

Iron and ferrous - metals




Josep Poch March 07

Slag cars in a steelwork in Belgium

© Harald Finster

Iron – where does it come from?

- ▶ Iron is the most important metal in industrialized societies
- ▶ The **main ores** are:

Magnetite (Fe_3O_4)	Hematite (Fe_2O_3)	Siderite (FeCO_3)
Iron oxide	Iron oxide	Iron carbonate
		

- Australia, China, Brazil, South Africa and Sweden are the world's major iron ore producers, with more than 88% of the world's iron ore exports



The Iron Age

- ▶ Humans started using iron to make tools and weapons around 1400 BC, when they invented its carburization (using coal) and therefore how to make steel
- ▶ It was preceded by the Bronze Age



Kirkburn Sword

(Yorkshire, England),
described as '*probably the
finest Iron Age sword in
Europe*'

Iron in history



Roman plough, 1st century AD



'Man in armour',
Tintoretto, 1550



Coalbrookdale bridge
(1779), the world's first
iron bridge (England)



Stephenson's *Rocket*
locomotive, 1829



El Alamillo bridge (Santiago
Calatrava), Sevilla, 20th century

A blacksmith at work

- Blacksmiths forge the iron. The outcome is a piece of wrought or forged iron



**Wrought iron
fence and bed**

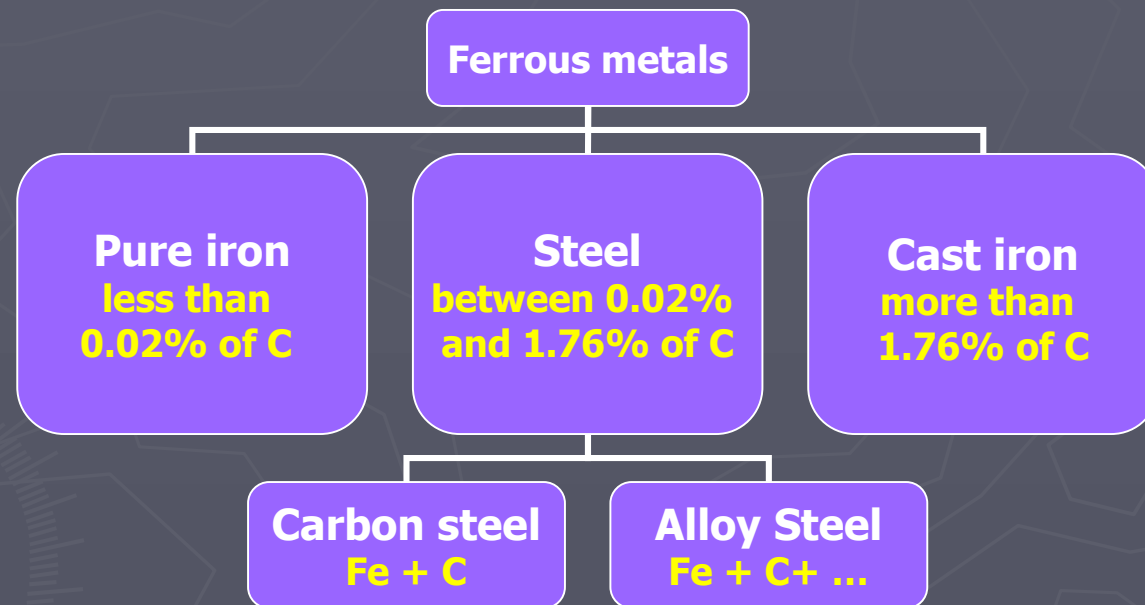
Blacksmiths throughout history

- Blacksmiths have existed since many centuries ago



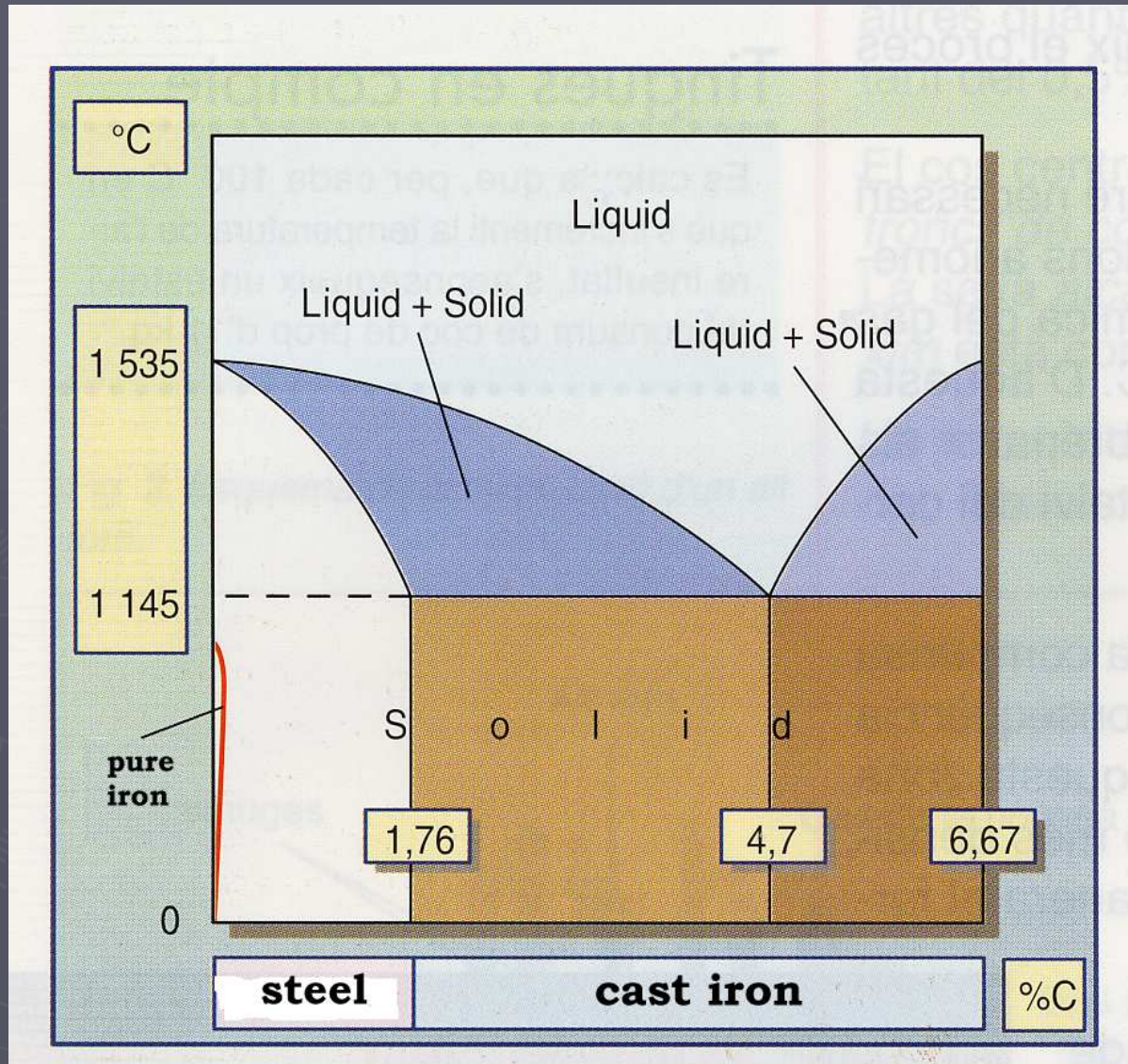
The Forge of Vulcan (Diego Velázquez) and Hephaestus forging on a piece of Greek pottery

Ferrous-metals



- ▶ Steel is the **main ferrous metal**
- ▶ **Carbon** acts as a **hardening agent**
- ▶ Pure iron has few uses

