastewater to bring about changes in its quality. They include pH control, coagulation, chemical precipitation and oxidation.

pH CONTROL: Waste from textile industries is rarely pH neutral. Certain processes such as reactive dyeing require large quantities of alkali but pre-treatments and some washes can be acidic. It is therefore necessary to adjust the pH in the treatment process to make the wastewater pH neutral. This is particularly important if biological treatment is being used, as the microorganisms used in biological treatment require a pH in the range of 6-8 and will be killed by highly acidic or alkali wastewater. Various chemicals are used for pH control. For acidic wastes (low pH) sodium hydroxide, sodium carbonate, calcium carbonate or calcium hydroxide, may be added among other things. For alkali wastes (high pH) sulphuric acid or hydrochloric acid may be added. Acids can cause corrosion of equipment and care must be taken in choosing which acid to use. Hydrochloric acid is probably better from an environmental view point but can corrode stainless steel therefore plastic or appropriately coated pumps and pipes must be used.

CHEMICAL COAGULATION AND FLOCCULATION: Coagulation is a complex process but generally refers to collecting into a larger mass the minute solid particles dispersed in a liquid. Chemical coagulants such as aluminium sulphate (alum) or ferric sulphate may be added to wastewater to improve the attraction of fine particles so that they come together and form larger particles called flocs. A chemical flocculent, usually a polyelectrolyte, enhances the flocculation process by bringing together particles to form larger flocs, which settle out more quickly. Flocculation is aided by gentle mixing which causes theparticles to collide.

III.PROGRAMMABLE LOGIC CONTROLLER (PLC)

Programmable logic controllers, also called programmable controllers orPLCs, are solid-state members of the computer family, using integrated circuits instead of electromechanical devices to implement control functions.They are capable of storing instructions, such as sequencing, timing, counting, arithmetic, data manipulation, and communication, to control industrial machines and processes. Figure 1 illustrates a conceptual diagram of a PLC application.

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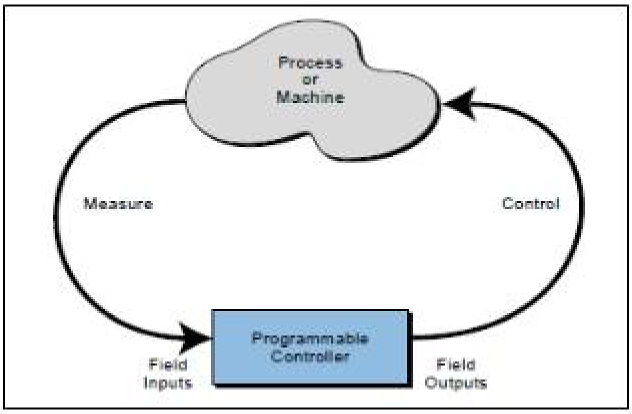

Fig.1 Conceptual Diagram of PLC

Programmable controllers have many definitions. However, PLCs can be thought of in simple terms as industrial computers with specially designed architecture in both their central units (the PLC itself) and their interfacing circuitry to field devices (input/output connections to the real world).

IV.BLOCK DIAGRAM

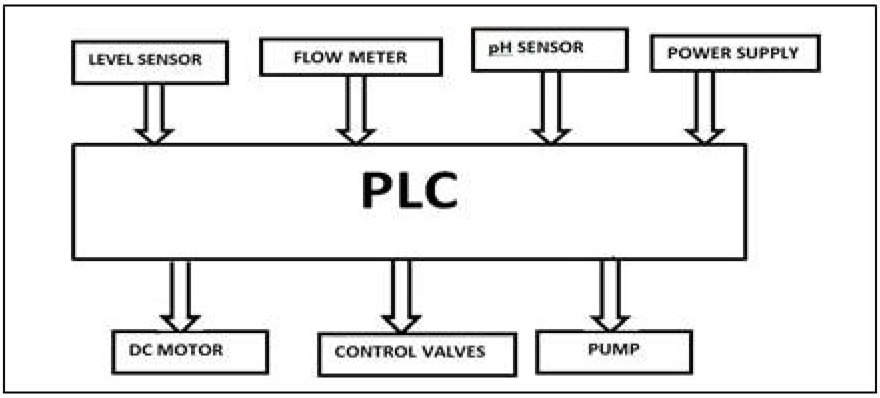

Fig. 2 Block Diagram of Process

In the fig 2, it shows the block diagram of the process. PLC is the main processing and controlling element. It controls both input and output parameters. Input parameters which are being controlled by PLC are level sensor, flow meter, pH sensor. Similarly, output parameters are DC motor, solenoid control valves and submissible pump.

