



**NORTHERN
MINERALS**

Microwave Reactor

MRIWA Research Showcase 2024

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ASX:NTU

Why is an alternative acid bake reactor needed?



Rare earth projects under development in Australia produce concentrates that are currently processed by baking at elevated temperature in the presence of concentrated sulfuric acid

This is done in rotary kilns that are heated either: directly or indirectly.

Heating directly uses simpler equipment but results in energy inefficiency and production of large volumes of off-gases

Indirectly heated equipment is more complex and relies on conduction of heat through equipment surfaces to provide heat. This suffers from scale build up, limiting campaign runs and can only be used with lower temperature processes.

Northern Minerals experience with acid bake

Northern Minerals used an indirectly heated rotary kiln at the Browns Range Pilot Plant to process a heavy rare earth concentrate into a rare earth carbonate.

Scale build up inside the kiln was problematic which limited campaign runs and was energy inefficient.



Scale build-up inside kiln



Indirectly heated kiln at Browns Range Pilot Plant



The challenge was to develop a better acid bake reactor

- The attributes required for a better acid bake reactor include
 - ▶ Reduced exhaust gas volumes
 - ▶ Energy efficiency
 - ▶ Reduced scaling
- The alternative reactor was developed in stages
 - ▶ Desktop study
 - ▶ Laboratory scale test work
 - ▶ Designing an improved reactor system
 - ▶ Building and testing a prototype



Developing a better acid bake reactor

DESKTOP STUDY PHASE

- Identified microwave heating to give:
 - ▶ Direct heating of kiln contents
 - ▶ Eliminating heat transfer through surfaces that can scale
- Gas tight system that can be insulated resulting in:
 - ▶ Reduced exhaust gas volumes
 - ▶ Energy efficiency



5 kW Microwave generator at AMT



Developing a better acid bake reactor

SMALL SCALE LABORATORY TEST PHASE

- **First tests in kitchen microwave:**
 - ▶ Showed that concentrate and sulphuric acid can be heated by microwaves
- **Second tests at Advanced Microwave Technology (AMT)**
 - ▶ Small scale batch sulphation bake tests completed to prove the concept