Iron-carbon phase diagram



Steelmaking (Steel = Fe + C)

Raw Materials



Coke Coal (C)

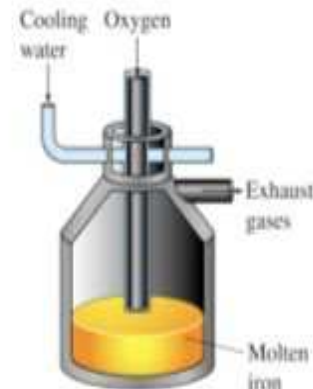
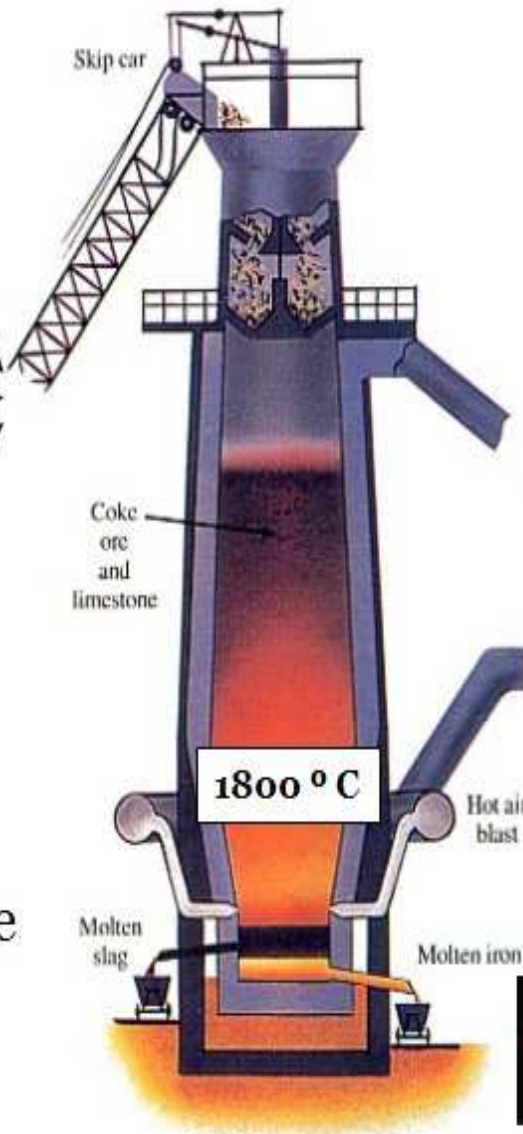


Iron Ore (Fe + impurities)



Limestone

Blast Furnace



Oxygen converter
The iron is converted into **CRUDE STEEL** burning off spare C. But there are still impurities!



