FRESH THINKING
IRON ORE PELLET PRODUCTION
AT LKAB

Agglomeration Seminar NyKoSi, Trondheim

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“An outstanding supplier of high-quality iron ore products to the global steel industry”
EUROPE’S LEADING PELLET MANUFACTURER

EUROPE
LKAB is the EU’s largest iron ore producer and mines around 76 PERCENT of all iron ore in the EU
90% of LKAB’s revenue comes from pellet sales

LKAB is the world’s 3rd largest producer of iron ore pellets

125 YEARS
LKAB is one of Sweden’s oldest industrial companies and has customer relationships dating back more than a century

4,500
Around 4,500 employees in total

100%
LKAB is a 100% state-owned company

16,2 SEK bn
Net sales of SEK 16.2 billion in 2015

BASED IN THE SWEDISH OREFIELDS
POSITIONING FOR A MARKET IN CHANGE
Requires us to be highly competitive

- A SIGNIFICANT SUPPLIER IN A SPECIALISED MARKET
- HIGH QUALITY PRODUCTS GET A HIGHER MARKET PRICE
- CAPACITY IN MINES, INFRASTRUCTURE AND LOGISTICS
- PRODUCT PORTFOLIO THAT SUPPLEMENTS THE PELLET STRATEGY

Cash cost – pellet producers around the world
HIGHER MARKET PRICE FOR PELLETS
The pellet premium appears strong relative to the spot price for fines

Source: Platts

- Pellet premium
- Spot price for fines

<table>
<thead>
<tr>
<th>Year</th>
<th>USD/tonne</th>
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<tbody>
<tr>
<td>2013</td>
<td>150</td>
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<tr>
<td>2014</td>
<td>140</td>
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<tr>
<td>2015</td>
<td>130</td>
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<tr>
<td>2016</td>
<td>120</td>
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Comparison price Platts Atlantic Basin BF pellet premium 65% Fe and Fines IODEX 62% Fe 19 Feb 2016

Source: Platts
During the post-war period of the 50s, there was a strong belief in the future. It was in this period of optimism that LKAB decided to begin producing pellets based on the so called sintering method. The origins of the method come from a patent taken out by A G Andersson in 1912, 1955 thus saw the opening of Europe’s first pellet plant.
OLIVINE PELLETS – A MAJOR SUCCESS STORY FOR LKAB

✓ The goal was to find a formula for pellets that could improve and increase the efficiency of the blast furnace process.

✓ The innovation was an immediate success. Fuel consumption in the furnace dropped by over 7%, and the rest is history. Olivine pellets have become LKAB’s greatest sales success in modern times.
The success of olivine pellets showed that LKAB’s interest in how the raw material behaved in their customers processes was the right approach.
FROM ORE TO FINISHED
IRON ORE PRODUCTS
R&D INFRASTRUCTURE
LABORATORIES AND DEMONSTRATORS

- LKAB Research Centre
  - Mining & Rock Mechanics Research
    - EMRS Experimental Mine Research Site
    - Rock Mechanic Research Laboratory
    - Blasting technique Research Laboratory

- LKAB Research Centre
  - Pelletising Research
    - Mineral Processing Laboratory & Pilot Plants
    - Agglomeration Laboratory
    - EPP Experimental Pellet Plant

- LKAB Research Centre
  - Ironmaking Research
    - EBF Experimental Blast Furnace
    - EDRP Experimental Direct Reduction Plant
    - Metlab Materials Laboratory

Laboratorier och anläggningar under utredning och planering
Befintliga anläggningar
R&D ORGANISATION

Production Process
Crude ore → Concentrate → Green Pellets → Sintered Pellet

Iron Making Process

100 people in R&D (LKAB 4200)
15 with PHD, 60 MSc / BSc,
15 Technician, 10 lab worker
30 % Women (LKAB 14 %)
Annual operational cost R&D 250 MSEK
R&D CROSS FUNCTIONAL WORK AREAS

- Mining Technology
- Mineral Technology
- Pelletizing Technology
- Iron Making Technology

- Technical Process Support
- Technical Support
- Process Development
- Product Development
- Application Development

- Applied Research Areas
- Geometallurgy
- Green Pellet Research
- High Temperature Metallurgy Research
  Oxidation, Sintering, Reduction & Melting
WHY ARE LKAB SO KEEN ON AGGLOMERATION?

- **Part of the product flow** ~90% of the production is agglomerated, not just some small waste flow.
- **Quality** - Green pellet quality → Final product quality !!
- **Capacity** – Optimal green pellets is one cornerstone for high and stable production.
- **Production Cost** – Energy(Fans, fuel etc)
AGGLOMERATION LABORATORY

- Total investment 120 MSEK
- Pilot hall
- Green pellet lab
- Particle lab
- Thermal Analysis lab (TGA & TMA)
- Micro lab (QEMSCAN, SEM & LOM)
Toolbox for R&D Pelletizing

Micro scale  Lab scale  Pilot scale  Full scale

Pilot balling unit

TGA/TMA  Pot furnace  EPP

Workshop
Agglomeration
Storforsen 24-25
oct 2012
PELLET
PROPERTIES

Balling
- Green Pellets with properties as……
  - Size Distribution
  - Strength
  - Plasticity
  - Porosity
  - Pore Size Distribution
  - Cracks

...and dynamic properties as...
  - Productivity in the balling units
  - Amount of over and under size green pellets

All this will effect both the process and the final product………

Drying

Oxidation

Sintering

Final Pellets
High quality green pellet is a prerequisite for good final pellet quality and an energy efficient production.
HOW DOES A GOOD GREEN PELLET LOOK LIKE?

**Strength**: Strong enough, no disintegration during handling and feed into to the induration machine.

**Size**: Narrow size distribution.

**Form**: As round as possible
TYPES OF GREEN PELLET

Form
Roundness, riders, fines

Perfect green pellet  Uggly green pellet
WHAT TO START WITH?

Size
- Active control to reach target value
- Optimal size of screen rollers
- Control speed of screen rollers

Form
- Roundness, riders, fines
- Control moisture in concentrate
- Control moisture in green pellet
- Minimize fines in to the industry

Strength
- Mixers
- Amount of bentonite
Dosering organiskt bindemedel, %

- Tacabind utan bent
- Tacabind med 0.2% bent
- Peridur 330V utan bent
- Peridur 330V med 0.2% bent
- Alcotac FE13 utan bent
- Alcotac FE13 med 0.2% bent

Bentonitdosering, %

- Destillerat
- Kran
- Pilothall
- Process

ISO standard - not enough
X-ray tomography

New state-of-the-art X-ray microtomography system (Zeiss Xradia 510 Versa), installed in Luleå Feb 2016.
Particle modelling

Experimental studies

Modelling & simulation
Thank you for listening

Questions?