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AUTOMATED EFFLUENT TREATMENT SYSTEM

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Abstract - This paper introduces the Programmable Logic Controller (PLC) Based Automated Effluent Treatment System as an innovative solution for efficiently managing industrial effluents. The system employs sophisticated technology, including PLCs and various sensors, to automate and optimize the treatment process. Specifically designed for industries like electroplating, where water contamination is prevalent, the system effectively monitors and controls water levels, temperature, gas presence, and pH levels to ensure the safe disposal of effluent. Through a detailed exploration of its components and functionalities, this paper demonstrates how the PLC-based system enhances efficiency, reliability, and environmental sustainability in industrial wastewater treatment.

***Key Words*:** Programmable Logic Controller, Automation, Effluent treatment plant, Environment safety, Sewage, Chemicals.

1.INTRODUCTION

Water stands as a fundamental natural resource, indispensable across various domains from household usage to critical industrial applications. However, industrial operations often result in water contamination, emphasizing the need for efficient systems to treat and reclaim this vital resource. Effluent Treatment Systems (ETS) play a crucial role in mitigating the challenges posed by industrial wastewater, especially in sectors like textiles, pharmaceuticals, leather production, and chemicals, where the risk of severe water pollution is prevalent.

The core objective of ETS is to purify industrial effluents, preventing the release of polluted water into the environment. Without such treatment, the availability of clean water for domestic use would be severely compromised. ETS employs diverse wastewater treatment processes targeting contaminants like organic and inorganic matter, heavy metals, oil, grease, and suspended solids. These treatment methods can range from batch processes to continuous flow systems.

Introducing advanced technology into this domain, the Programmable Logic Controller (PLC) Based Automated Effluent Treatment System emerges as an innovative and efficient solution. Utilizing PLC technology, specialized computers designed for industrial process control and automation, this system monitors and manages industrial effluent treatment seamlessly. By automating tasks and incorporating advanced control mechanisms, PLC-based systems significantly contribute to optimizing industrial wastewater disposal processes.

The urgency to address industrial effluent challenges is evident in scenarios such as the Electroplating (ETP) system. The current manual operation of the ETP requires 3-4 personnel and consumes considerable time, ranging from 45 to 60 minutes. Apart from time constraints, safety concerns for both personnel and the environment arise due to the lack of efficient monitoring mechanisms.

The deficiencies in the existing ETP system underscore the need for improvements. Proposed enhancements should not only tackle operational inefficiencies but also prioritize safety measures. Automating tasks like solvent mixing and pH level monitoring is crucial for optimizing the electroplating process while ensuring higher safety standards for personnel and the surrounding environment. The proposed system aims to revolutionize current manual operations, providing a technologically advanced and streamlined approach to industrial effluent treatment at Garud Allied Technologies[5].

Wastewater generated by electroplating industries often contains elevated concentrations of heavy metal ions such as chromium, nickel, copper, cadmium, and zinc. The presence of these heavy metals raises significant environmental concerns due to their non-biodegradable nature, high toxicity, and potential carcinogenic properties. Around 60-70% of the metals utilized in plating processes end up as contaminants in rinse waters, necessitating compliance with global environmental regulations to ensure discharged effluents meet acceptable standards before entering the environment.

02. LITERATURE SURVEY

The survey was conducted by Hindustan Times newspaper [6] the causes of the froth in Yamuna River which was due to Industrial and Domestic Effluents. Reason for froth was directly release of effluents without any treatment. Chlorinated phenols, guaiacols, catechols, furans, dioxins, aliphatic hydrocarbons, and similar substances are highly worrisome. Certain compounds within this group are recognized for their toxicity, mutagenicity, persistence, and tendency to accumulate in living organisms. They are believed to provoke various harmful disruptions in biological processes, posing a potential risk to humans through extended exposure via drinking water and accumulation in the food chain mentioned in paper[7].

