Water Atomization of Iron-Nickel Alloys

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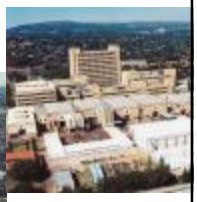
Mintek, Randburg, Johannesburg, South Africa

Mintek (Established 1934)

- Government-owned minerals research organization
- Employs ~800 people (300 professionals)
- Annual budget of US $50m
- State & corporate funding (30:70)



Recovery of oxide nickel

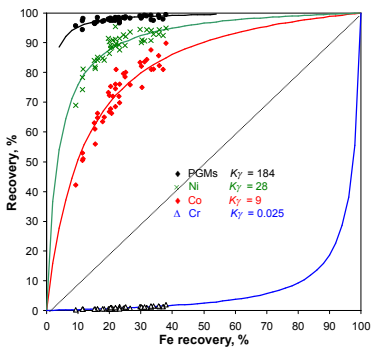
- Many secondary raw materials contain valuable metals in oxide form
- Reductive smelting is required to recover these metals
- DC arc furnaces are well suited to this type of process
- Previous examples include Co recovery from slag, and PGM recovery

DC arc furnaces at Mintek

1.5 MW furnace

3 MW furnace

$K\gamma$ Recovery model for PGM smelting



$$R_{Co} = \frac{K\gamma \cdot R_{Fe}}{1-(1-K\gamma)R_{Fe}}$$

- $K\gamma$ recovery equation for NiO, CoO, and CrO
- PGM behaviour can be modelled this way too (empirically)

Products from reductive smelting

Discardable slag
– negligible valuable metals

Alloy ingots
or granules

Typical composition of alloy

	Fe	Ni	Cu	Co	S
Mass %	77	15	4	2	2

This alloy is 'unbreakable' for practical purposes

Main objective

- Produce small particles of metal (100μm to 2mm) instead of 700kg ingots

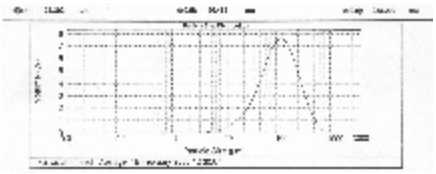
Water atomization is easy at small scale, but …

Atomising Systems Ltd, Sheffield, UK

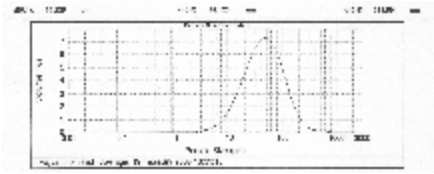
Atomising Systems Ltd – Testwork, Feb 2008

- 90 kg sample treated in 25 kg melter;
  5-7 kg/min atomization with 4 mm nozzle

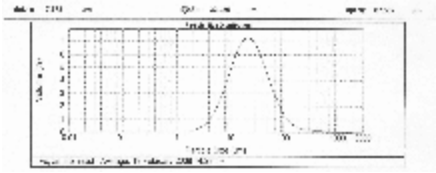
- Particle size distribution from 50 bar pressure, d_{50} = 90 μm



- Particle size distribution from 100 bar pressure, d_{50} = 44 μm



- Particle size distribution from 195 bar pressure, d_{50} = 22 μm

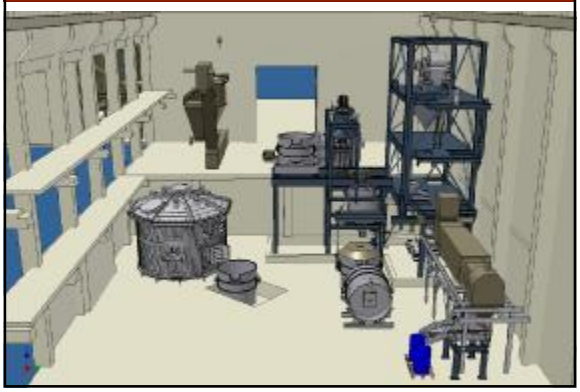


Water pressure and metal particle size

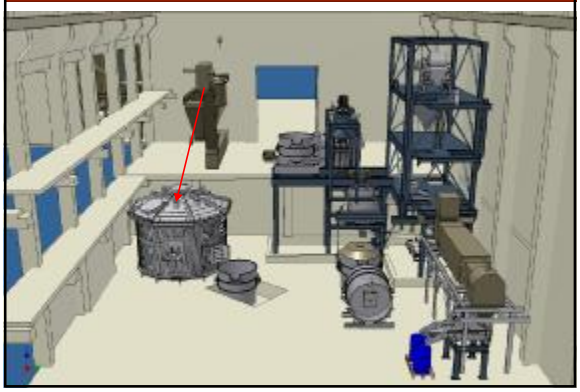
- Mean particle size can be halved by doubling the water pressure (over the conditions of interest)

