TiZir

Ilmenite Pellet Production and use at TiZir

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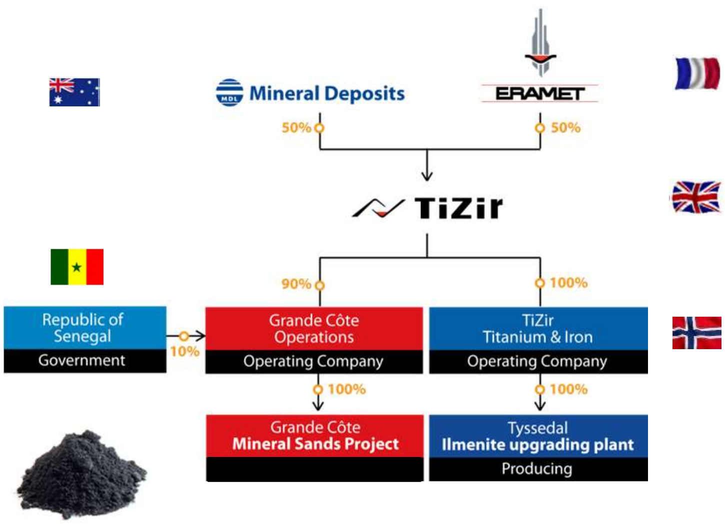
History

Tyssedal ilmenite upgrading facility - History

- **1908** — **Start production of hydro electrical power in Tyssedal**
- **1916-81** — **DNN Tyssedal – Aluminium plant in operation**
- **1986** — **Start up Ilmenite smelter**
  State owned
- **1988** — **TINFOS acquired the plant.**
- **2008** — **ERAMET acquired the plant**
- **2011** — **Joint Venture ERAMET – Minerals Deposits Ltd.**

➢ TiZir Limited, a Joint Venture Between MDL and Eramet



What is ilmenite (Source; Wikipedia)

- **Ilmenite** is the titanium-iron oxide mineral with the idealized formula $FeO\text{-}TiO_2$.
- It is a weakly magnetic black or steel-gray solid.
- Ilmenite is the most important ore of titanium. Ilmenite is the main source of titanium dioxide, which is used in paints, fabrics, plastics, paper, sunscreen, food and cosmetics.
- Ilmenite in nature is associated with other gangue minerals as well as having some of the Fe and Ti atoms substituted with other elements. Most common are quantities of magnesium and manganese and the full chemical formula can be expressed as $(Fe,Mg,Mn,Ti)O_3$.

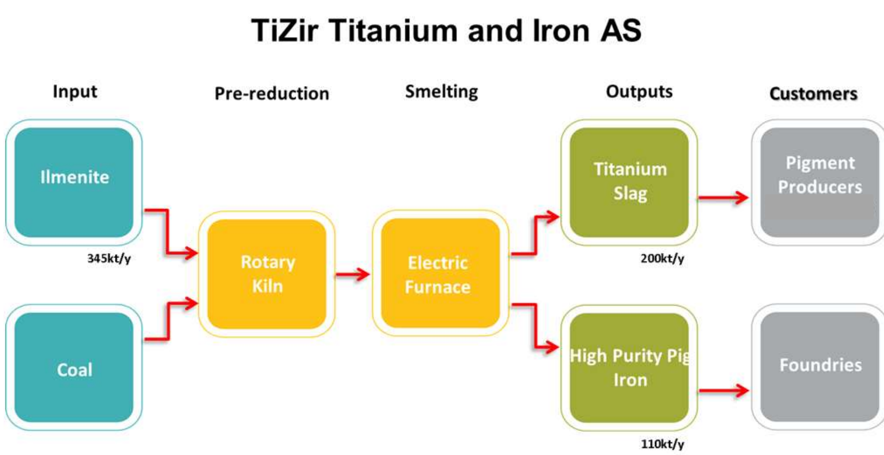
TTI - creating values from water

TiZir upgrade an ilmenite containing 45-55 % TiO_2 in ore-concentrate to 80-85 % TiO_2 in finished tapped UGI (also known as ilmenite slag)

This is done by separating the Iron and TiO_2 inherent in the ilmenite by electro-metallurgical reduction of the iron oxide to metallic iron in a 3ph AC smelter.

