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FROM ORE TO FERRONICKEL
DESCRIPTION OF THE TECHNOLOGICAL PROCESS

EURONICKEL INDUSTRIES
KAVADARCI – RN MACEDONIA

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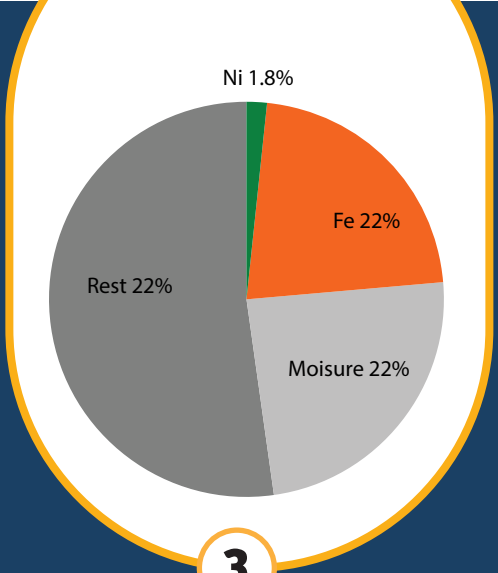
Euronickel Industries is a pyro metallurgical plant that produces ferronickel from ore. Ferronickel is iron and nickel alloy, mainly used in stainless steel production.

2

The ore used in Euronickel Industries is ordinary soil (earth) that just contains a higher concentration of iron (Fe) and nickel (Ni). The composition of the Earth's core is mainly an alloy of nickel and alloy. The presence of iron in the soil is a common occurrence. It is present in all kinds of soil. Only its concentration changes, and it varies from 5% to 60%. The ore that is used in Euronickel Industries contains around 22% Fe on average.



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Unlike iron, nickel is not present in all types of soil and its concentration is much lower. The ore used in Euronickel Industries on average contains 1.8% Ni. And another important parameter in this ore is the moisture content. The moisture (i.e. water) varies between 10% and 35%, depending on the time period and on average is around 24%.

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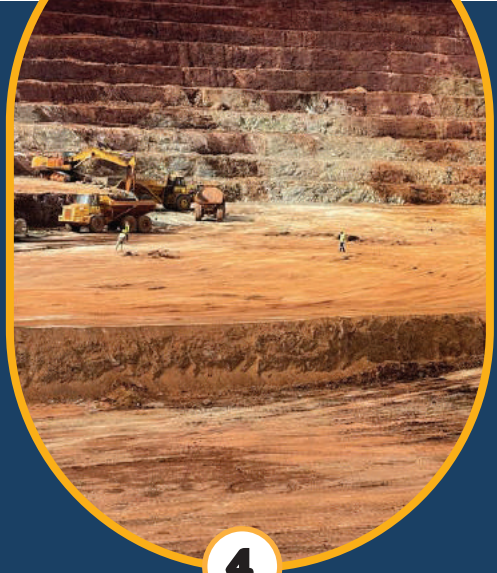

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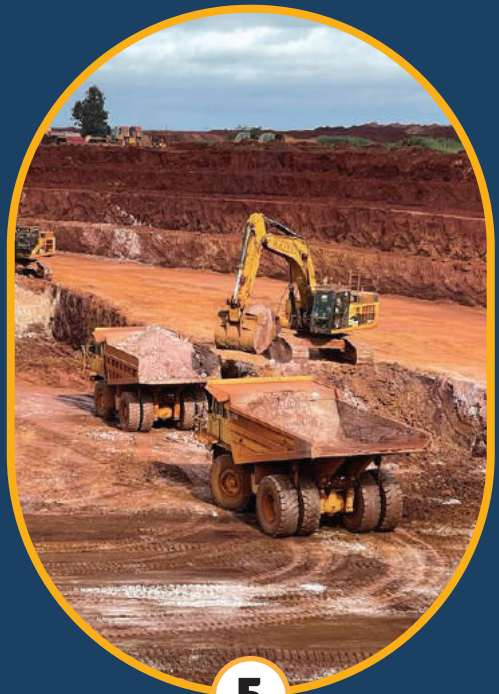
Historically, the smelter used ore only from the R'zhanovo Mine. Later however, it started using imported foreign ore from Indonesia, the Philippines, Guatemala, Turkey, Albania, and from 2018, the production is mainly based on ore from the Ivory Coast.