V. FLOW CHART

In the fig 3, it shows the flow chart of process in the effluent treatment plant using PLC. First of all the waste water from the waste water tank is pumped to the screening section where all the solid waste are removed. Then after clearance control valve CV-1is activated. This stage is the pH testing stage. There exists a condition if pH sensor detects that the pH value is greater than 7, then it is basic waste so for that CV-5 is activated and to neutralise the effect of basicity, some acid is added like HCl. In a similar context, if pH value is less than 7, being an acidic waste CV-6 is activated and base NaOH is added. In next stage, Stirrer is being driven by DC motor CV-2 being activated and coagulant alum is being added. After that control valve CV-3 is activated, in this stage filtration of water is done where flocs are removed after that control valve CV-4 is activated. Now stabilization and disinfection of water is done by

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adding alum, sodium bisulphate and chlorine. After this stage is over control valve CV-5 is activated and water is stored in the reservoir tank which is fitted with level sensor that will show the level water being treated.

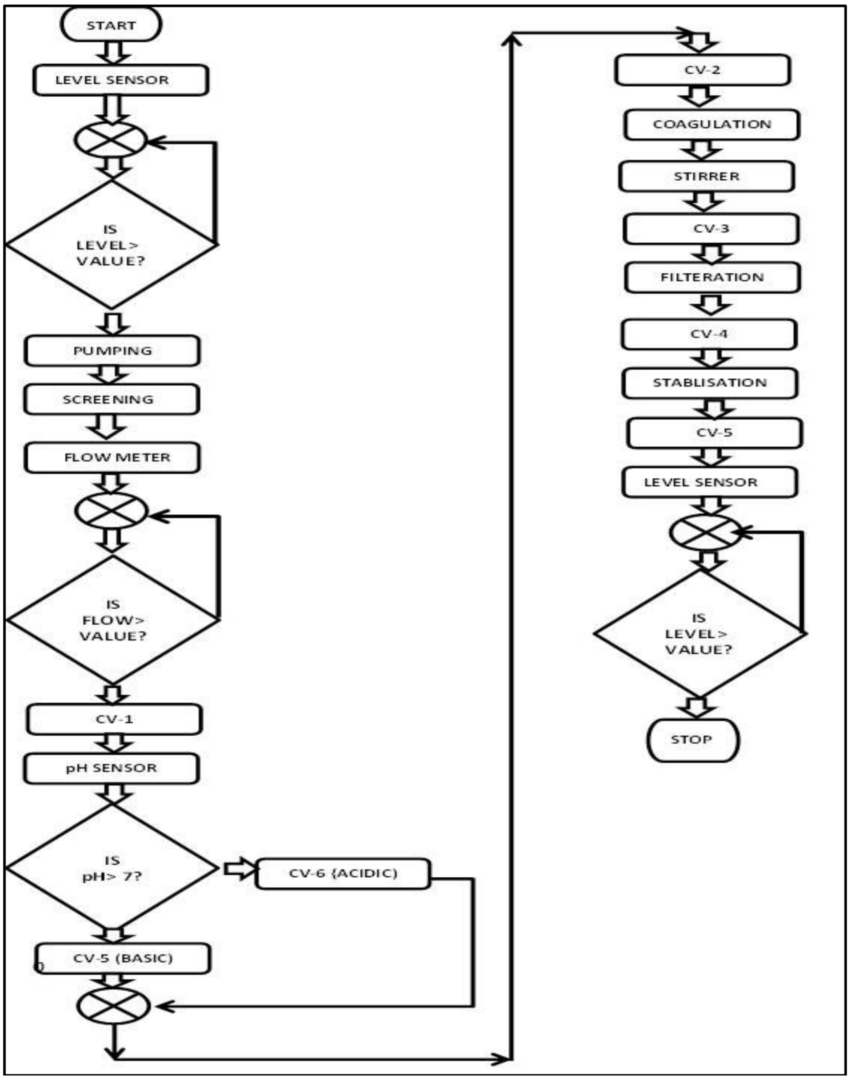

Fig.3 Flow Chart of Process

VI. PROGRAM IMPLEMENTATION

We have programmed the PLC using RS Logix software which supports ladder programming. The program plays an important role in the whole automation process.

