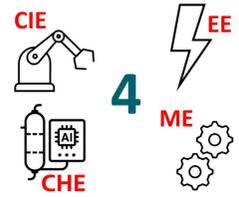


Neutralizing Hazardous Chemicals pH Value during Emergency Shutdown

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INTRODUCTION

• **Problem Statement** is a Hazardous Materials Neutralization System that activates during an Emergency Shutdown (ESD) to safely neutralize hazardous chemicals in pipelines and tanks.

Constraints and Specifications

pH level neutralized at 7
Response time less than 5 minutes
Pressure Limit less than 3 bar
Voltage Limit of 12 V
Pipeline diameter of 0.5 inch
Tank size of 3 L
Total volume after reaction less than 3 L
PI Coefficients within ($10 < K_p, K_i < 10$)
Valves to operate for 5 Seconds per act
Controller to operate at 3.3 V
Sensor to operate at 5 V
Temperature during reaction does not exceed 40 Celsius
Backup voltage supply to supply 12 V
Inject remaining liquid of 7 pH for reuse

Prototype Design

• The system features precise flow control using a peristaltic pump with a stepper motor

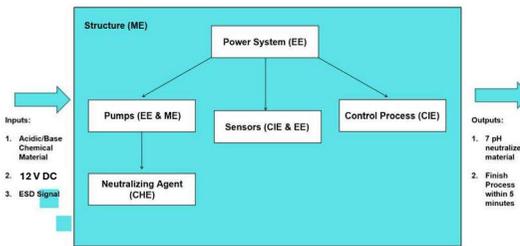


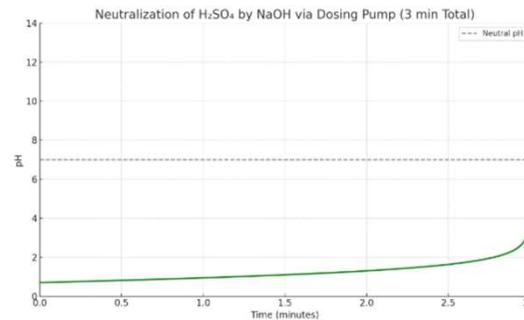
Figure 1 – Summary Figure for Prototype Deliverables

Key Components

- **ESD Valve** – Cuts off the hazardous chemical supply.
- **pH Sensor** – Continuously monitors the tank's pH level.
- **Neutralizing Agent Injection System** – Uses a dosing pump with PI control.
- **Magnetic Stirrer** – Ensures uniform mixing for fast pH stabilization.
- **Water Injection System** – Flushes neutralized liquid for safe disposal or reuse.
- **PI Controller** – Reads pH data and adjusts the pump to maintain pH at **7.0**.

Testing/Validation

Neutralization of H₂SO₄ by NaOH via Dosing Pump (3 mins Total)



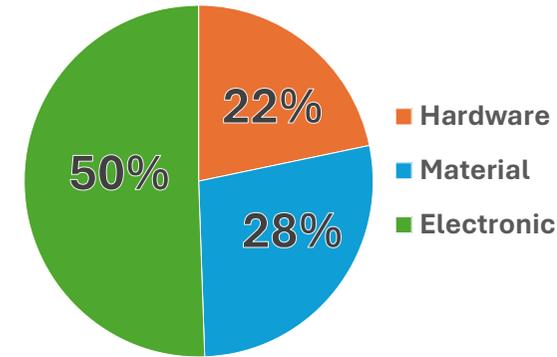
- Dosing Pump Duration: NaOH is added over 3 mins at a constant rate.
- Reaction: Instantaneous neutralization of 0.4 mol NaOH with 0.2 mol H₂SO₄ (stoichiometric).
- Stirring: Ensures complete and uniform mixing.
- pH Behavior:
 - Starts acidic pH ~ 1
 - Gradual rise as NaOH is added (dosed)
 - Hits neutral pH = 7 right around 3 mins

Time to Empty the Tank

- Given: Tank volume = 3 L = 0.003 m³*
- Flow rate of the pump = 800 L/h = 0.8 m³/h Substituting the values:
- Thus, the time required to empty the 3L tank is approximately 13.5 seconds.

Cost Analysis

TOTAL COST



Conclusions

This project offers a solution to the undesirable pH problem for companies dealing with hazardous chemicals in their industries. Furthermore, compared to other projects, this project is efficient and cost-effective. All processes are automatically controlled by sensors and a PI controller.