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Currently, a blend of Ivory Coast ore and Albanian ore is used, in ratio 75% to 25%, respectively.

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All these foreign ores are transported on large vessels from 10 000t to 50 000t (50 000t equals to 2 000 trucks with a capacity of 25 tons).

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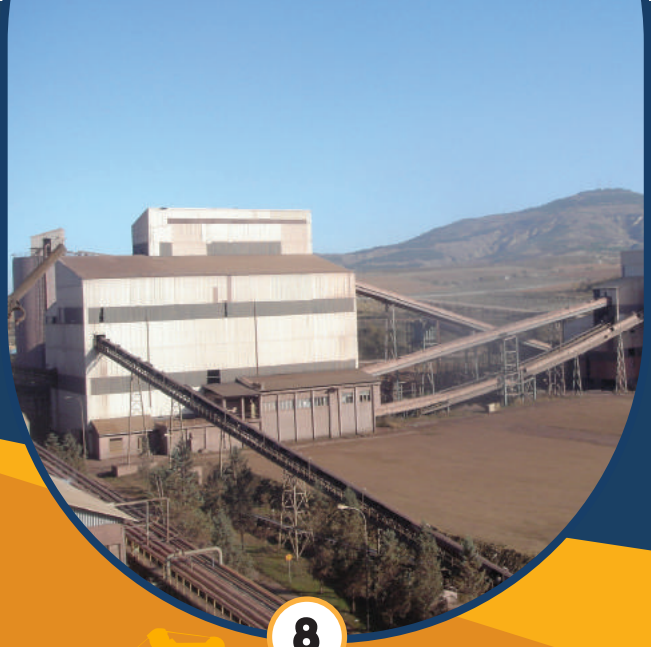
Once unloaded at the Thessaloniki port, the ore is transported to Euronickel in Kavadarci by trucks or railway.



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Then, the ore is crushed (the stones are broken) before it is stored. After crushing, the ore pieces size is between 10 and 80mm.

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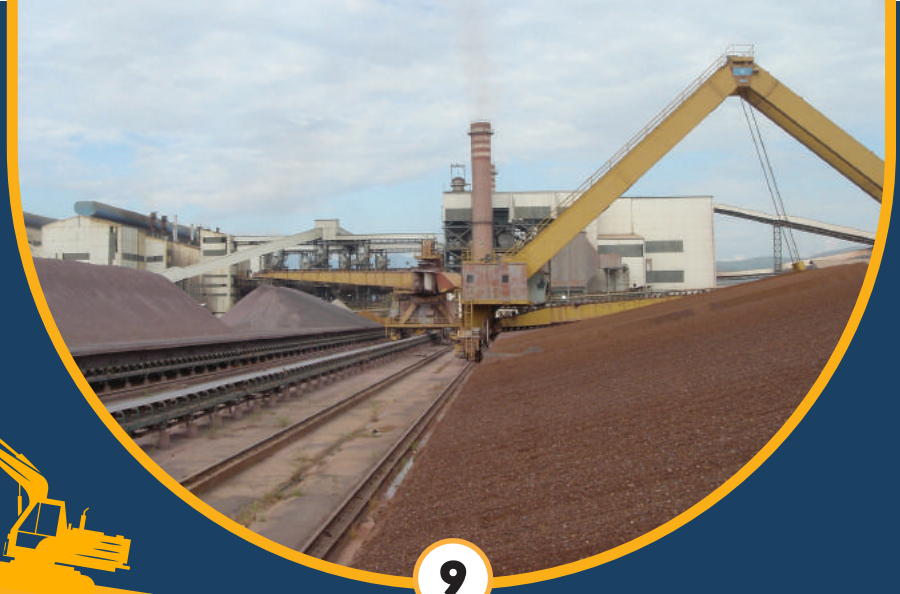

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Simple math

About the ore and final product quantities.

For an average production of 1 350 t per month, around 100 000t of ore with 1.8% Ni and moisture 25% are needed.