Electric furnace It takes out the impurities. We have now **MOLTEN STEEL!**



"PIG IRON"
Iron with too much C and impurities: it's **BRITTLE**

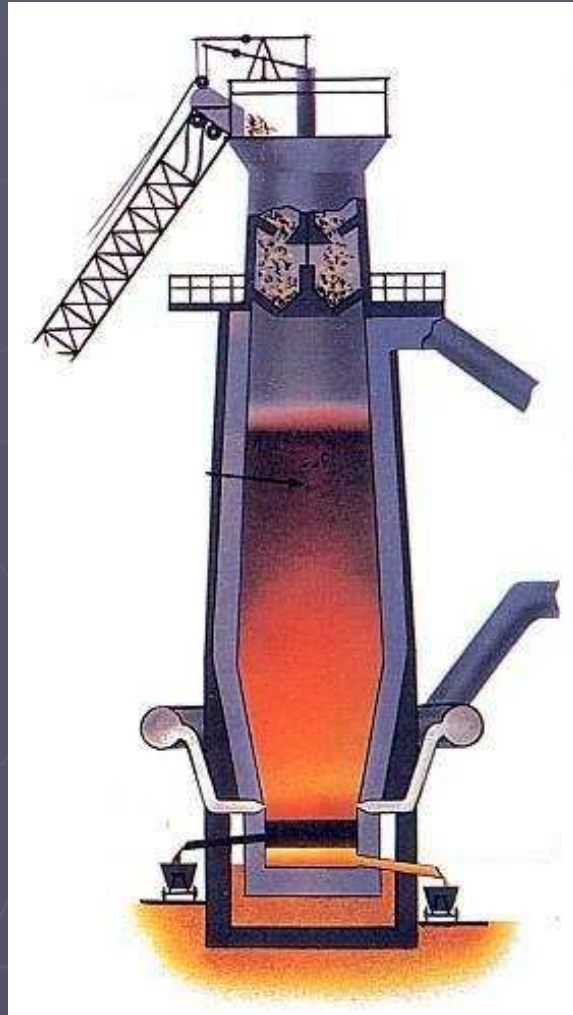


Products

Raw materials and products

► Raw materials:

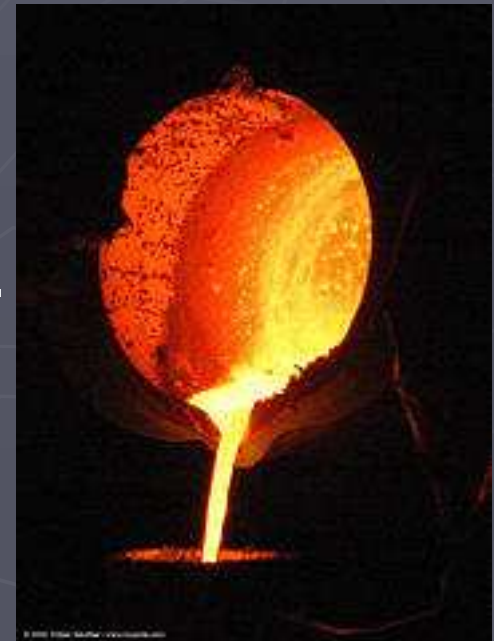
- Iron ore
- Coke
- Limestone



BLAST FURNACE

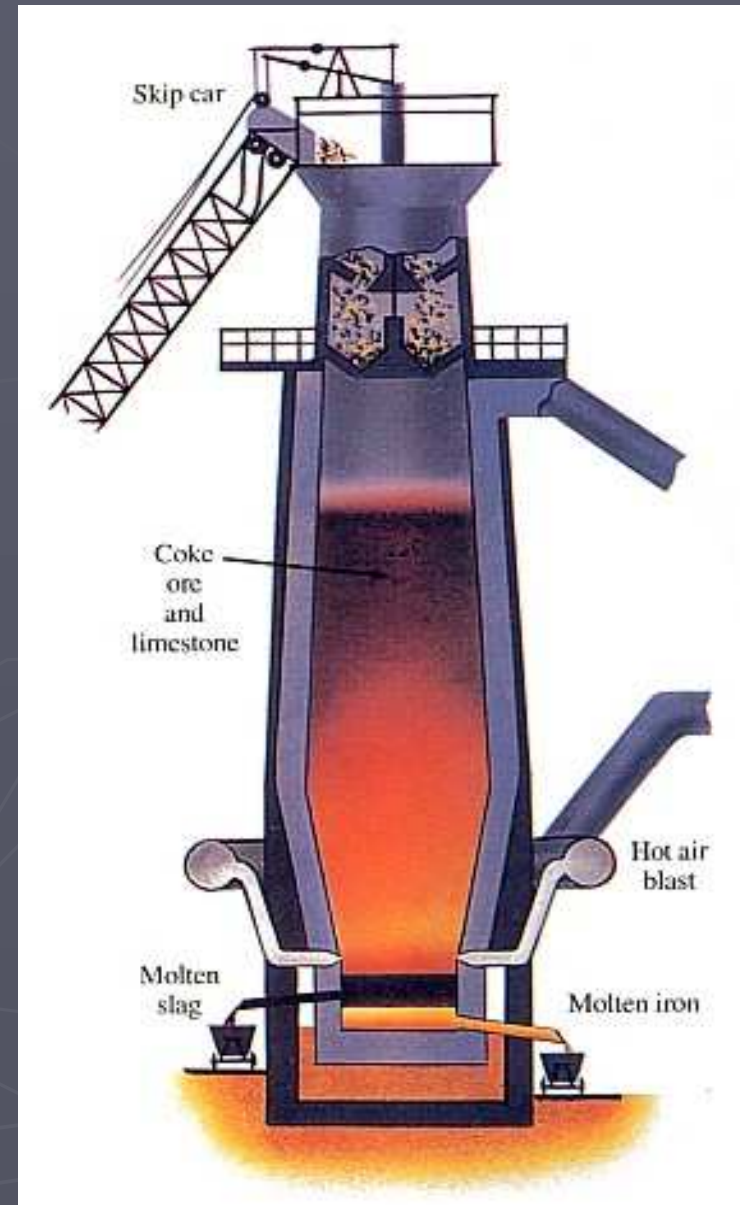
► Final product:

