Council for Mineral Technology

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Presentation to

Environmental Considerations in Hydrometallurgical Base Metal Refining Circuits

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Head: Extraction

Context

- Economic Crisis
  - Current low base metal prices
  - Affecting bank funding/credits
- Legislation and Standards
  - EIA's, Auditing
  - Fines and Penalties
- Resource/Site Limitations
  - Reagents
  - Infrastructure/Transport of goods
  - Skills

Economic Aspects [1] (1)

Resource Management and Environmental Economics:

- Regional and global ecosystems have become adversely affected by economic activity
- Destruction of natural resources and ecosystems can threaten our survival
- Under-utilisation of resources can cause substandard living conditions, economic collapse and unrests

Balance between resource use and environmental considerations to be maintained by:

- Obtaining the most rapid rate of economic development to satisfy our needs and aspirations
- Whilst managing environmental quality to maintain capability to satisfy needs and aspirations of future generations → Sustainability

Economic Aspects [1] (2)

Criteria for evaluation of resource use:

- Efficiency → Benefits exceed costs
- Equity → Benefits and costs distributed fairly among society
- Sustainability→ Benefits exceed costs over multiple generations

Benefits and Costs expressible in monetary terms, however limitations are:

- Ecologic processes not tradable →no price exists
- Market prices do not reflect environmental costs link between consumption of commodity and damage to environment through production is not captured
- Consumers not always rational → skewed price values

Price information useful to measure efficiency, but of limited use to measure equity and sustainability

No agreement on relative importance of criteria, however desirable that resource use passes all criteria

Implications [5]

Constraints and problems are:

- Location → Mining can only occur where mineral deposits are
- Mitigation of environmental impacts by refining at environmentally more suitable site often not feasible (Efficiency)
- Mining & Refining not sustainable at one place →deposits are finite and eventually exhausted
- Beneficiation and refining processes, especially flotation and hydrometallurgy, require significant amount of water
- Waste and tailings
- Power sources and requirements

Opportunities to minimise environmental impacts are:

- Mining methods
- Location of mining infrastructure
- Design & Location of waste deposit sites/tailings dams
- Surface rehabilitation

Most importantly:

- Choice and design of refining process

Metal Refining and Environment

Is there a conflict between process economy and environmental considerations?

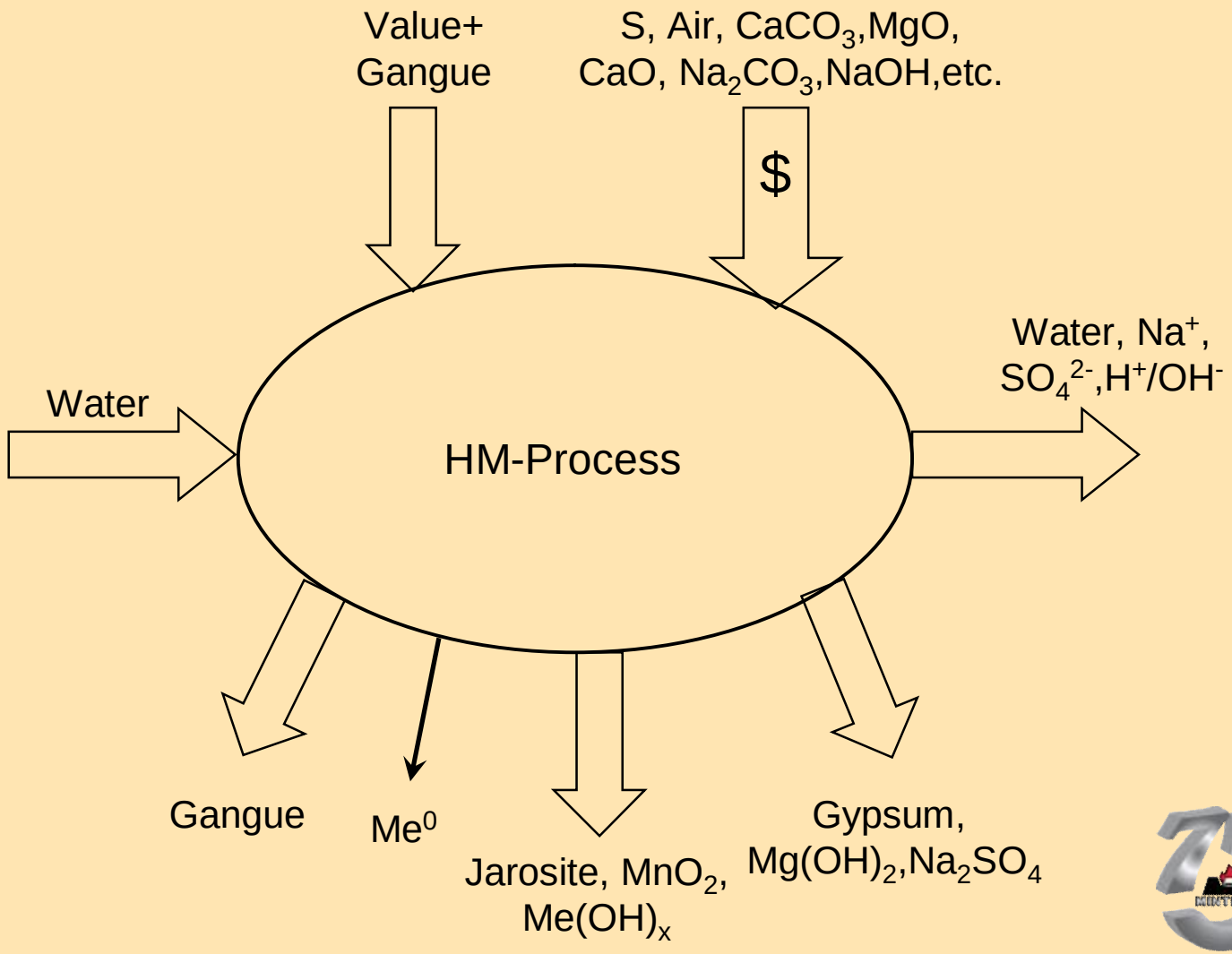
- 85% of life cycle costs and environmental impact defined in early design stages [2]
- Significant part of capital costs dedicated to handling wastes[2]
- EIA is conducted between detailed and definitive design when process route already specified

