Task 4-D. Desktop Version of: Mine Tailings Reuse

Proposed and Developed by Freeport-McMoRan

This desktop study is identical to the full version of Task 4, but omits all aspects related to building or testing of the bench-scale apparatus. The key technical element in this desktop study is the process flow diagram and may benefit from computer simulations. The virtual competition will include an oral Zoom presentation and a follow-up Zoom Brochure Discussion.

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, and design 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)

Task 4-V. Mine Tailings Reuse–Virtual Contest

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.
- Provide a detailed and accurate process-flow diagram, complete with quantified mass and energy inputs/outputs for the process needed to produce your product. This is the key element of your technical report. See the 2021 Team manual for an example of an acceptable PFD.
- Your analysis may include a computer simulation, but it must be based on the PFD.
- Determine quantities and proportions of mine tailings in the product.
- List all equipment, materials, and chemicals needed, and indicate all efforts to reduce costs.
- List all vendor sources, and report and reference all performance data for each piece of equipment or materials.
- Identify any waste products or by-products that will be produced.
- Present an engineering analysis on the ability to scale up the production process.
- Describe any tests that would be needed to ensure integrity and environmental safety of the product, including TCLP tests to ensure that none of the RCRA eight metals exceed the detection limit, ASTM tests for building material integrity, efflorescent testing, etc.
- 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.
- Discuss your plan's adherence to appropriate federal (USA), state and local laws and regulations. Be sure to attend WERC's webinar for helpful tips for addressing regulatory issues. (Email us for details.)
- Address safety aspects of handling mining water of the chemistry shown in Table 1 and any final products. Be sure to attend WERC's webinar for helpful tips for addressing health and safety issues.
- Include a Public Involvement Plan, as applicable (See Team Manual).
- 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.
- To qualify for the P2E2 award, in a separate section of the report, document success in improving energy efficiency, pollution prevention, and/or waste minimization, as it applies to your project.

Tailings Description

Due to mining variabilities, the water content, particle-size distributions, density, and mineralogy of the 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 (if your team requests tailings) 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 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 writing quality, organization, clarity, reasoning, and coherence. Standards for publication in technical journals apply.

The report must address in detail the items highlighted in the Problem Statement, Task Requirements, Evaluation Criteria, and the 2021 Team Manual.

This desktop-study technical report should total no more than 16 pages, including title page, executive summary, and references. Note that this is shorter than the full-contest entry, because virtual contest entries do not include discussion of bench-scale results. The required page formatting has changed this year—check the 2021 Team Manual for more information.

Technical Report Checklist:

- Title Page
- Executive Summary
- Body
  - Background Research
  - Detailed Process Flow Diagram quantifying all mass/energy balances
  - Materials List
  - CAPEX
  - OPEX
  - Public Involvement Plan (no more than 1.5 pages)
  - Regulatory Discussion (no more than 1.5 pages)
  - Health and Safety issues associated with full-scale treatment (no more than 1.5 pages)
- References
- Audits (not included in page count)

Evaluation Criteria

Refer to the 2021 Team Manual for a comprehensive explanation of the evaluation criteria. For a copy of the Team Manual, Public Involvement Plan, and other important resources, visit the WERC website: https://iee.nmsu.edu/outreach/events/international-environmental-design-contest/guidelines/.

Evaluation of your solution will be based on the items highlighted in the Problem Statement, Design Considerations, and the following:

- The volume or weight per day of mine tailings that your product is expected to use.
- 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 proposed technology

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

FAQs/Deadlines

- Teams are responsible for all task updates posted in the FAQs online (wercdesigncontest.nmsu.edu)
- Due 15 January 2021: Request quantity of tailings to be shipped, if desired. Include rationale for the amount requested. Since this is a paper-only study, it is not likely that your team will want tailings, but they are offered to you in case you do.
- Due 29 March 2021: Technical Report.

Awards

Each year, the WERC Environmental Design Contest and its sponsors award more than $25,000 in cash prizes. Successful completion of every stage of the design project qualifies each team for the following awards.

1. Full 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) ($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/