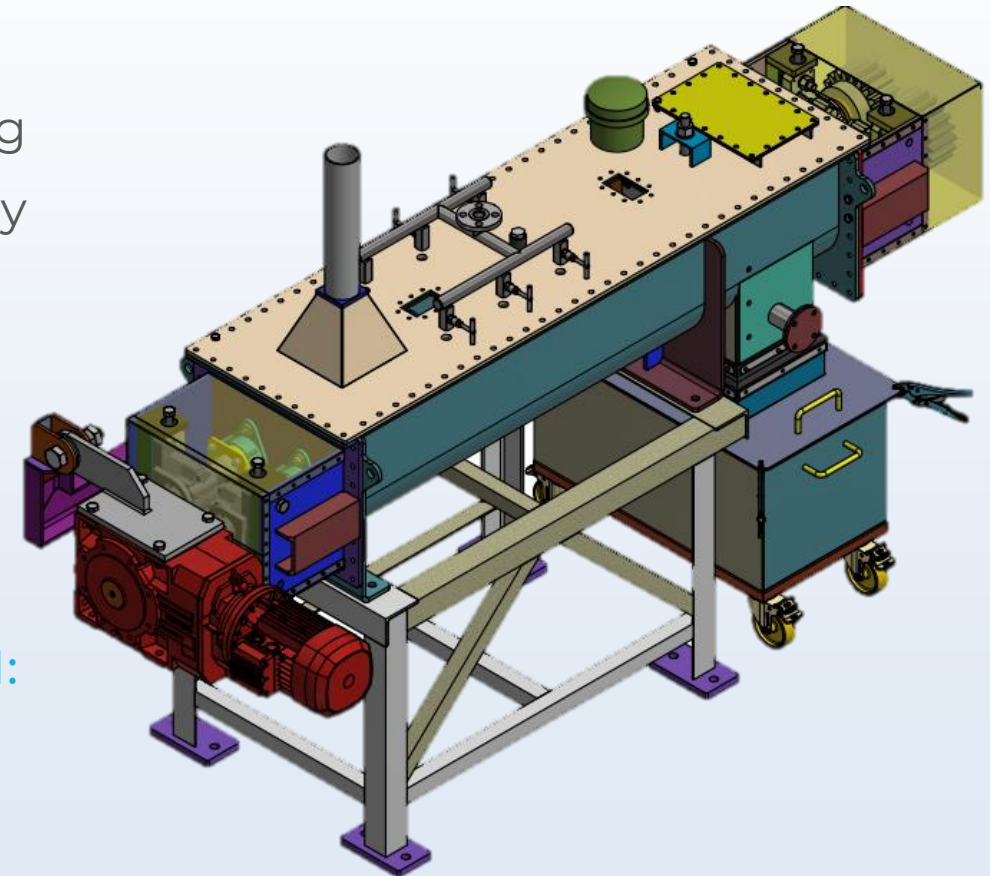
Laboratory scale reactor at AMT



Developing a better acid bake reactor

DEVELOPING A CONTINUOUS REACTOR

- **Development team:**
 - ▶ Process conditions, raw materials handling properties, funding and integration by Northern Minerals
 - ▶ Equipment design IBS Bulk Handling
 - ▶ Microwave heating AMT
 - ▶ Continuous operation at ALS
- **The operation of the continuous reactor needed:**
 - ▶ Raw materials from Pilot Plant
 - ▶ Site with gas treatment facility
 - ▶ Additional funding from MRIWA



Designed pug mixer reactor

Partnering to develop the project

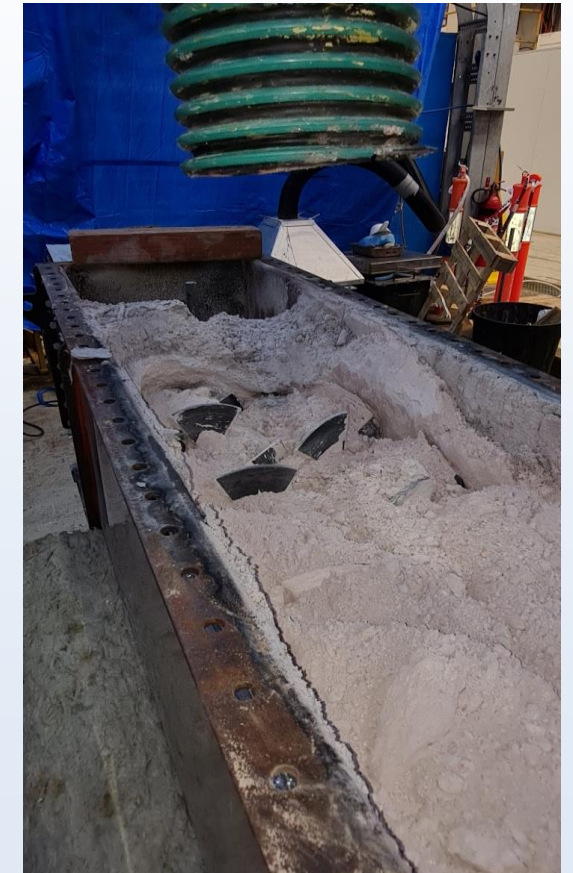


OPERATION AT ALS OVER TWO PERIODS FOR 8 DAYS

- ▶ Northern Minerals provided funding for the development and fabrication
- ▶ MRIWA provided part of the funding to run the microwave reactor at ALS



