Foundry minerals: supply, demand and market outlook

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Overview

• Foundry market: current trends & output

• Foundry minerals supply & demand
  ➢ Zircon
  ➢ Chromite
  ➢ Bentonite
  ➢ Graphite

• Additive manufacturing: ‘3D printing’
  ➢ Implications for foundries

• Foundry market outlook to 2020
Foundry market: current trends
Production of castings – strong regional shifts

- Castings in 2013 were 103.2Mt
- Estimated at 107Mt in 2014
- Castings output has relocated to Asia

Source: Modern Casting

Graph shows regional castings output with significant increase in Asia.
Global castings lead by ferrous, 84.9Mt in 2013
• Growth average of 4%py since 2010
Production of castings – non-ferrous trends

- Non-ferrous castings were 18.3Mt in 2013
- Primarily aluminium – 15.3Mt
- Growth average of 9%py since 2010

Source: Modern Casting

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Production of castings – driven by automotive uses

- Motor vehicle (cars) industry is main consumer of castings
- Car output was 46.8M units (2005), risen to 67.5M (2014)
- Output of cars in China grew by 19.8%py in 2005-2014

Source: OICA

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Foundry minerals: supply & demand
Key minerals used in foundries

- Foundry sands:
  - Silica sand
  - Olivine
  - **Chromite**
  - **Zircon**
  - Spherical ceramic sand
  - Other sands: andalusite, bauxite, ilmenite, kyanite, mullite, perlite, sillimanite, fused silica, staurolite

- Foundry additives
  - **Bentonite**
  - **Graphite**
  - Other additives: alumina, gilsonite, kaolin, mica, talc
Foundry sands – zircon

- World zircon use was 1.06Mt in 2013
- 190,000t used in foundry applications
- Similar levels in 2014

- **Recent trends:**
  - Price spikes 2010-2012
  - Substitution in sand casting: chromite, spherical ceramic sand
  - Higher rates of recycling
  - Strong demand in investment casting
  - Stable zircon prices from 2013-2015 have reduced substitution
Foundry sands – chromite

- Chromite consumption 29Mt in 2014 (ICDA)
- 2% or ~550,000t used in foundries
- Includes foundry & metallurgical grades
- Down from 860,000t in 2012

- **Recent (and continuing!) trends:**
  - Substitution – a bonus in 2010-12 (zircon), now a hindrance (spherical ceramic sand)
  - More metallurgical chromite diverted to foundry markets
  - New projects (MTI/Tharisa/ORC) and overcapacity
  - Higher recycling rates, better recovery systems

Source: Roskill; ICDA

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Foundry additives – bentonite

- Bentonite production 21.2Mt in 2014
- 27% or 7Mt used in foundries
- Half now used in Asia

- **Recent trends:**
  - Slower growth of ferrous castings (primarily sand casting = bentonite)
  - Non-ferrous casting growing strongly (die-casting & investment)
  - Lower unit use in iron castings (<8kg/t)
  - Long-term 4-10kg/t expected globally

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Foundry additives – graphite

- Natural graphite output 820,000t in 2014
- 140,000t or 17% used in foundries
- Flake & amorphous used
- Some synthetic graphite (~30,000t)

- **Recent trends:**
  - Price spikes in 2011-2013
  - Slower growth in sand casting for ferrous (iron) metals
  - Die casting and permanent moulds – synthetic graphite opportunities
  - Competition in foundry coatings – mica, talc, coke, olivine, zircon flour

Source: Roskill
3D printing: implications for foundries
3D printing – what is it?

- Additive manufacturing, parts are printed in layers
- Myriad technologies, depending on material used

- **Metal-based:** electron beam welding, selective laser melting, direct metal laser sintering
  - Compatible with: stainless steel, cobalt-chrome, titanium, nickel-chrome, tool steel, aluminium, gold etc

- **Polymer based:** stereolithography, fused deposition modelling, 3D printing, selective laser sintering
  - Compatible with: epoxy-based materials, nylon, ABS, wax, polystyrene
3D printing – how is it used?

- Numerous applications
  - Automotive
  - Medical & healthcare
  - Consumer goods & retail
  - Aerospace & defence, etc

- **3D print case study: fuel injector**
  - Material: Inconel 718 (austenite nickel-chrome superalloy)
  - Dimensions: 60mm x 160mm, layer thickness 40µm
  - Build time: 50 hours, finishing 3 hours
  - Cost ~£3,500 per unit
  - (Source: 3T RPD Ltd, UK)
3D printing – partnership with foundries? (1)

- Materials used in the Voxeljet printers include PMMA for investment casting, silica sand for coreprinting

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<td>200dpi</td>
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</table>

Source: Voxeljet
3D printing – partnership with foundries? (2)

- Voxeljet 3D printed complex impeller model in PMMA
- Used in investment casting: ceramic coating applied, model is put into kiln and mold is burned out
- Shell is cleaned with air, molten metal poured into this

Source: Voxeljet
3D printing – industry prospects

• Industry grew 35% between 2013-2014, now worth US$4.1Bn

• Growing quickly as machines become more affordable and patents expire

• Time-consuming, but research is reducing print time

• Sheffield University to build £1M 3D printer with production rate similar to injection molding (seconds per small piece); Voxeljet aiming to sell printer in 2017-2018

• Industry forecast to grow 15%py to 2020, reaching ~US$9.5Bn (US foundry market currently ~US$40Bn)
Foundry market outlook to 2020
Foundry market – outlook to 2020 (1)

• Car production to remain key driver:
  ➢ World car output likely to be close to GDP levels at 3.2%py, China to drop to 6%py in 2014-2020

• Aerospace growth – more demand for specialist sands?
  ➢ Passenger traffic forecast to grow 5%py to 2033, cargo traffic to grow 4.7%py
  ➢ Requires >31,000 new aircraft worth US$4.6 trillion

• Recycling and reclamation, more environmental awareness

• 3D printing – consumers print ‘on demand’, a move away from traditional foundries?
Foundry market – outlook to 2020 (2)

- Castings forecast to grow 3.0%py to 2020 - reaching 128Mt
- Higher growth in investment casting – boost for zircon
- In short-term, 3D printing only expected to compete in complex & high-cost shapes
- **Zircon**: 3.5%py growth to reach 240kt
- **Chromite**: 2%py growth to reach 620kt
- **Bentonite**: 4%py growth to reach 8.8Mt
- **Graphite**: 2.5%py growth to reach 195kt
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Foundry mineral reports:

Bentonite
Chromite
Zircon
Graphite

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