Not conflict but rather benefit and opportunity by:

- Avoiding certain wastes rather than handling and remediating (costs)- in early design stage already
- Recycling of reagents, Opex savings
- Tight margins call for lower costs
- Making products from otherwise waste - in early design already
- Achieving better quality by environmentally friendly process
- More efficient processes with greater potential to have less environmental impact

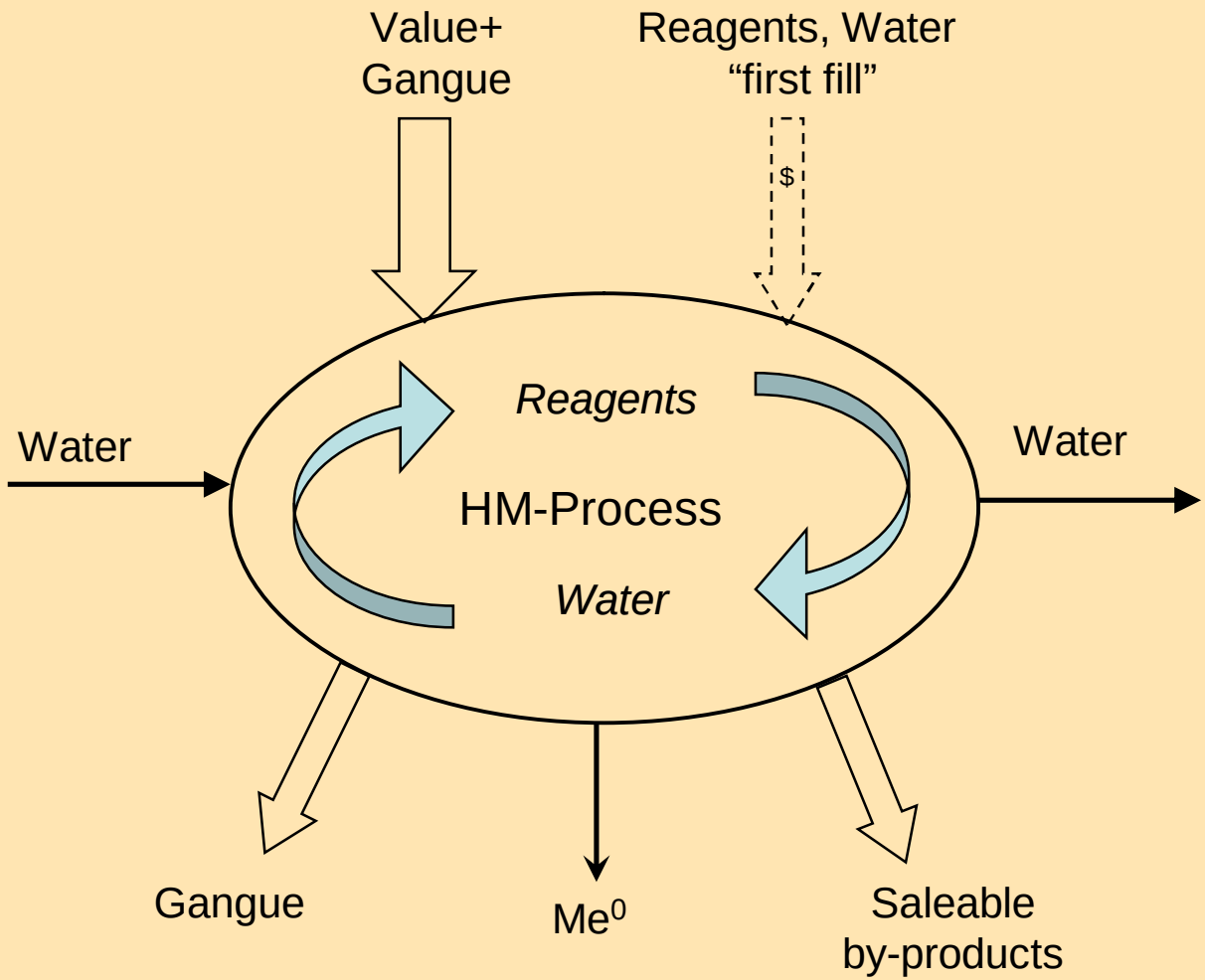
Base Metal Hydrometallurgy (1)