Ladder logic program for the process with brief explanation:

As soon as the master switch is on the process get latched the level sensor checks the level of the waste water in the reservoir when the level is well above the desired value pump starts its action after that a delay of 10 seconds control valve CV-1 gets on. This is explained in fig.4.

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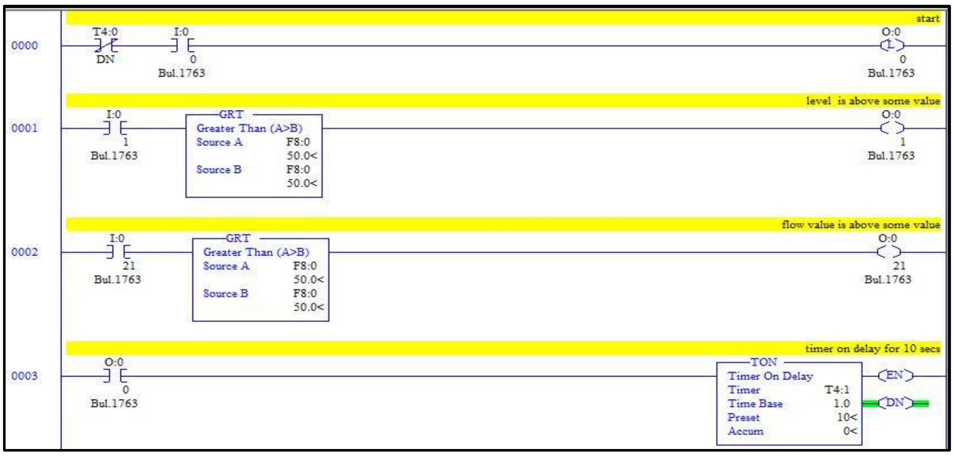

Fig. 4 Logic Program part 1

Now the screening process occurs for 5 seconds after that control valve CV-2 gets on. Now in pH testing stage pH value is checked using pH meter. If the pH value is greater than 7 then acid is added by staring the control valve CV-6 for 5 seconds. Also if the pH value measured is less than 7, then base is added by starting the control valve CV-7 for 5 seconds. This has been explained in fig.5.

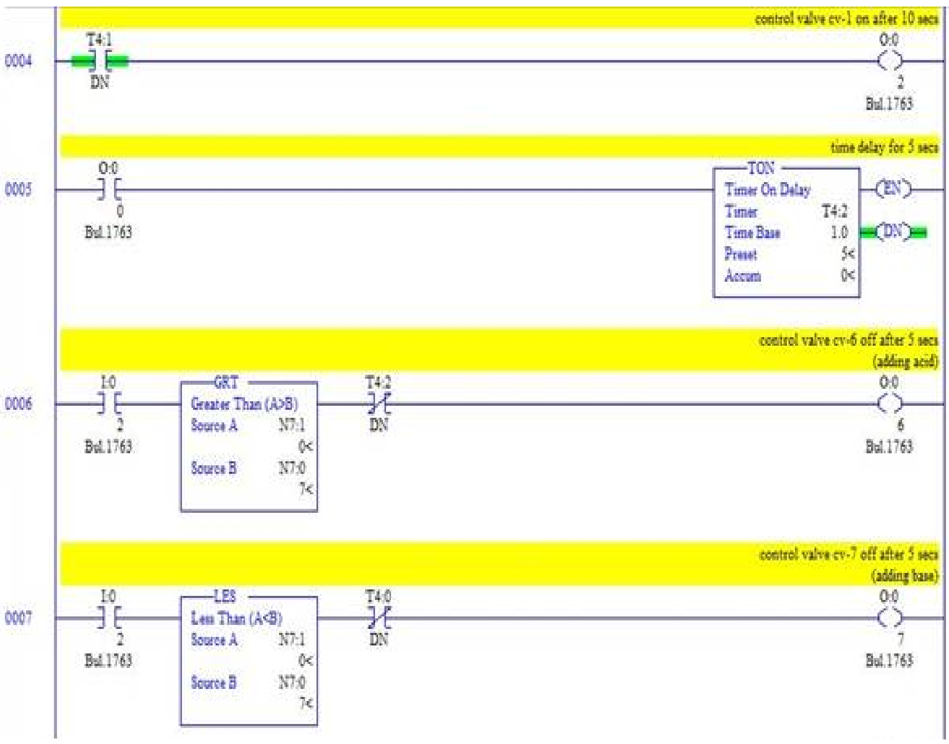

Fig. 5 Logic Program part 2

Now in this stage coagulation is done by adding alum in it and stirring the solution using stirrer which is being operated by dc motor and dc motor is being controlled using PLC. After stirring the solution , control valve cv-3 is activated after a delay of 10 seconds. This has been explained in fig.6.

