Hardness Removal Through Electrocoagulation (E.C)

Group (68)

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INTRODUCTION / BACKGROUND

Overview: Our project pioneers innovative water treatment to address pipe scaling and clogging caused by water hardness. Using monopolar electrocoagulation, we selectively eliminate undesirable molecules with precision, ensuring a controlled flow rate through a sophisticated reactor.

Problem Statement: Optimize electrocoagulation (E.C.) process to reduce water hardness efficiently and cost-effectively, ensuring consumption quality standards are met.

Constraints

- For our water to be safe to consume you need 6.5 - 8.5 pH level for humans to consume and use
- The water treated shouldn't be above 300 ppm as that range isn't save to consume
- Voltage: 5 to 50 volts
- Current density: 5-50mA/cm^2

Technical Specifications

- Water Hardness should be between 85 – 120 mg/L
- Product mass: Maximum 30 Kg
- Product Size: 35 cm x 25 cm x 15 cm
- Cost Efficiency: Max: 2000 SAR per device
- Maintenance Frequency: Yearly
- Set-up Time: 60 min
- Fluid Rate: 30L/h

Project Goals

- Revolutionize water treatment methodologies.
- Integrate expertise in chemical engineering, control systems, and pipeline infrastructure.
- Substantiate the viability of our method through the development of a functional prototype.
- Offer a groundbreaking solution marking a significant stride forward in the evolution of water treatment.

FUNDEMANTALS

Chemical Formulation: The project relies on an electrochemical reaction. Fundamental chemistry principles guide our understanding of reaction rates, constants, and kinetics, crucial for optimizing the effectiveness of the process.

Fluid Mechanics: Operating within a water system, our reactor demands expertise in fluid mechanics. Understanding water flow dynamics, fluid movement behavior, and the concept of head ensures optimal performance and efficiency.

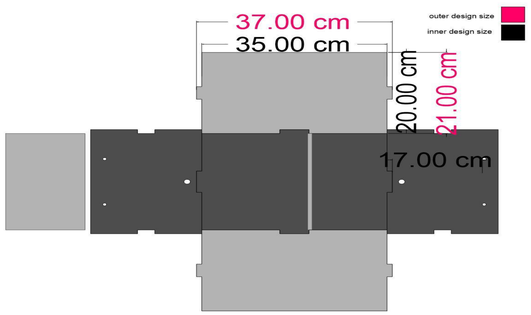
FUNDAMENTALS (CONT.)

Process Design and Optimization: Efficient hardness removal requires a robust process design. Considerations such as reactor sizing, material selection, and system optimization, including residence time, electrode configuration, and energy consumption, are pivotal for achieving optimal water quality and system performance.

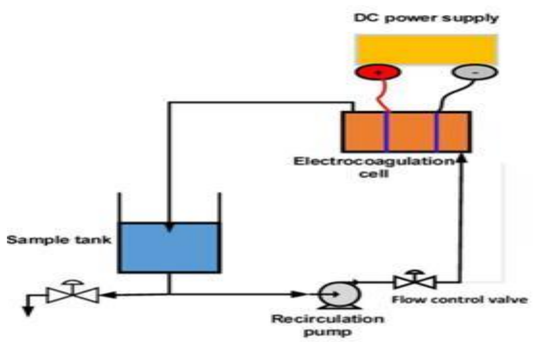
Water Quality Analysis: Designing our hardness removal system involves comprehensive water quality analysis. Techniques such as pH measurement, conductivity analysis, and titration methods guide engineers in characterizing influent water composition, monitoring treatment performance, and making informed decisions for process adjustments or chemical dosing.

PROTOTYPE DESIGN

Drawings:



Process Flow Diagram:



METHODOLOGY

- The product is designed to eliminate hardness ions, primarily calcium and magnesium, from water sources using the electrocoagulation method.
- Electrocoagulation is a water treatment process that uses electrochemical reactions to remove contaminants from water.
- The product consists of an electrocoagulation unit with sacrificial electrodes, a power supply, and a control system.
- The sacrificial electrodes dissolve and release metal ions as coagulants when an electric current is applied, neutralizing charged particles such as hardness ions.
- Coagulants form flocs that trap hardness ions and impurities, making it easier to separate them from the water.
- The power supply energizes the electrochemical reactions, and the control system enables parameter adjustments for optimal hardness removal.
- The product has advantages such as cost-effectiveness, minimal reliance on chemical additives, a smaller physical footprint, and seamless integration into existing water treatment infrastructure.

TESTING / VALIDATION

- Meeting the specifications of this product involves an experimental process with various factors.
- Factors that need to be considered include the direct current voltage and density, inlet flow rate, number of plates, and plate thickness.
- The size and thickness of the tank and plates were determined based on literature and material reviews.
- The efficiency of the hardness removal process needs to be measured to assess its effectiveness.
- The goal is to determine if a practical operating time of 10 to 15 minutes can be achieved.
- Three trials were conducted, and the following data was collected.

Sample	TDS before	TDS after	Classification
untreated	280 ppm	280 ppm	Moderately hard
10 min	268 ppm	150 ppm	Slightly hard
15 min	270 ppm	120 ppm	Soft
20 min	274 ppm	90 pm	Soft

OUTCOMES

- The Electrocoagulation process successfully reduced dissolved solids in the water, improving water quality by removing hardness ions, heavy metals, suspended solids, and certain organic compounds.
- The specified detention time of 10 to 15 minutes was found to be suitable for effectively removing hardness ions and achieving the desired water quality, as indicated by the metric used to assess product efficiency.
- The product meets the specified mass and size requirements, staying within the acceptable range for installation and operation.
- The cost efficiency specification was not met as the prototype of the product exceeded the specified budget of 2000 ryals. Further cost optimization measures or adjustments may be necessary to align with the desired cost targets.
- The product is designed to meet the setup time and maintenance frequency requirements, allowing for efficient installation and upkeep without significant disruptions to operations.

CONCLUSION

- The electrocoagulation (E.C.) process offers an efficient and cost-effective solution for reducing water hardness while meeting consumption quality standards.
- The product utilizes electrocoagulation to eliminate hardness ions, providing advantages such as cost-effectiveness and minimal reliance on chemical additives.
- The electrocoagulation process successfully reduces dissolved solids, including hardness ions, heavy metals, suspended solids, and certain organic compounds, improving water quality.
- The specified detention time of 10 to 15 minutes proves suitable for achieving optimal water quality through hardness ion removal.
- Electrocoagulation is a promising solution for addressing water hardness concerns with efficiency and cost-effectiveness while meeting quality standards.