Pressure, bar	50	100	195
d_{50}, μm	90	44	22

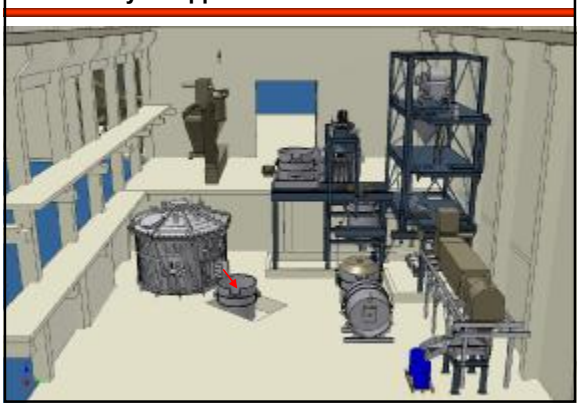
Furnace and atomizing plant



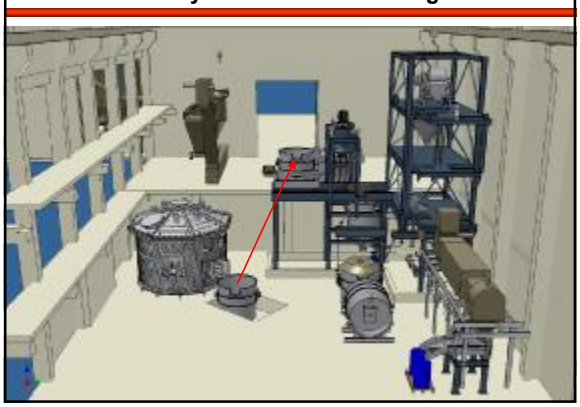
Feed material enters DC arc furnace



Molten alloy is tapped into ladle



Ladle is moved by crane to ladle-heating furnace

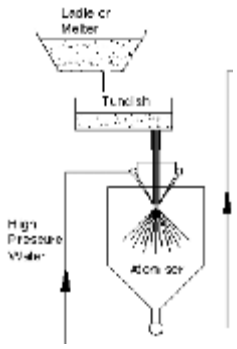


Ladle is moved by crane to ladle-heating furnace

Ladle moves into position along rails

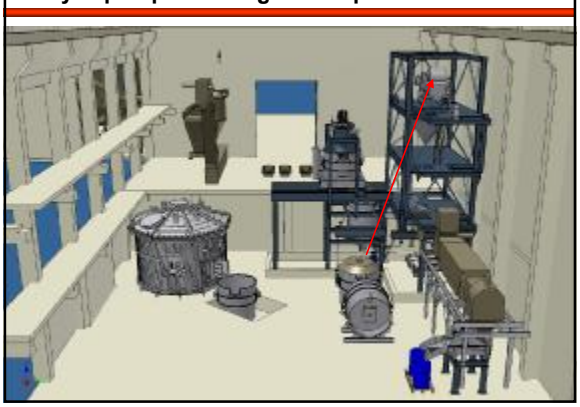
Molten alloy flows into atomizer

Molten alloy flows into atomizer

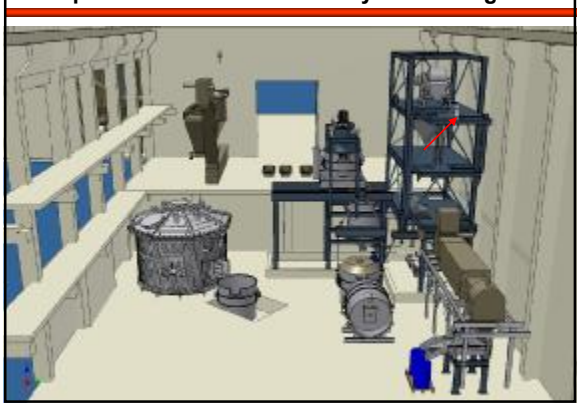


- Ladle-heating furnace controls temperature
- Tundish controls pressure
- Nozzle size controls flowrate
- Water pressure controls particle size