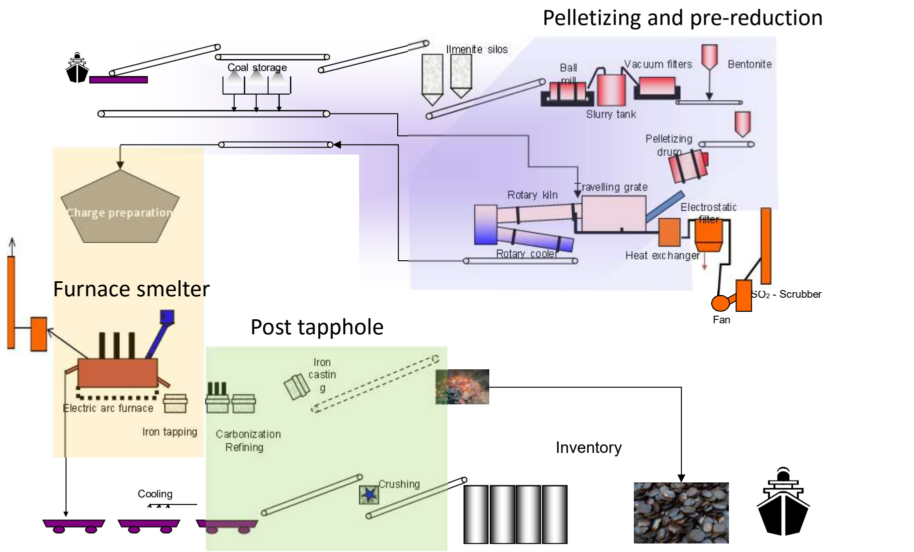
The iron is a virgin high purity pig iron with special properties suitable for high strength castings

The TiZir process



- Smelts ilmenite to produce a titanium-rich slag and a pig iron co-product

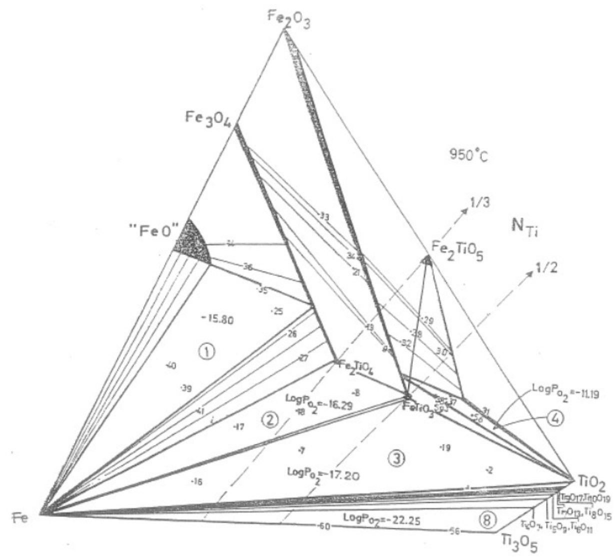
2 stage proses, Pre-reduction and smelting are done in separate units



What are the challenges in pelletizing of ilmenite on industrial scale

- First off all; It does not behave completly like Iron-ore in a pelletizer even though it contains iron oxide.
  - Ex: Some ores get stronger when applied to higher induration temperature, but some get weaker.
  - It has a more complex phase diagram compared to iron
- There are few commercial research labs involved with pelletizing
- Even fewer have worked with pelletizing of Ilmenite.
  - There was one in Sweden (Minpro) but it closed down. External knowledge is thus hard to come by

Phase diagram for TiO_2- Fe-Fe_2O_3



What are the challenges in pelletising of ilmenite on industrial scale

- Grinding energy can not be predicted by using Bond Work Index and scaled up from lab experiments.
- Strenght of indurated pellet is not only dependent of particle size but also on
  - Particle shape,
  - oxidation potential,
  - sieving curve etc.
  - Therefor; Knowing the grinding parameters does not tell the whole story on what to expect as properties on indurated pellets

Ilmenite material processed at TiZir

	ROCK ILMENITE	SAND ILMENITE
TiO_2	**44**	**51**
FeO	**34**	**34**
Fe_2O_3	**14**	**13**
CaO	0,3	0,03
MgO	3,7	0,6
SiO_2	2,5	0,7
MnO	0,3	0,6
Cr_2O_3	0,1	0,06