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Fig. 6 Logic Program part 3

Now filtration process stage comes, after filtration is done control valve cv-4 is activated after 30 seconds. Now the filtered water has to be disinfected and stabilised by adding chorine and sodium bisulphate. After this process, the control valve cv-5 is activated. Now the level sensor used in the storage tank will keep on checking the level of the treated water. If the limit is reached then the all the process is stopped by unlatching. Otherwise it will keep on checking the level of the treated water. This has been in explained in fig.7.

Fig. 7 Logic Program part 4

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VI. IMPLEMENTATION AND RESULT

The fig. 8 shows the hardware implementation of our process control concept and result.

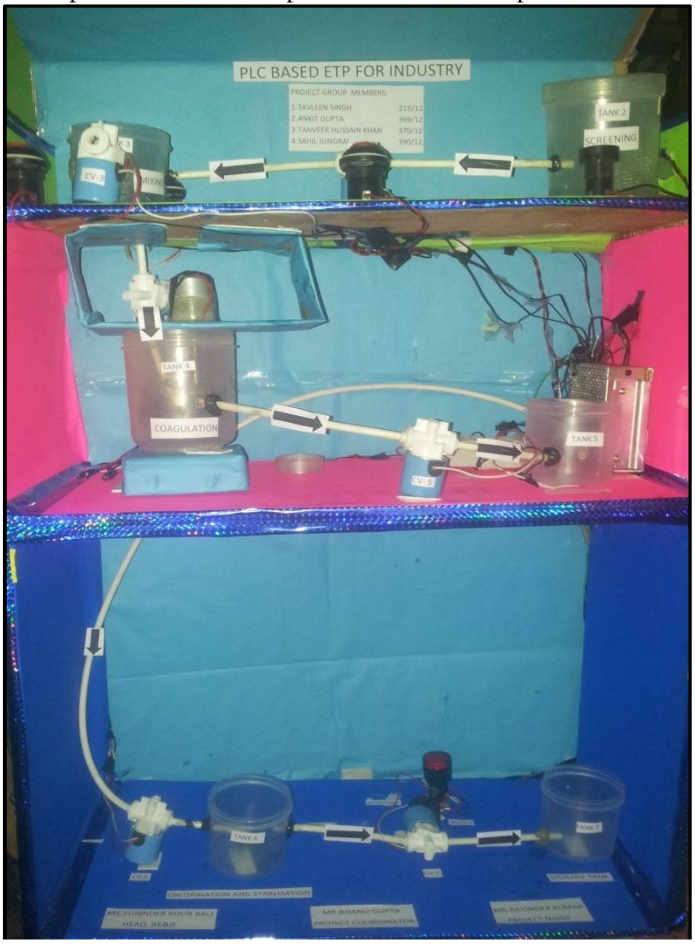

Fig. 8 Hardware Implementation of process control

As clearly seen in the figure a prototype project is explaining our concept of process control using automation in ETP.This concept can be further implemented to large scale with further additions of biological treatment. Our idea can be implemented to make a system that can be installed in household waste treatment as well. The result of our process is that it is controlling the following input and output parameters which are: control valves, DC motor, pH meter, Level sensor, flow sensor , pump. With the control of these parameters all the treatment process can be controlled in a fully automated fashion. The resultant treated water as per concept of implementation can be reused for further purposes. If we want to have drinkable water ,then addition of RO stage can be further used in future.

VI. CONCLUSION

The ETP has a great role to play in discharging the contaminated and polluted water before releasing it back to the environment. Without these water treatment plants, we would not be able to get clean water for domestic uses.
By using PLC the cost effective automation system for residences can be developed and it is very user friendly for the operator or control engineer to troubleshoot the process if any errors occurs and can also be kept track of what is happening in the process. In this we have showed the prototype model and program through which one can be able to install this model at residencies and other platforms to treat water in a cost effective manner. In future project we would

also try to include SCADA which will increase its efficiency as well as provide an operator to visualize, supervise and control the process.

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