- Molten steel



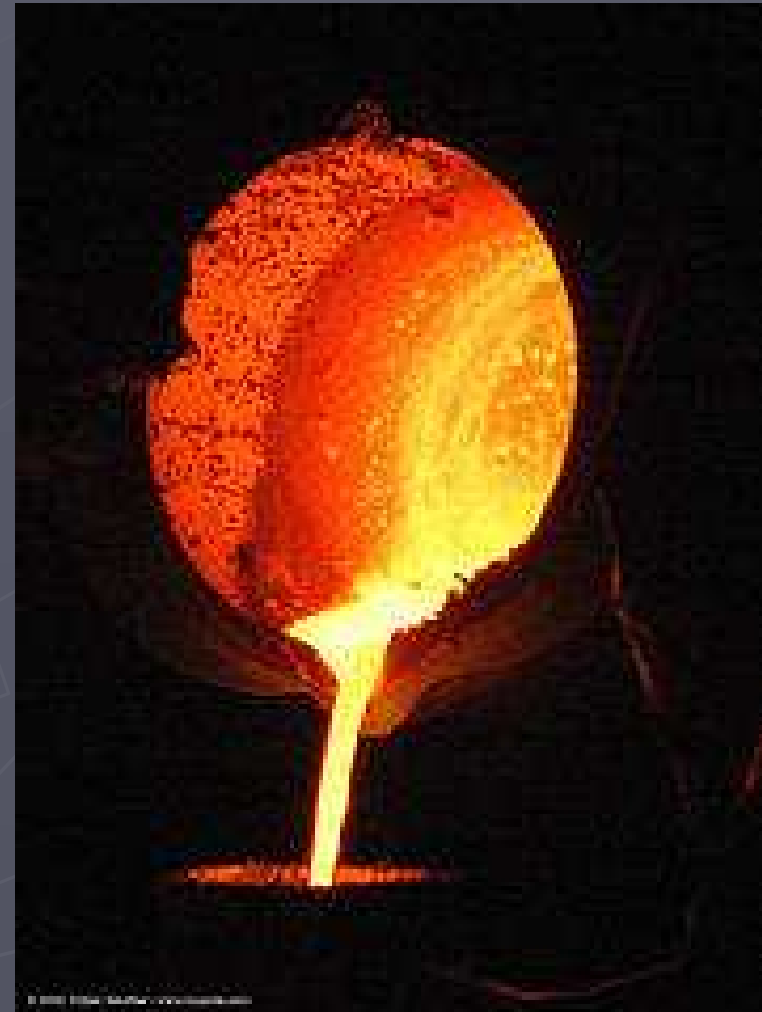
Reducing the iron ore to iron

- ▶ The coke burns and produces carbon dioxide:
 - $C + O_2 \rightarrow CO_2$
- ▶ The CO_2 reacts with non-burnt coke to form CO:
 - $CO_2 + C \rightarrow 2CO$
- ▶ The carbon monoxide reduces the iron ore to iron:
 - $3CO + Fe_2O_3 \rightarrow 2Fe + 3CO_2$
- ▶ The result is molten iron and CO_2
- ▶ The limestone reacts with the impurities and the reaction produces slag



