

Waste Management through the Utilization of Carbonated Water and Red Mud in Cement Additive Production

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Introduction/Background

Problem Statement:

- Aluminum production generates over 150 million tons of red mud annually, posing environmental risks due to its high alkalinity.
- CO₂ emissions contribute significantly to global warming.
- This project addresses these issues by neutralizing red mud using carbonated water, transforming it into a cement additive.

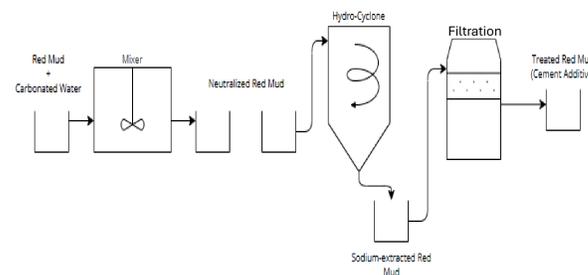


Constrains & Specifications:

Discipline	Specification	Constraint
Chemical (CHE)	Final product pH between 7.4 – 7.9	Use CO ₂ -neutralized water to reduce red mud alkalinity
Mechanical (ME)	Use a 30 L./min pump for adequate flow rate	Cyclone length must not exceed 40 cm
Industrial (ISE)	Scalability: Process range from 0.1 kg to 1 ton	Maintain a 50 g CO ₂ water : 1 g red mud ratio

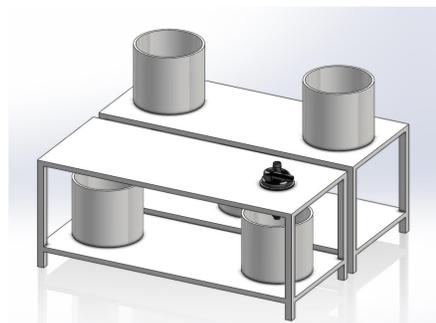
Prototype Design

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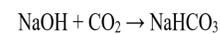


A continuous-flow system featuring:

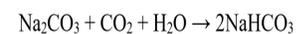
- Mixing Chamber:** Blends carbonated water and red mud.
- Hydro-cyclone Separator:** Separates red mud from water.
- Filtration Unit:** Separates additional solids and removes excess water for improved clarity.



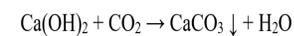
Neutralization of Sodium Hydroxide (Main Contributor to High pH)



Conversion of Sodium Carbonate into Bicarbonate



Precipitation of Excess Calcium Hydroxide (If Present)



Testing/Validation

Tests:

- pH neutralization experiments using carbonated water.
- Sodium reduction analysis via Atomic Absorption Spectrometry (AAS).
- Prototype performance testing for flow rates, power consumption, and leakage.



Results:

- pH Neutralization:** Reduced from 15.3 to approximately 7.3.
- Cement Industry Compliance:** Final product meets SASO standards for cement additives.

Specification	Target	Standard / Data Basis
pH level	7.4 – 7.9	Preliminary tests show pH 7.37–7.9 after 1 min CO ₂ treatment.
Na ₂ O content	≤ 5%	Process goal to reduce free alkali; ≤ 5% Na ₂ O makes red mud comparable to natural pozzolans.
SiO ₂ + Al ₂ O ₃ + Fe ₂ O ₃ sum	≥ 70%	ASTM C618 requires ≥ 70% combined oxides for (Class N) pozzolans.
SO ₃ content	< 5%	ASTM C618 limit for pozzolans.

Conclusion

Summary:

- This project successfully developed a scalable, cost-effective process to neutralize red mud using carbonated water, converting it into a safe and usable cement additive.
- The solution addresses environmental waste concerns while utilizing captured CO₂.

Future Recommendations:

- Upgrade materials to stainless steel for long-term durability.
- Explore ion exchange as an advanced method for enhanced sodium removal.
- Investigate long-term stability and performance of the cement additive in real concrete mixes.

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