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Steel Recycling with Graphite Electrodes - An Industrial Success Story -

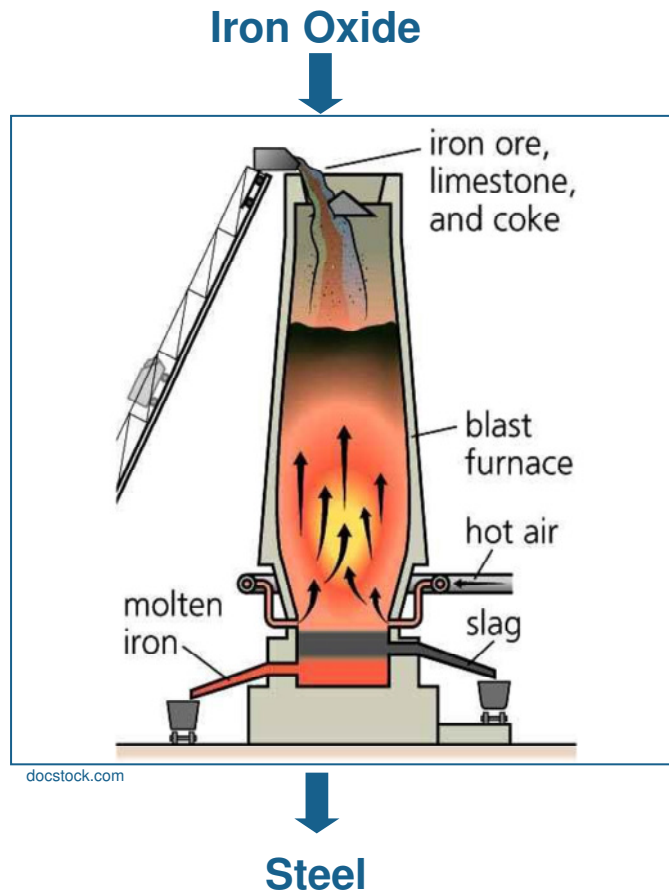
**2nd German – Polish Symposium
October 16th 2013
TU Bergakademie Freiberg**

BROAD BASE. BEST SOLUTIONS.