Rock ilmenite is blasted, crushed and beneficiated to a concentrate at the mine. Very fine grained as received at the plant, Approx 45 % less than 75 µm

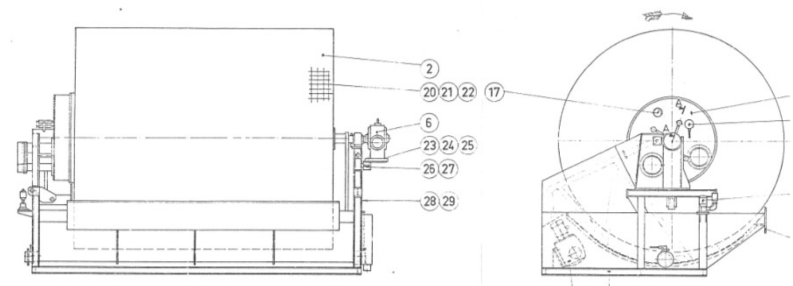
Sand ilmenite is beneficiated but grain size is as ROM. Size is as natural classification made it when deposit was created. Majority of grains approx 200 µm

First unit, Grinding

- So. From previous slide one can see, large difference in input material grain size and chemistry.
  - every child know it is easier to make sand castle of clay rather than of coarse silt.
  - Grinding is done to make the ore fine enough to make the surface tension in water keep particles together during balling
  - Thus a finer material is easier to pelletize. **But!** grinded to much/to fine and it retains to much water between particles. You get sludge instead of pellet.
- Grinding is done by wet ball milling in open circuit.
  - Lack of conversion factors from lab grinding to real world grinding. Lab can only indicate difference between known sample and unknown and do not give the fact.
  - Wet material return streams are recirculated to mill (i.e hosing of floor, sludge from offgassystem/scrubbers etc)
- Quality control is
  - density of millpulp
  - Blaine measurement on dried pulp
  - green pellets dropp test
  - Dust creation of indurated pellets tumble
  - Dust creation in the process equipment (% dust produced ration to feed rate)

Second unit, Filtering

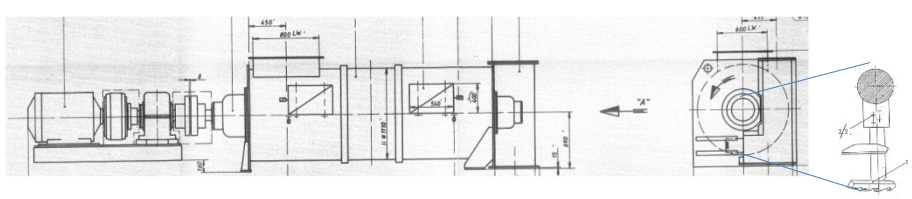
- Filtering is done by drum wacuumfilters
  - To be able to ball, the moisture content have to be lower than 8 %. Control of balling is done by adjusting water to ball circuit. To handle this, the moisture content have to be low



- To much grinding makes it impossible to get a dry filtercake because the capillary force from water on a small particle is stronger than a vacuum of 100 % (equals 1 bar). The droplet can not be removed from the particle

Third unit, Mixing with binder and perhaps other material

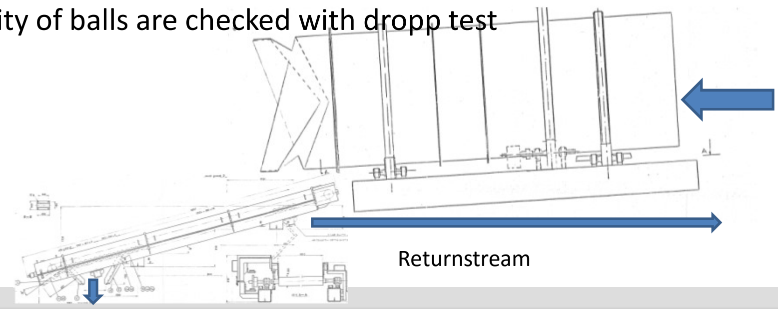
- Mixer is a horizontal compulsory shear mixer with rotating arms where the filtercake is mixed with binder and dry returnstreams. (i.e fines from makeupfilters in the plant)



- After mixing is completed, conveyor belts will bring the mix to a temporary storage bin. Under the bin there is weightfeder feeding the balling drum with controlled amount of material
- Capacity in the filter, mixing circuit is twice the capacity of the balling circuit

