

Recycling of Industrial Waste Gypsum Using Mineral Carbonation – Supplementary Material

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1. Assumption

Real discount rate: 3.2%

- Real discount rate was calculated by applying the Korean deposit interest rate and the consumer price index growth rate from 1993 to 2007. Equivalent conversion of life cycle costs by applying the real discount rate.

2. Initial Investment Cost

2.1 Equipment

The types of main equipment are as follows:

- Reactor: direct contact type between gas and slurry, co-current type, continuous type
- CaCO₃ separator: Vacuum belt press, continuous type
- Evaporator: falling thin film type, triple effect, continuous type
- Crystal tube of ammonium sulfate: draft tube baffled (DTB) type, single utility, continuous type
- Ammonium sulfate crystal separation device: pusher type centrifuge, continuous type
- Ammonium sulfate crystal drying equipment: dynamic fluidized bed dryer, continuous type
- NH₃ degassing and absorption device: column with structured packing

Lifetime of equipment

- Devices, heat exchangers, and vessels: 25 years
(except for mixing tank, vacuum belt press, DTB crystallizer, centrifuge, wet crystal screw conveyor, Fluidized bed dryer, dried crystal screw conveyor – 15 years)
- Pump and blower: 10 years
- Instrument: 15 years

2.2 Construction

Calculation of construction cost by creating P&ID (Piping & instrument diagram)

Lifetime of construction: 25 years

Citation: Kang, C.-U.; Ji, S.-W.; Jo, H. Recycling of Industrial Waste Gypsum Using Mineral Carbonation. *Sustainability* **2022**, *14*, 4436. <https://doi.org/10.3390/su14084436>

Academic Editors: Federica Raganati and Paola Ammendola

Received: 15 February 2022

Accepted: 6 April 2022

Published: 8 April 2022

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3. Operating Cost

3.1 Material

Gypsum: 300,518,400 kg/year

Ammonia gas: 59,443,200 kg/year (0.597 \$/tonne)

Flue gas: 556,492,800 kg/year

3.2 Utility

- Steam: 48,700 kg/h, 6 bar-G (164.9°C) (32.025 Mcal/h)
- Electric power: 45,672,960 kW
- Colling water circulation: 7223 tonne/h from 32°C to 37°C (9260.3 RT)
- Clean water: 6095 kg/h
(180 tonne/h make-up water required if cooling tower is used)
- Compressed Air Requirements: 0.6 m³/min, 6 bar-G

3.3 Labor costs

- 2 Process engineers: Supervise the capacity and performance of the facility, and suggest corrections and supplements if there are problems in the process
- 4 Mechanical engineers: Supervises the operation status of mechanical equipment and, if there is a problem in operation, corrects and supplements under the direction of the process engineer
- 2 Mechanical engineers: Supervises the operation status of mechanical equipment and, if there is a problem in operation, corrects and supplements under the direction of the process engineer

4. Operating Income

Ammonium sulfate: 0.184 \$/tonne

Certificate emission reduction (CER): 76,877 tonne/year

- Emissions trading has not been calculated in this study, because of carbon emission rights including allowance and credit are different for each country and each project.