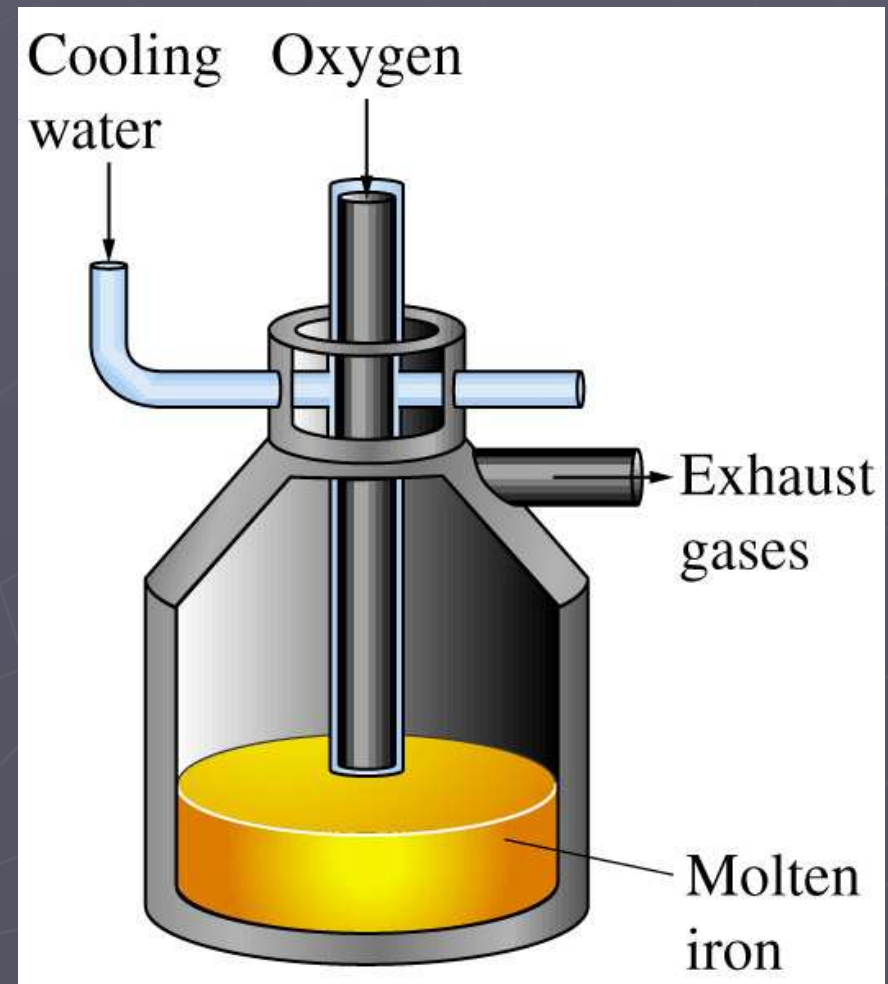
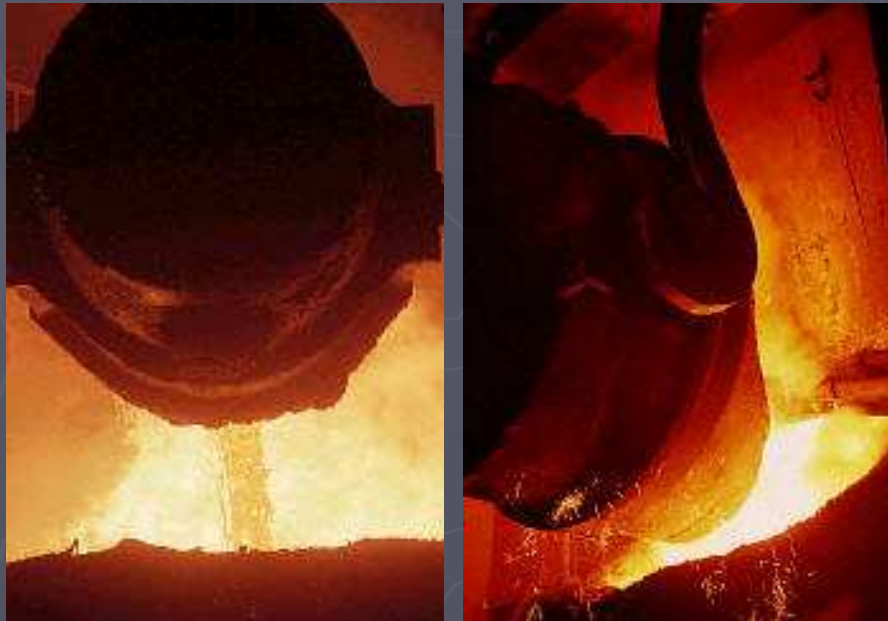
Producing steel from iron (1)