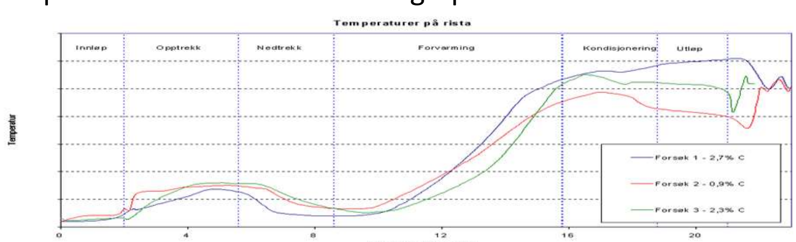
Fourth unit, Pelletizing

- The balling unit is a rubberlined drum.
  - 3 meter in diameter and 10 meter long.
- On the outlet there is a roller screen,
  - Undersize pellet are returned to the balling drum, Oversized are crushed and returned to the drum as well, Only proper sized pellets are feed to the traveling grate machine.
  - The rolling movement of the material inside the rotating drum creates small balls and the force of water make the hold together
- Quality of balls are checked with dropp test

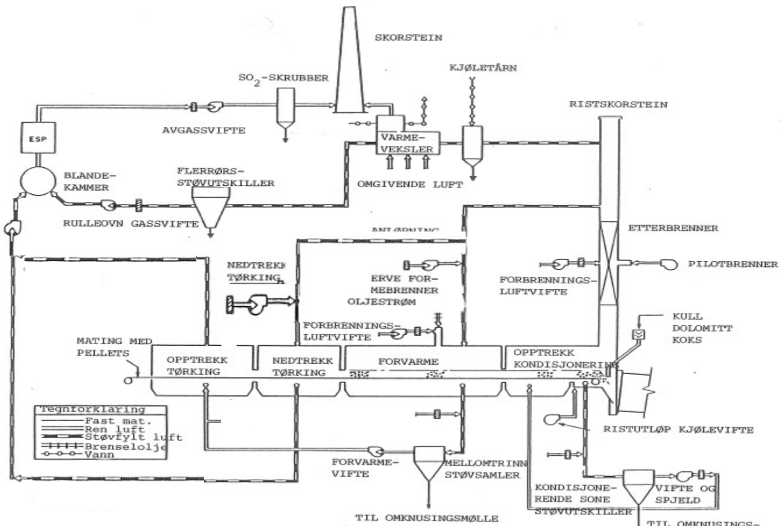


Fifth stage, Traveling grate for induration

- After balling, a layer of green pellets are spread out on a conveyer made of steel grates with slits.
- The conveyer moves through a gasfurnace. On the grate, waste gas from the kiln are drawn through the bed of pellets.
  - With zones having different temperatures the pellets are gently dried and heated to reaction temperature during the conveyers movement through the zones
- The strength of the pellets are made in the induration zone where an oxidizing reaction takes place and the particles grow together, temperature timeline shown on graph



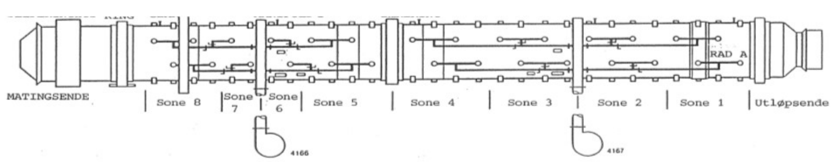
The traveling grate prinsipal gasflow(source, Metso)