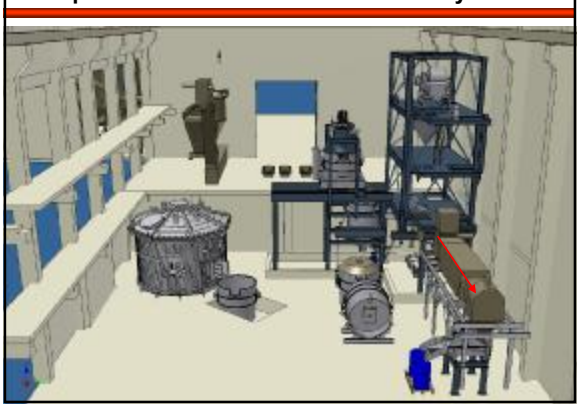
Slurry is pumped to magnetic separator



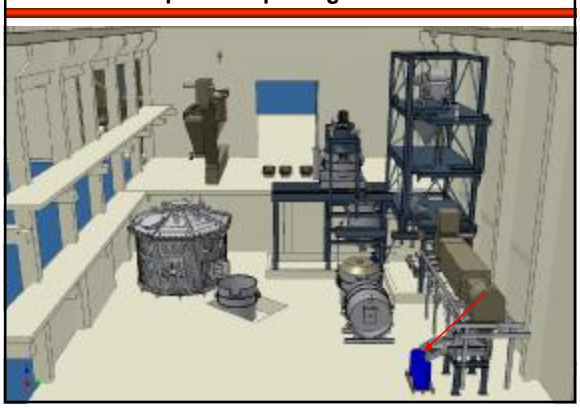
Metal powder is further drained by dewatering screw



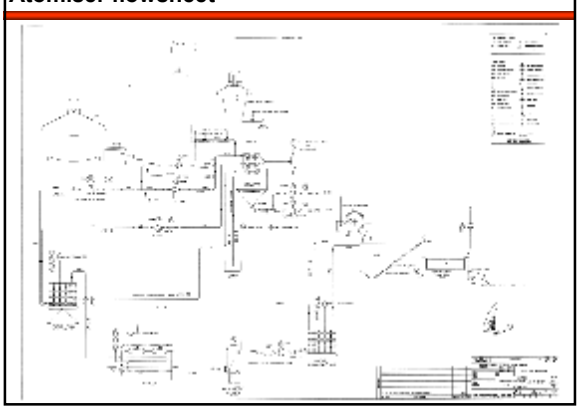
Metal powder is dried in an electrical rotary kiln



Powder is sampled and packaged



Atomiser flowsheet



Bay 2 with 3 MW DC arc furnace before upgrade

Bay 2 with old equipment stripped out

Bay 2 with old equipment stripped out

Bay 2: Starting excavations

Bay 2: Continuing excavations

Bay 2: Starting foundations

Bay 2: Erection of first columns

Bay 2: Erection of structure

Bay 2: Structure with magnetic separator

Bay 2: Structure in preparation for kiln drier

Bay 2: Overview of structure

Bay 2

Bay 2

Bay 2: Atomizing vessel & slurry pumps

Bay 2: Installation of kiln drier

Bay 2: Rotary kiln drier

Bay 2: Dewatering system

Bay 2: Structure and piping

Bay 2: Ladle in motion

Bay 2: New water tanks for atomizer

Bay 2: Water cooling and pumping system

Ladle station: Hole in the ground

Ladle station: Digging

Ladle station: Preparation of foundations

Ladle station: Casting of concrete

Ladle station

Ladle station

Ladle station

Ladle station

Ladle station

Ladle station used for loading of alloy powder

Main challenge: Getting metal to flow correctly

Metal tap-hole on DC arc furnace

Flow through slide-gate valve

Tundish nozzle

Slide-gate valve and porous plug at base of ladle

Mintek's DC furnaces

http://www.mintek.co.za/Pyromet/