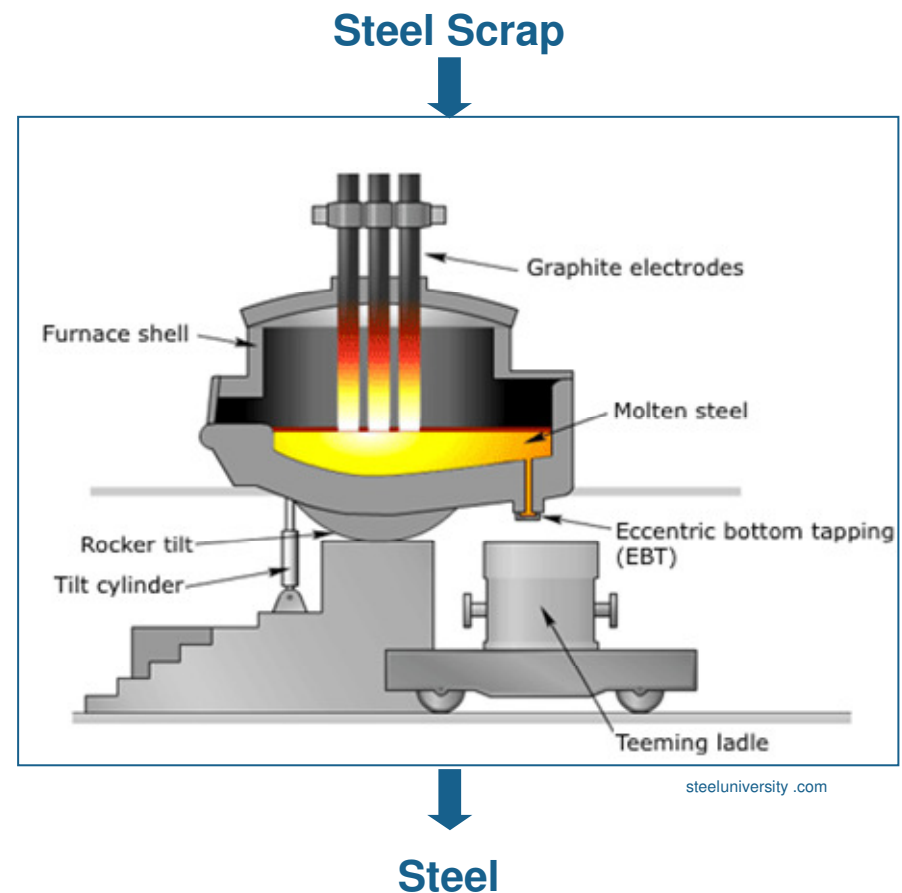
Steel Making Processes

Blast Furnace & Electric Arc Furnace

Blast Furnace (BOF)



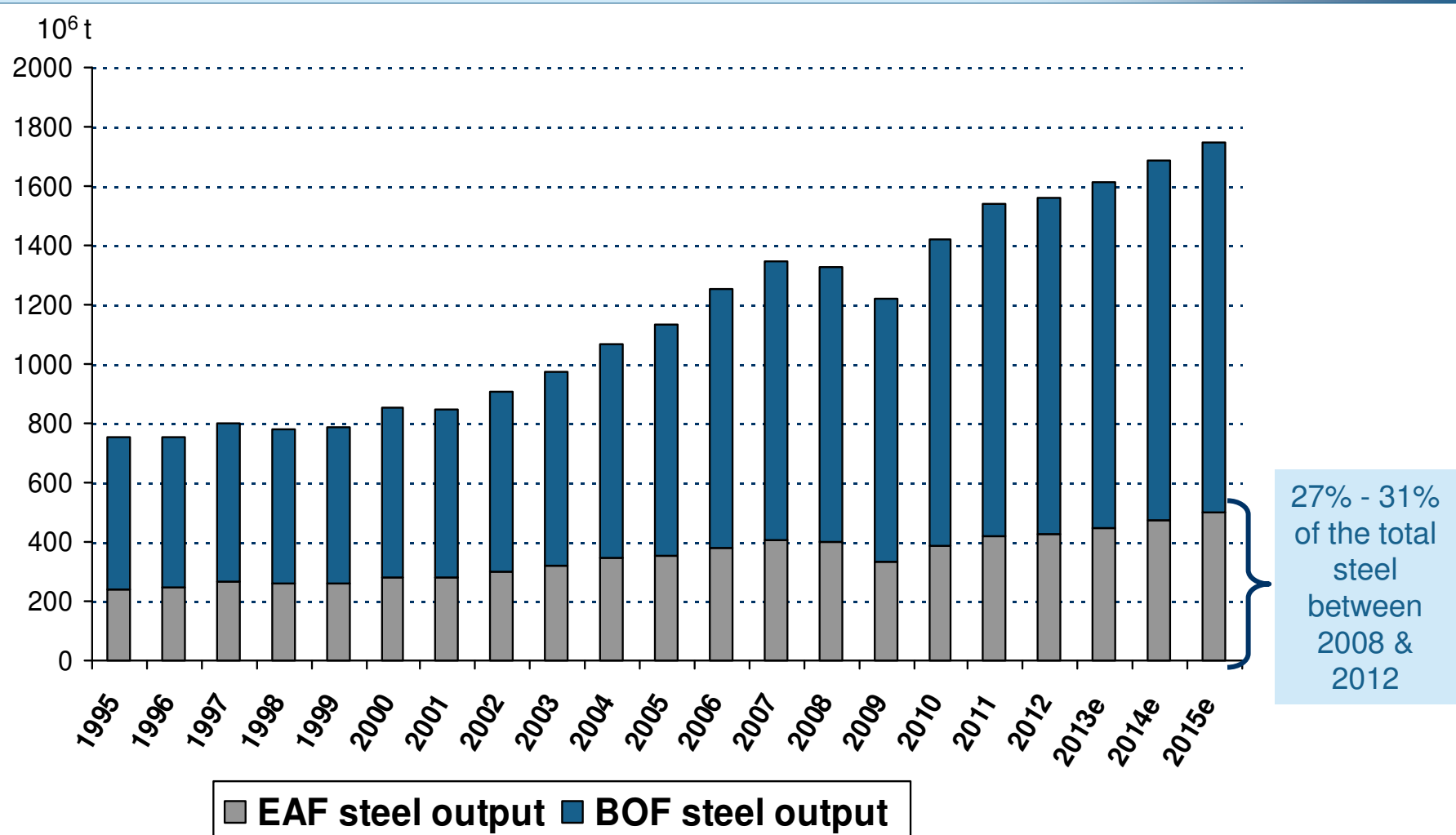
Electric Arc Furnace (EAF)