03. METHODOLOGY

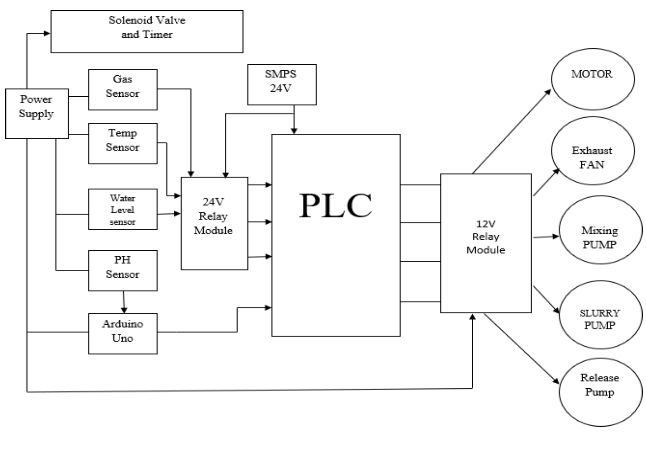

FIG. 01 BLOCK DIAGRAM

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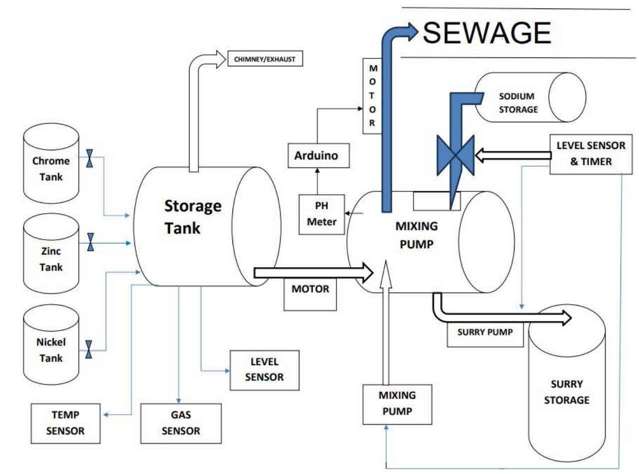
The block diagram illustrates the prototype system, with the PLC serving as the central controller. Various inputs and outputs are connected to the PLC. Initially, 240 volts AC is supplied to an SMPS to convert it to 24 volts DC, required by the PLC. Additionally, power supplies of 5V and 9V are provided to different sensors via rectifier circuits. The water level sensor receives input from float sensors, activating a relay to trigger the PLC. Similarly, the gas sensor detects surrounding gas, sending pulses to trigger another relay, which in turn activates the PLC.

The temperature sensor constantly monitors the environment, activating a relay if the temperature exceeds the permissible level, thereby switching on the PLC input. The PLC, powered by a separate power supply, is controlled by an Arduino board (ATmega380P), which manages relay operations acting as inputs to the PLC.

The PLC's outputs control various equipment such as motor pumps, mixers, valves, and exhaust fans. For instance, if the temperature sensor detects high temperatures, the PLC activates the exhaust fan until the temperature returns to normal.

The level sensor triggers the motor, mixer pump, and solenoid valve for the slurry pump based on water level readings. Float sensors monitor water levels and adjust output statuses accordingly to operate the motor and fill another tank. Similarly, another float sensor activates the slurry pump as per the level indicated. Additionally, a pH meter continuously monitors the tank's pH level. If it deviates from programmed levels, the PLC adjusts output statuses to activate the pump for corrective action. Any changes in sensor parameters result in corresponding adjustments to inputs, altering output statuses accordingly.

04. OPERATION



When water is released into ETP plants after washing jobs or electroplated metals or after clearing the chemical tank for maintenance or metals following their electroplating process (such as zinc, nickel, or chrome), a significant volume of water is required for the washing process. However, the water used becomes contaminated with heavy metals, and its pH level becomes either too acidic.

This contaminated water from the washing area and the three tanks where electroplating takes place is directed into a main tank equipped with various sensors including temperature, gas, and float sensors.

Given that electroplating involves high temperatures, the effluent water in the main tank can become excessively hot, potentially causing damage to the tank and associated motor parts. To mitigate this, a thermistor functions as a temperature sensor, detecting high temperatures and activating an exhaust fan to dissipate heat through a chimney.

Moreover, the effluent may contain combustible gases, posing health risks and fire hazards. To address this concern, an MQ2 sensor is employed to detect combustible gases within the tank. When such gases are detected, the sensor triggers the fan to expel them, ensuring a safer environment. A float sensor is utilized to monitor the water level in the main tank photo electric sensors can also be used to check the water level in tank as mentioned in the paper published by Basant Tomar and Narendra Kumar [1]. When the water level reaches 80% capacity, indicating sufficient volume for further processing, it activates Motor 1 to transfer water from the main tank to a mixing tank.

The mixing tank is equipped with several components including water level and pH sensors, a slurry pump, a mixing pump, a sodium inlet motor, timers, and an outlet motor (Motor 2). Once the water level in the mixing tank reaches 80%, Motor 1 ceases operation, and the sodium inlet motor initiates, adding a specific quantity of water containing sodium into the tank. Subsequently, the mixing pump commences operation, thoroughly blending the sodium with the effluent water.