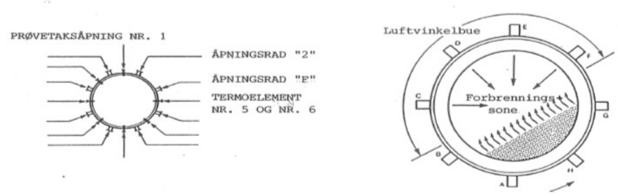


Figur 1.2 - Vandrerist for GRATE-CAR system

Sixth unit, Kiln for prereduction

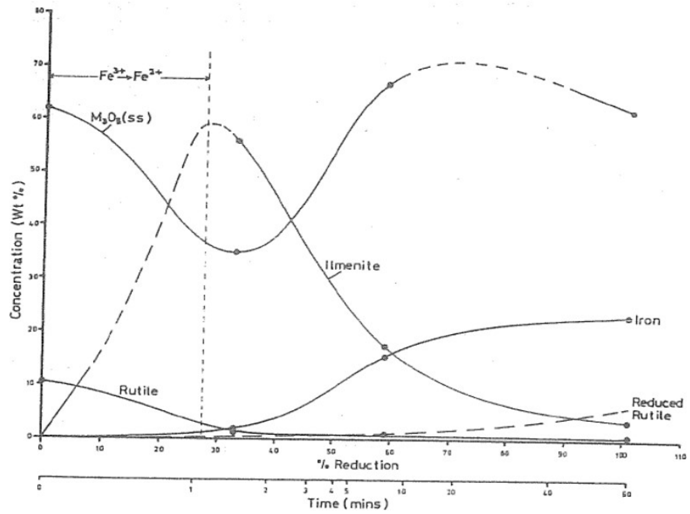
- The prereduction takes place in a 6 meter diameter, 72 meter long rotating kiln where the preheated and indurated pellets are feed together with coal.





- Fe_2O_3 in the pellets will immediately start reacting with the CO from the carbon in coal. Some of the hydrogen from the volatiles might also participate. Produced CO2 will react back to CO if it hits a carbon particle in the burden

Reduction phases in simulated kiln (source;D.G. Jones CSIRO)



Distribution of phases during reduction of Western Titanium N.L. Ilmenite at 1200 degree C

Sixth unit, Kiln for prereduction

- The reaction is running as long as there is carbon available and the temperature is maintained. To maintain temperature air is feed into the freboard where excess CO is burned to CO_2. The rotation bring the energy down in the burden
- Result is a "**DRI" ilmenite** where TiO_2 is untouched together with most of the gangue. Fe_2O_3 on the contrary, is partly transformed to metallic Iron and the remaining iron oxide is left as FeO
- The "DRI" is cooled down and stored for feed to the smelter. Smelter operates on pellets that is partly reduced and charge preparation is done with that in mind.

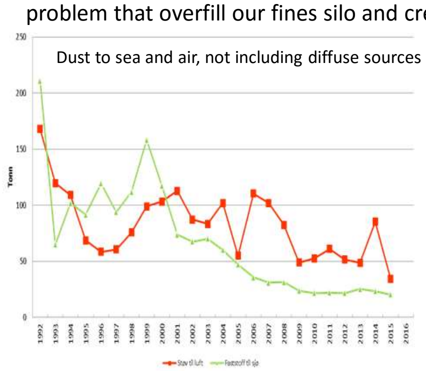
What are the pro and cons of pelletizing

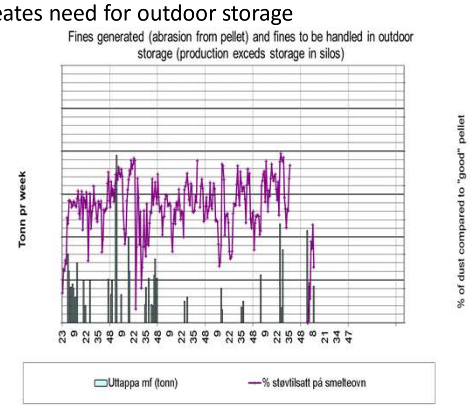
- Pro:
  - Can handle very fine material and broad size distribution.
  - Is suitable for a variety of raw material sources and give the AC furnace consistent ilmenite “DRI”
  - Induration preheats the material to reaction temp and oxidizing also improves the reduction rate.
  - Makes a valuable means of recirculating streams of material that otherwise would have been a waste stream.
    - i.e Dust from make-up filters
    - Dust from process smoke filters
    - Sludge from venturi scrubbers 3 ph furnace
- Cons:
  - Extra piece of machinery
  - Difficult to predict behavior of raw material since no testlabs have experience and models for ilmenite
  - Long response time for changes to input parameters.
  - Few and bad models for kiln reactions.
  - Generates dust intermittently when things go bad in process.

Development in total discharge of dust to air and sea in previous years,

Generating of dust compared to «good» pellet can not always be in control. i.e pellet quality is not always in control.

But dust to atmosphere have improved over the years even with the intermittent problem that overfill our fines silo and creates need for outdoor storage





Questions ?