Task 4. Mine Tailings Reuse

Proposed and Developed by Freeport-McMoRan

Background

Mine tailings are produced during the recovery of metals from their ores. For copper mines, tailings are created when the copper ore is finely ground to liberate the copper minerals from the host rock. The copper minerals are recovered, and the finely ground host rock is sent to tailing repositories as a slurry where they consolidate into a large earthen dam. The purpose of the earthen dam is for storage of the tailings.

Copper mines can produce from 5,000 to over 100,000 tons of tailings per day, with particle sizes P_{80} of 150 microns. The material in the tailings repositories is typically never reused and the repositories become permanent landforms. These landforms may potentially be reclaimed by clean-up operations such as covering with topsoil and planting with natural vegetation, but such reclamation ignores and underutilizes the valuable resource of finely ground rock produced during the copper extraction process.

Mine tailings landforms must be continually monitored for the presence of sulfates, acid, or trace metals in the tailings that may warrant draindown treatments. Alternatively, reusing the mine tailings may reduce or eliminate the need for tailing repository clean up and monitoring.

Many companies have researched transforming mine tailings into useful products. Potential products include concrete, other building materials, glass, fiberglass, tiles, frac sand, soil amendments, erosion control media, etc.

Reusing the tailings material can potentially provide several significant benefits to the environment including reduced dust emissions, reduced risk of tailing dam failure, and reduced risk of dissolved metals in tailings water leaching into neighboring areas. In addition, by reusing the mine tailings, there is a potential to recover more of the water that is currently tied up within the tailings dam and in tailing ponds. Reuse of tailings, rather than starting with new solid rock, also reduces energy input for products requiring finely ground rock, since large amounts of energy have already been used to grind the rock to a fine sand-like consistency. Finally, mine tailing reuse is another step toward achieving zero-waste operations.

Problem Statement

In this task, your team will research, evaluate, design, and demonstrate one or more uses for mine tailings. Ideally, the proposed solutions would have the following benefits.

- Use large tonnages of mine tailings
- Maximize the use of tailings in final product
- Provide a permanent destination for tailings
- Achieve a chemically stable state that will not leach out minerals or metals
- Serve a practical use to society
- Be cost effective (does not need to be profitable to be cost effective)

Design Considerations

Your proposed design should provide specific details and outcomes as follows:

- Describe the product, including how it is produced, how it is valuable to society, and why people would use it instead of current similar products.
- Identify any waste products or by-products that will be produced.
- Determine quantities and proportions of mine tailings in the product.
- Report TCLP test results. None of the RCRA eight metals should exceed the detection limit.
- Report ASTM tests, if needed. For building materials, final products must pass ASTM tests for the targeted building material and efflorescent test, when applicable.
- Report additional tests, as needed, to confirm the integrity and/or environmental safety of the product.
- Present an engineering analysis on the ability to scale up the process.
- Provide a process-flow diagram, complete with quantified inputs/outputs for the designed process.
- Estimate the capital costs (CAPEX) to build a full-scale plant that processes a minimum of 1000 tons/day of mine tailings. This includes, but is not limited to, equipment, buildings, land use, construction costs, engineering mark-up, etc.
- Estimate the operating costs (OPEX) (calculated as $\$/m^3$ of product produced, or other units, as appropriate) on an annual basis for a full-scale plant that processes a minimum of 1000 tons/day of mine tailings, including, but not limited to, any consumables used (chemicals, sacrificial components, etc.), labor, and energy requirements assuming industrial electricity rates.
- Include a financial analysis of any potential product salable value. Note that plant location in reference to raw materials and final consumers will have a major impact on the cost of the final product.
- Include a Public Involvement Plan, as applicable (See Team Manual).
- Address safety aspects of handling the mine tailings, processing equipment, and any final products. Safety issues should be addressed in both the written report and the Experimental Safety Plan (ESP). Attend WERC's webinar for helpful tips for addressing health and safety issues. (See website or email us for webinar info.)
- Document success in improving energy efficiency, pollution prevention, and/or waste minimization, as it applies to your project to qualify for the P2E2 Award. Place this in a separate section of the report.
- Discuss the intangible benefits of the product compared with using mine tailings repositories, e.g., higher stability, reduced footprint, salable by-product, less energy input.