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Steel Making Processes

World Steel Market



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Steel Making Processes

Use of Graphite Electrodes



Graphite electrodes are used in so called mini mills. These are steel plants, where steel scrap is melted in a recycling process. The electrode enables an energy transfer to melt steel scrap via an electric arc.



DC furnace at Peiner Traeger

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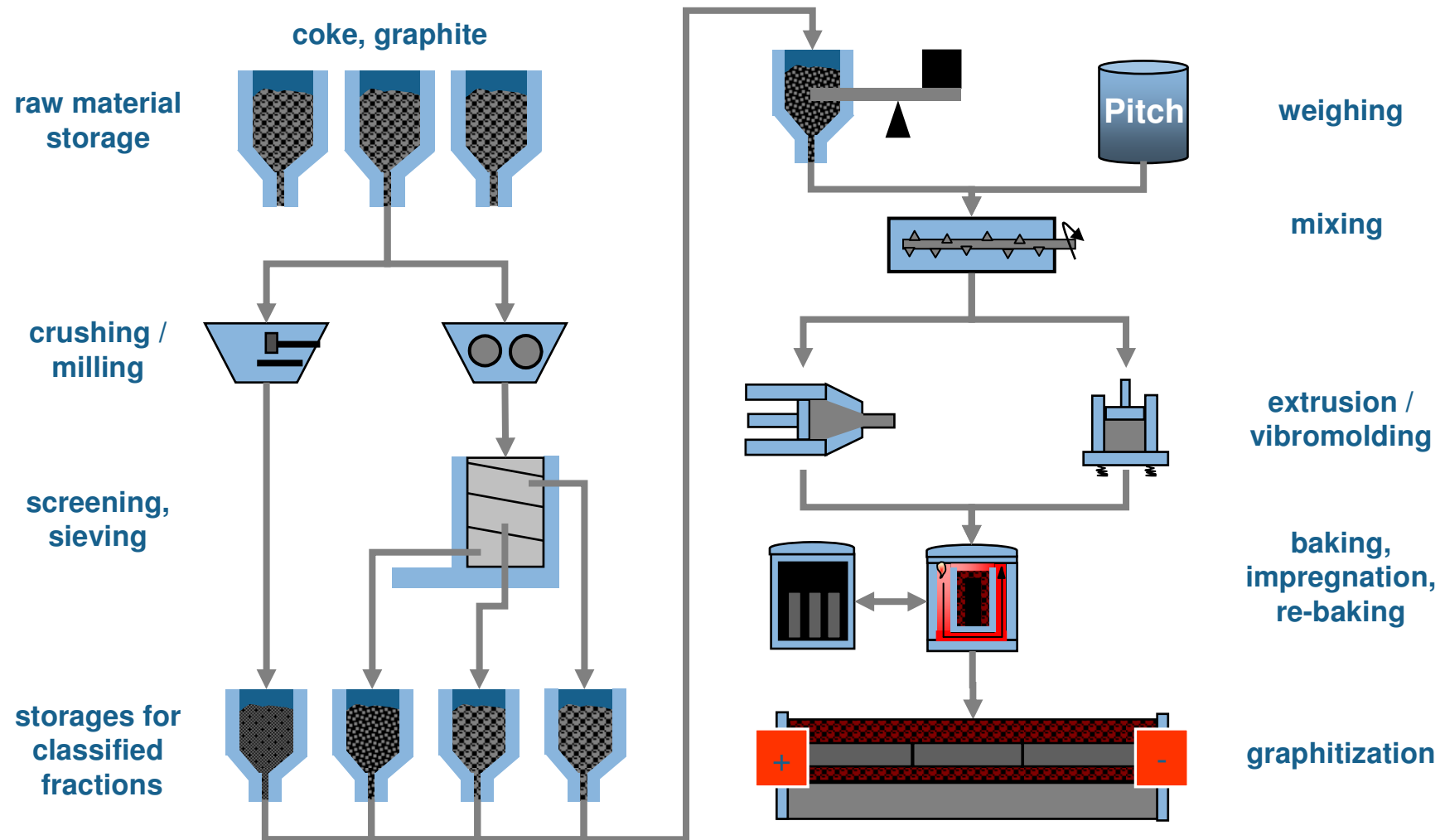
Improvements in Electrode Production - Some Examples -