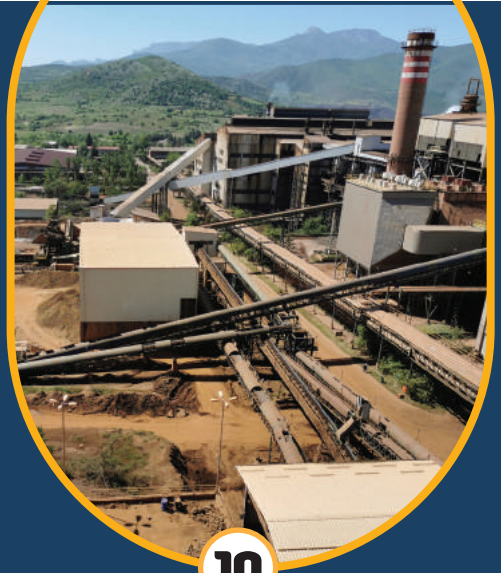
(75 000 tons dry ore x1.8%Ni = 1 350 tons Ni).

This means 3 300 tons of ore per day is being processed (130 trucks of 25 tons each).

1 350 t nickel, that is 45 t nickel per day, are produced from this quantity of ore.

However, our product is not only nickel, but an alloy made of 20%Ni and 80% Fe.

This means that 200 t ferronickel are produced per day (around 10 trucks of ferronickel per day).



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There around 12 kilometers of conveyor belts in Euronickel Industries.

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The ore from the stockpiles is directly delivered to the Pelletizing Department by conveyor belts.

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In this department, the ore first goes to balling disks - pelletizers. Euronickel Industries has 6 pelletizers. Due to the rotational motion of the disks, the fine fraction of the ore mixture increasingly agglomerates, forming small balls of ore (called “pellets”). By agglomeration, the mass of these pellets increases after each rotation. When the pellet reaches a certain mass, by the effect of centrifugal force only (the force which occurs on rotating objects and that tends to eject the objects outwards), the pellets are ejected from the disc.

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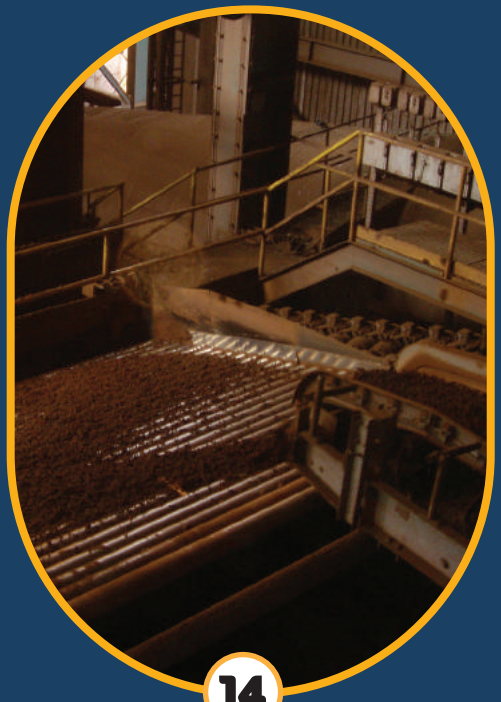
These pellets are with a diameter below 2 cm, and are called “green pellets”, but once they come out from the rotary kiln, they are called “red pellets”.