During this mixing process, the system pauses for a designated period to allow the sodium to neutralize the toxicity of the water, correcting its pH level and reducing heavy metal contamination. The pH sensor continuously monitors the water's pH level within the mixing tank. If the pH level falls within the acceptable range of 6, 7, or 8, the outlet motor (Motor 2) is activated to release the treated water into the sewage system. However, if the pH level deviates from this range, the system remains on hold until the pH sensor detects the appropriate value.

As the treated water is released and the water level in the mixing tank decreases, another float sensor senses when the water level drops to 20%, signaling Motor 2 to stop. Simultaneously, it activates the slurry pump to remove any remaining water and slurry mixture from the tank, facilitating a complete drainage process known as mixing. Once the mixing tank is emptied, another float sensor detects this and triggers Motor 1 to transfer water from the main tank to initiate the next mixing cycle. However, Motor 1 only starts when the water level in the main tank exceeds 80%, ensuring an adequate supply for the subsequent process.

PHOTO OF PROTYPE WORKING MODEL:

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05. COMPARISON

Existing System:

Require human intervention for operation, monitoring and control of process. System relies on periodic checks and observation by operator. May have slower response time due to need for human intervention. Lack of capabilities making it more challenging to identify trends of diagnosis problem.

Automated system.

Require minimal human intervention.
Plc can monitor the various parameter such as flow rate pH level temperature combust stable gases.
Responds rapidly to changes in the effluent characteristics or operating conditions adjusting setting and process accordingly.
Reduces the hazardous environment by continue monitoring and clears the high temperature and gases.
Increase's the efficiency by use of PLC by using power only whenever required.

06. RESULTS:

Effluent from the waste area is stored in tank and continuously level, temperature and gases are monitored with help of float temperature and gas sensor of the effluent.
The temperature and gases present in the tank are brought to normal level and released in the environment with help of exhaust fan.
Effluent is transferred to mixing tank as soon the storage tank gets filled up to 80%.
Sodium is poured with help of solenoid valve and mixer is turned on to mix sodium with effluent.
pH sensor senses the pH of effluent continuously and releases the effluent when under the permissible value.
The remaining effluent is successfully made to release in slurry storage with the help of slur pump and cycle is repeated An industrial automation system comprises various components that operate harmoniously to perform tasks including sensing, controlling, supervising, and monitoring industrial processes with synchronized precision which can an be done through PLC [4].

07. FUTURE SCOPE

Integrate advanced automation technologies such as HMI and artificial intelligence to optimize the entire process. This could involve predictive maintenance of equipment, real-time adjustment of treatment parameters based on sensor data, and continuous optimization of energy consumption. Advanced Sensor Technologies: Explore the use of more advanced sensors for detecting contaminants and monitoring water quality parameters. This could include sensors capable of detecting a wider range of pollutants, such as organic compounds and microplastics, as well as sensors with higher sensitivity and accuracy. Develop systems for remote monitoring and control of the wastewater treatment plant, allowing operators to monitor performance and make adjustments from anywhere. This could involve the use of Internet of Things (IoT) devices, cloud-based software platforms, and remote sensing technologies as mentioned by Parneel and team in their paper. SCADA can also be implemented to keep the record of effluent data which can be very important for showcasing the safe release of exact amount of data to the Pollution control boards and SCADA can also help to keep record and clear the Slur on periodic basis which was implemented with PLC in the paper published by the Abdul Yaseen & Birinderjit Singh Kalyan[3].

08. CONCLUSIONS

In conclusion, the implementation of Programmable Logic Controller (PLC) Based Automated Effluent Treatment Systems represents a significant step forward in addressing the challenges posed by industrial wastewater. By integrating sophisticated technology with efficient processes, these systems play a vital role in safeguarding water resources and protecting the environment. Through meticulous monitoring and management of industrial effluent treatment, PLC-based systems ensure the purification of contaminated water, thereby preventing its release back into nature. The utilization of sensors, motors, and pumps facilitates a seamless and automated treatment process, optimizing efficiency and minimizing environmental impact. Furthermore, by neutralizing toxins, correcting pH levels, and reducing heavy metal contamination, these systems contribute to the sustainable management of water resources. Overall, the adoption of PLC-based automated effluent treatment systems signifies a commitment to environmental stewardship and underscores the importance of technological innovation in mitigating the adverse effects of industrial activities on water quality.

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