Example of a typical hydrometallurgical base metal refining process



Base Metal Hydrometallurgy (2)

Example of an ideal hydrometallurgical base metal refining process



Possibilities

Novel and optimised technology:

- Environmental consulting in early design stages
- Alternative neutralising agents to NaOH
  - Avoiding of dilute Na streams (too dilute for direct crystallisation)
  - Release of Na into environment in regions with torrential rains (overflowing slimes dams)
- Use and recycle of ammonia
  - Replacing NaOH as neutralising agent in solvent extraction
  - Addressing disadvantages of lime boil for ammonia recovery from $(NH_4)_2SO_4$-streams
- Use of MgO as precipitating agent for intermediate MHP's
  - Higher theoretical (stoichiometry) and practical value grades in MHP as compared to Na_2CO_3-precipitation
  - Addition as slurry is possible
  - Regeneration of $MgO/Mg(OH)_2$ with ammonia showed success in preliminary study[3]
  - Manipulation of stoichiometry to avoid sulphur buildup in Precipitation-EW circuits
- Choice of bacterial oxidation in place of roasting

Possibilities (2)

- Ion Exchange technology
  - Resin-in-Pulp (RIP) technology for recovery of valuable metals from waste streams, thereby increasing overall value recovery
  - Fibrous Ion Exchange technology offers fast adsorption/desorption kinetics compared to conventional resins- this would decrease plant size and water requirements
- Application of hydrochloric acid as lixiviant
  - Neat and selective separation of Fe^{3+} from base metals by solvent extraction
  - $FeCl_3$-product saleable, or used to regenerate HCl by forming hematite
  - Lixiviant can be regenerated and recycled from chloride streams by various processes
  - Separation of other base metals from Ni easy
- Process integration
  - Thermal Pinch
  - Process and Utility Water Pinch[4]

The requirements for successful implementation are:

- Overcoming the culture of reluctance to applying new technology not yet established on industrial scale

Mintek's Roles

Maximising efficiency, equity and sustainability through:

- Championing research and development of new processes which are both economically feasible and environmentally friendly
- Demonstrating operability of such new processes
- Optimising existing processes to reduce environmental impact
- Partnership with industry offering specialist expertise and testwork for implementing such processes
- Consulting on environmental matters
- Providing accredited environmental testing facilities and auditing capabilities

References

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[2] Marr, S.M; von Blottnitz,H.;Mudondo, Z; (2004) ,*Design for Cleaner Technology in the South African Minerals Processing Industry*, Book of Proceedings: Waste Management, Emissions and Recycling in the Metallurgical and Chemical Processing Industries, Mintek Conference Randburg, pp. 1-10

[3] Krishna, S; (2009), *Lab Investigation on Cobalt Hydroxide Precipitation from Synthetic Leach Liquor using Magnesia and the Regeneration of Magnesia from Resulting Test Solution*, Unpublished Mintek Report, Randburg

[4] Brouckaert, C.J.; Gianadda P.; Buckley, C.A.; (2004) ,*Process Integration for Water and Energy Management*, Book of Proceedings: Waste Management, Emissions and Recycling in the Metallurgical and Chemical Processing Industries, Mintek Conference Randburg, pp. 11-22

[5] Wells, J.D; van Meurs, L.H.; Rabie M.A. (2005), Chapter 15, 'Terrestrial Minerals' in Fuggle&Rabie (eds) *Environmental Management in South Africa*, Fifth Impression 2005, Juta&Co, Ltd

Thank you