Bench Scale Demonstration

Demonstrate the production process using a bench-scale design for the final mine-tailing product using actual mine tailings. Teams will be shipped up to ten 5-gallon pails of mine tailings in late January 2021, according to needs specified in the team's preliminary report. Prior to using the tailings, the contents of all pails should be combined and mixed until the mixture is homogenous.

Due to mining variabilities, the water content, particle-size distributions, density, and mineralogy of mine tailings can vary somewhat from day to day, but average values are given below.

- *Water Content.* The tailings slurry has 45% to 50% water by mass on average when it is sent to the tailings dam for impoundment. The tailings sample that teams receive will be dry.
- *Particle-Size Distribution*. Approximately 50% of the material will be sand with +100 mesh size, and the remaining will be fines with -100 mesh size, with some fines being -500 mesh size.
- *Tailings Density*. Dry density of the tailings averages 1.44 $tons/m^3$
- *Mineralogy.* The tailings have, in general, the mineralogy shown in the table (next page).

Mineral	%
Plagioclase	25.3
Quartz	24.4
Orthoclase	17.9
Muscovite	7.4
Biotite	5.8
Hornblende	2.5
Epidote	1.9

Mineral	%
Gypsum	1.8
Calcite	1.8
Chlorite	1.3
Kaolinite	1.3
Magnetite	1.0
Pyrite	0.7
Amorphous	6.9

Technical Report Requirements

The written report should demonstrate your team's insight into the full scope of the issue and include all aspects of the problem and your proposed solution. The report will be evaluated for quality of writing, logic, organization, clarity, reason, and coherence. Standards for publications in technical journals apply.

In addition to the listed requirements, your report must address in detail the items highlighted in the Problem Statement, Design Considerations, Evaluation Criteria, and 2021 Team Manual. The required page formatting has changed this year—check the 2021 Team Manual for more information.

Evaluation Criteria

Refer to the 2021 Team Manual for a comprehensive explanation of the evaluation criteria. Additionally, your proposed solution will be evaluated on the following:

- Technical fundamentals, performance, safety, and other issues stated in the problem statement
- Potential for real-life implementation
- Thoroughness and quality of the economic analysis (Scale-up CAPEX and OPEX)
- Originality, innovativeness, functionality, ease of use, maintainability, reliability, and affordability of the design.
- How well the bench-scale design represents your full-scale design concept
- The quality of the final product – the bench-scale-processed product will be evaluated for TCLP, tailings quantity and concentration, ASTM results (if applicable), and time to process

Other specific evaluation criteria may be provided at a later date.

FAQs/Deadlines

- Watch for FAQs online for any updates in the task requirements. (wercdesigncontest.nmsu.edu)
- Due 15 January 2021: Request quantity of tailings to be shipped. Include rationale for the amount requested.
- Due 1 February 2021: Experimental Safety Plan (ESP).
- Due 29 March 2021: Written Report.

Awards

The WERC Environmental Design Contest and its sponsors award more than $25,000 in cash prizes, below.

1. Task awards (First, Second, Third Place; minimum amounts: $2500-$1000-$500, respectively).
2. Virtual Desktop Study Awards (awarded independently of the full bench-scale designs. Amounts TBA.
3. WERC Resources Center Pollution Prevention/Energy Efficiency Award (P2E2 Award) ($500)
4. Judges' Choice Award ($500)
5. Peer Award ($250)
6. Terry McManus Outstanding Student Award. ($500-$1000, according to funding).

Additional awards may be announced at a later date.

Award amounts listed are minimum amounts and may increase with available funding.
Detailed criteria for each award are listed in the 2021 Team Manual:
https://iee.nmsu.edu/outreach/events/international-environmental-design-contest/guidelines/