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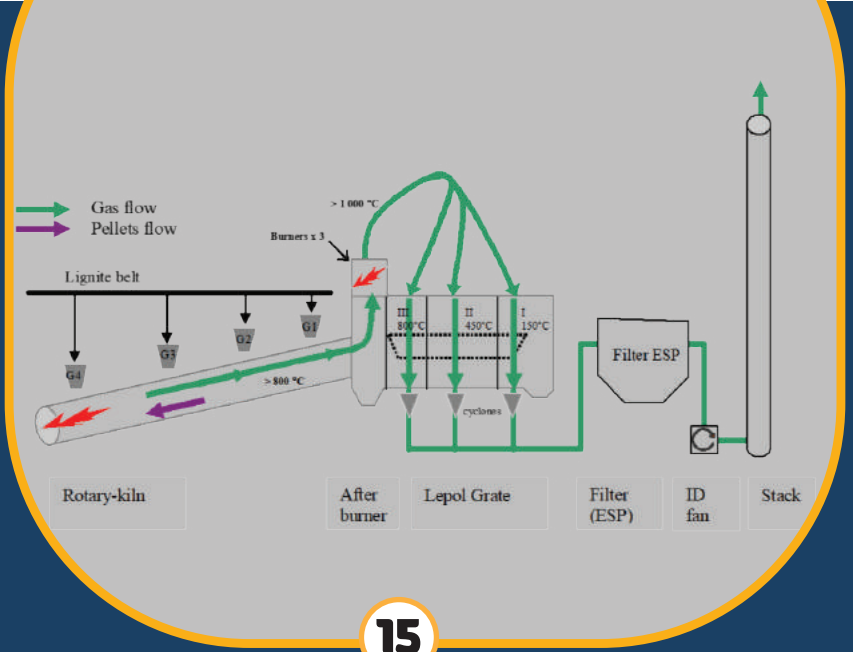
Next, these green pellets go into the system Lepol Grate -Rotary Kiln.



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The green pellets are then laid on a chain which moves inside the Lepol Grate (it is as if the pellets go inside a tunnel where the temperature increases from 150°C at the inlet to 800°C at the outlet of this tunnel).

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At the end of the Lepol Grate, the pellets ‘fall’ into the rotary-kiln. There are two rotary-kilns in Euronickel Industries. The rotary-kiln is a type of furnace which rotates slowly around its axis. Due to its small inclination, at each turn (rotation) of the kiln, the pellets move forward towards the outlet of the kiln. The length of the rotary kilns is 75m, and it takes approximately 3 hours for the pellets to go from the inlet to the outlet.

17

Inside the rotary-kiln, the temperature is above 800°C. Huge flames are generated at the outlet. When pellets leave the rotary-kiln, they are red pellets (because of their incandescence).

18

The temperature inside the kiln is generated by combustion of lignite (coal) and mazut (heavy fuel oil), which are mainly carbon (C) based materials.

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Carbon participates in the pre-reduction (removal of the oxygen from the ore, so as finally to extract only nickel and iron). Nickel is reduced first, and then iron. The pre-reduction is done in soid state, in the rotary-kiln, at a relatively low temperature (<1000°C). When the lignite (carbon) is in contact with the oxides of the ore, part of the oxygen from the ore is captured by the carbon (C), thus creating CO_2 which is emitted. The volatile part of the lignite also helps the combustion inside the kiln).

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At the outlet of the rotary-kiln, the red pellets are dispensed into a container placed below the kiln. The container now full with pellets, is lifted to the roof of the electric-furnace with a crane.

21

The red pellets are then fed inside the electric furnace, where they first float on the surface. Then, due to the high temperatures (generated by the electricity supplied through the electrodes that get in direct contact with the content of the furnace) pellets melt (become as volcanic lava) at a temperature of around 1600°C.

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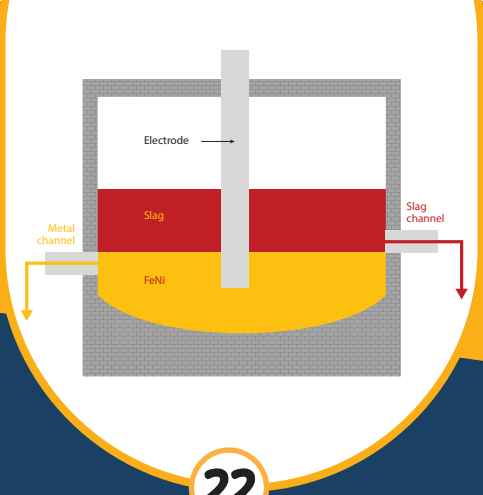