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Steel Recycling with Graphite Electrodes

Graphite Electrode Production Process

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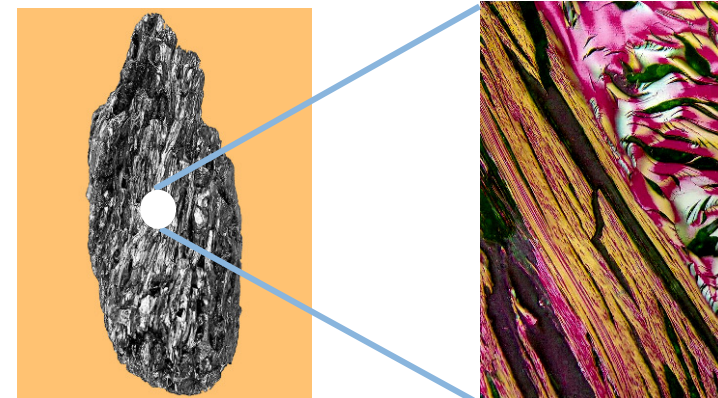
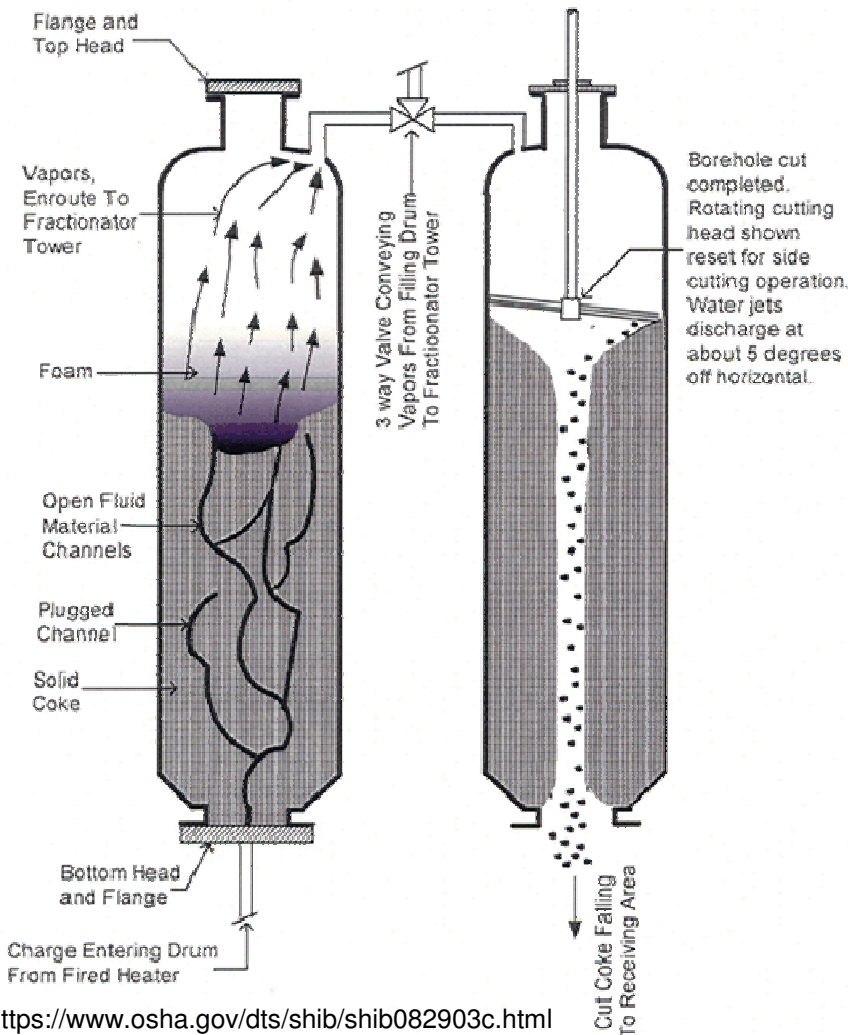