- ▶ The **molten iron** is also called ***pig iron***, the immediate product of the blast furnace
- ▶ Pig iron has **impurities** and a **very high carbon content**, typically 3.5%, which makes it **very brittle** and not useful directly as a material



Producing steel from iron (2)

- The **pig iron** is converted into **crude steel** burning off spare C using an **oxygen converter**



Producing steel from iron (3)

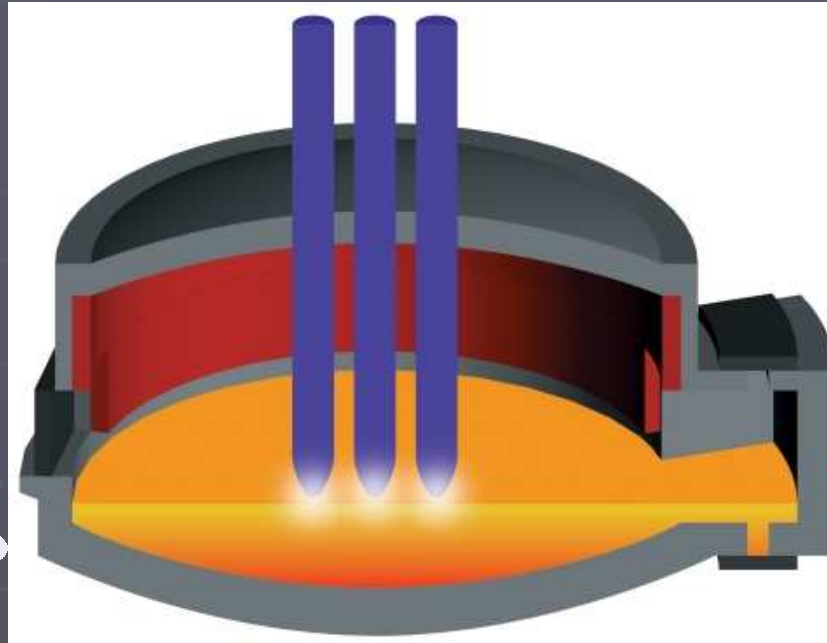
- **Impurities** are removed from the **crude steel** and **steel scrap** using an **electric arc furnace**



Crude steel



Steel scrap



Molten steel

- We get **molten steel**, ready to be used. **Alloy steel** can be produced too

Blast furnace and **hot-blast stove** facilities, which provide hot air during the process of production of molten iron. The furnace is about 50 m high, like a 17-floor building

Blast
furnace

hot-blast stove