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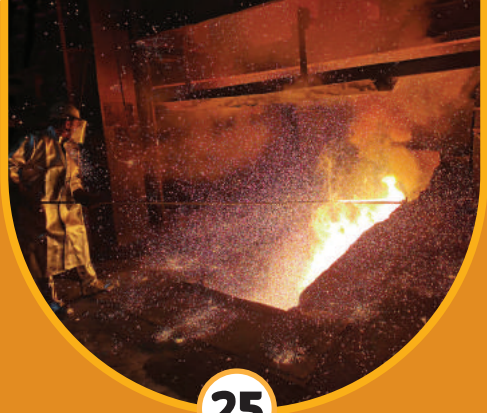
When the ore is in lava state, the nickel and iron present in the ore sink to the bottom of the furnace (due to their weight), whereas the other elements (SiO_2, CaO, MgO, etc.) float above (they are lighter). This floating layer or phase is called “slag”. The slag is tapped out from one side of the furnace. The channel for discharging of slag is located higher than the chanel for metal. This slag is removed separately from the metal.

23

There are 2 electric-furnaces in Euronickel Industries.These are very large facilities (35 m x 14 m). On the inside, they are lined with refractory bricks in order to resist heat above 1600°C.

24

After tapping, slag is disposed on two slag landfills, one near Vozarci village and the other near Shivec village. Once it cools down, slag is inert material. The company managed to market the slag during the previous years, and now it is exported as a by-product. More than 3 000 tons of slag are removed from the electric furnaces, daily.



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The metal from the electric -furnace (raw ferronickel) is “tapped” (discharged) through the metal channels on the other side of the furnace. This liquid metal (at a temperature of 1500°C) is poured in a ladle positioned under the furnace. This ladle has one metal tap capacity (approximately 40 tons of FeNi i.e. 5 tons of nickel). Usually, 10-12 metal taps per day are made (50-60 tons nickel or 400-500 tons FeNi).

26

Then, a 100 tons bridge-crane lifts the ladle full with liquid metal (the weight of the ladle and the charge is over 50 tons) and the metal is then poured into the converter.

From the refining process in the converter, converter slag is generated and dumped at a specific location (2 km from the plant). This by-product is then crushed and marketed worldwide as a high-density aggregate.

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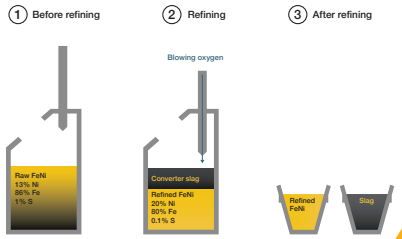

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The raw ferronickel with 13%Ni needs further refining to become ferronickel with approximately 20% Ni. This process takes place inside the converter. Oxygen is blown inside the liquid raw ferronickel (lava). This oxygen re-oxidizes a part of the iron, thus creating iron oxide (slag). This converter slag, floating above the liquid metal, is removed from the surface of the liquid metal by tilting the ladle of the converter. This removal of iron mathematically increases the nickel content. In this stage, he ferronickel is also de-sulfurized by adding limestone.

28

The refined ferronickel (around 25t FeNi per charge, that is 5t nickel (25t FeNi x 20% Ni = 5t nickel) is lifted again with the same crane and poured into the Holding Furnace. In this stage, final adjustments are made. The nickel thus processed and refined, is ready for granulation.

29

The liquid metal is poured inside a pool against a strong water flow. When in contact with water, the liquid metal transforms into granules with a size of around 3 cm.

30

The ferronickel is now ready for export. It is delivered either in big bags or in bulk in containers.

31

Euronickel's product is used mainly for the production of steels and stainless steel. Steels are made by smelting together a mixture of ferroalloys, such as ferrochrome, ferrosilicon, ferro-manganese and ferronickel. The share of the different ferroal-loys depends on the desired characteristics of the steel. Most often, the stainless steel contains 8% nickel. Nickel provides the anti-corrosive feature of the steel. This explains why nickel is intensively used for all steels for medical and agro-industrial purposes, as well as for aeronautics and high technologies.

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Euronickel's clients are located around the world and appreciate Euronickel's ferronickel due to its very low level of impurities (ultra low carbon).

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Locations of Euronickel's major clients

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ENGLAND
GERMANY
SPAIN
ITALY
INDIA
CHINA
SOUTH KOIREA
TAIWAN
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