Microwave reactor operating at ALS

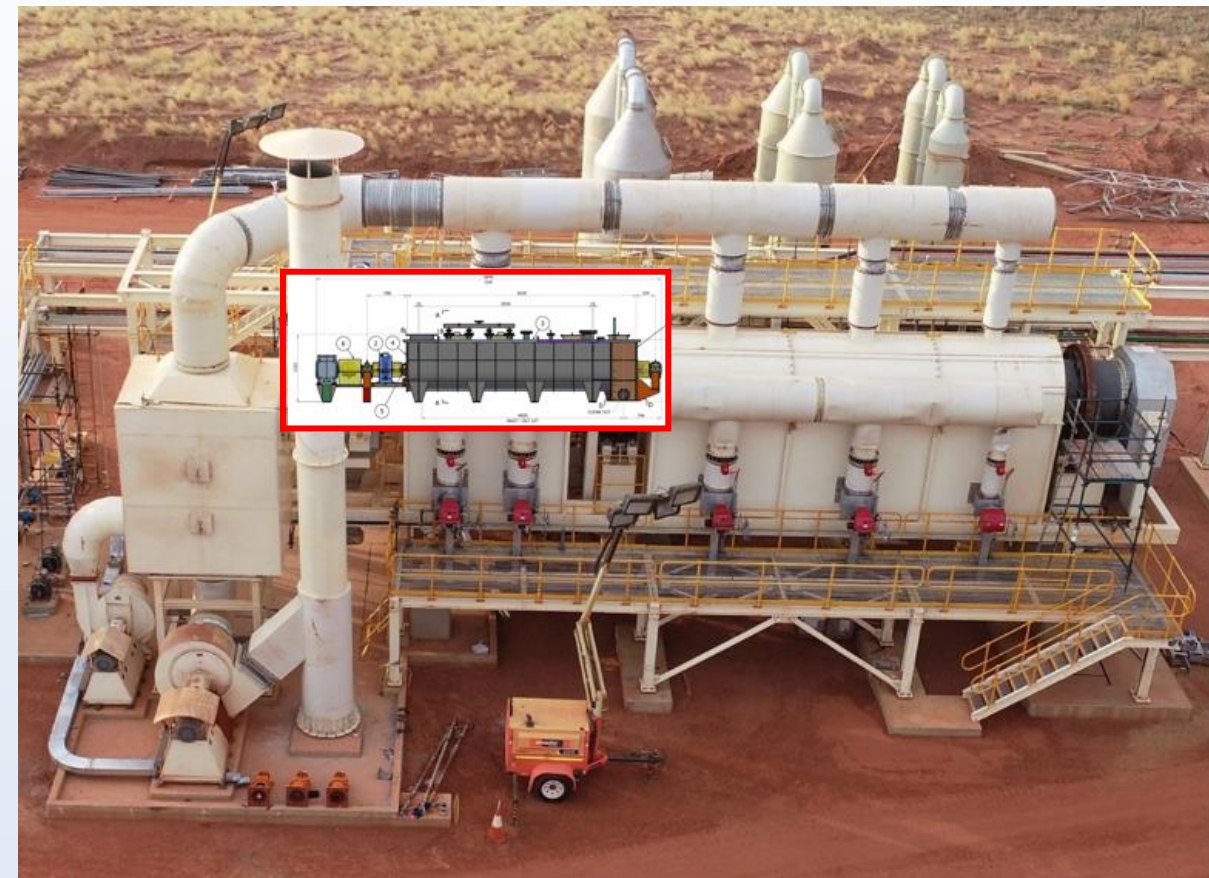


Baked solids in reactor at ALS



Results from the microwave test runs

- The microwave reactor design and operation proved the concept of the microwave sulphation bake reactor
 - ▶ Achieved conversion of more than 95% of the HREE to sulphate form
 - ▶ Proved the ability to heat reactor unit with microwaves during continuous operation
 - ▶ Showed ability to run without solid flow problems
- The microwave test conditions enabled the sizing of a microwave reactor of similar capacity to the pilot plant kiln



Size of microwave reactor vs. indirect fired kiln for same throughput

What's required to further develop the design?



- Need to run the unit for extended periods to:
 - ▶ Prove that scaling won't become a problem
 - ▶ Confirm that operating conditions can be optimized to reliably produce product on specification
 - ▶ Obtain design information for a larger scale unit



Required for adoption and utilisation of the technology

PARTNERSHIP NEEDED FOR CO-DEVELOPMENT, WHICH WILL REQUIRE:

- Funding
- Site that can process the off-gases
- A project owner to supply raw material
- Equipment supplier to design a full scale prototype