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Graphite Electrodes – Major Developments

Raw Material Improvement: Needle Coke



Needle coke for GE:

- Elongated shape → orientation in green processing
- Low in ash content
- Low CTE along needle
- High thermal conductivity
- Low electrical resistivity along needle
- High graphitizability

<https://www.osha.gov/dts/shib/shib082903c.html>

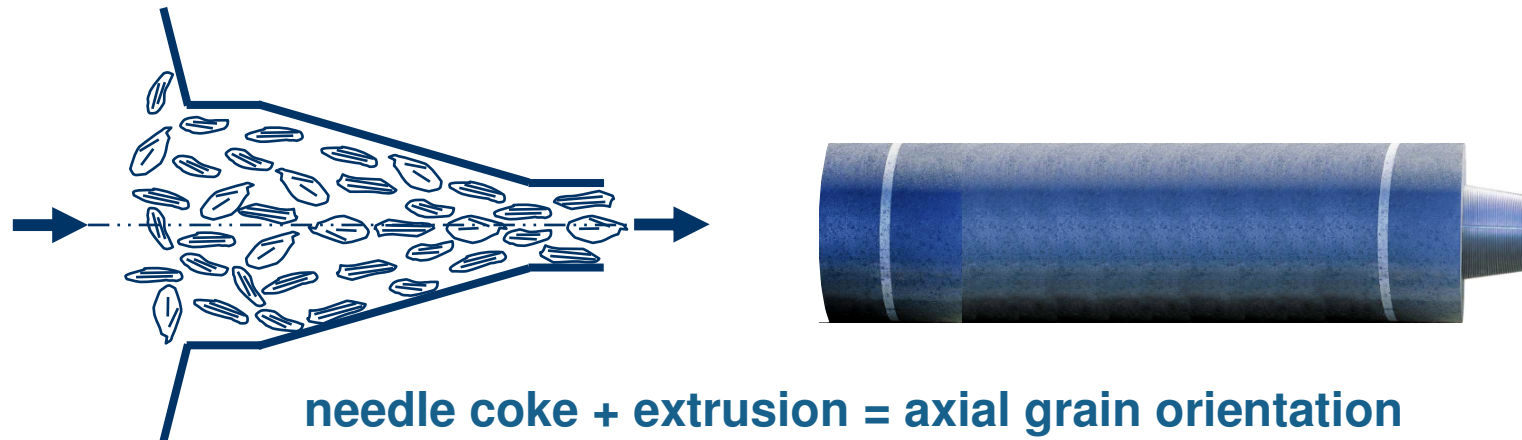
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Graphite Electrodes – Major Developments

Raw Material Improvement: Needle Coke



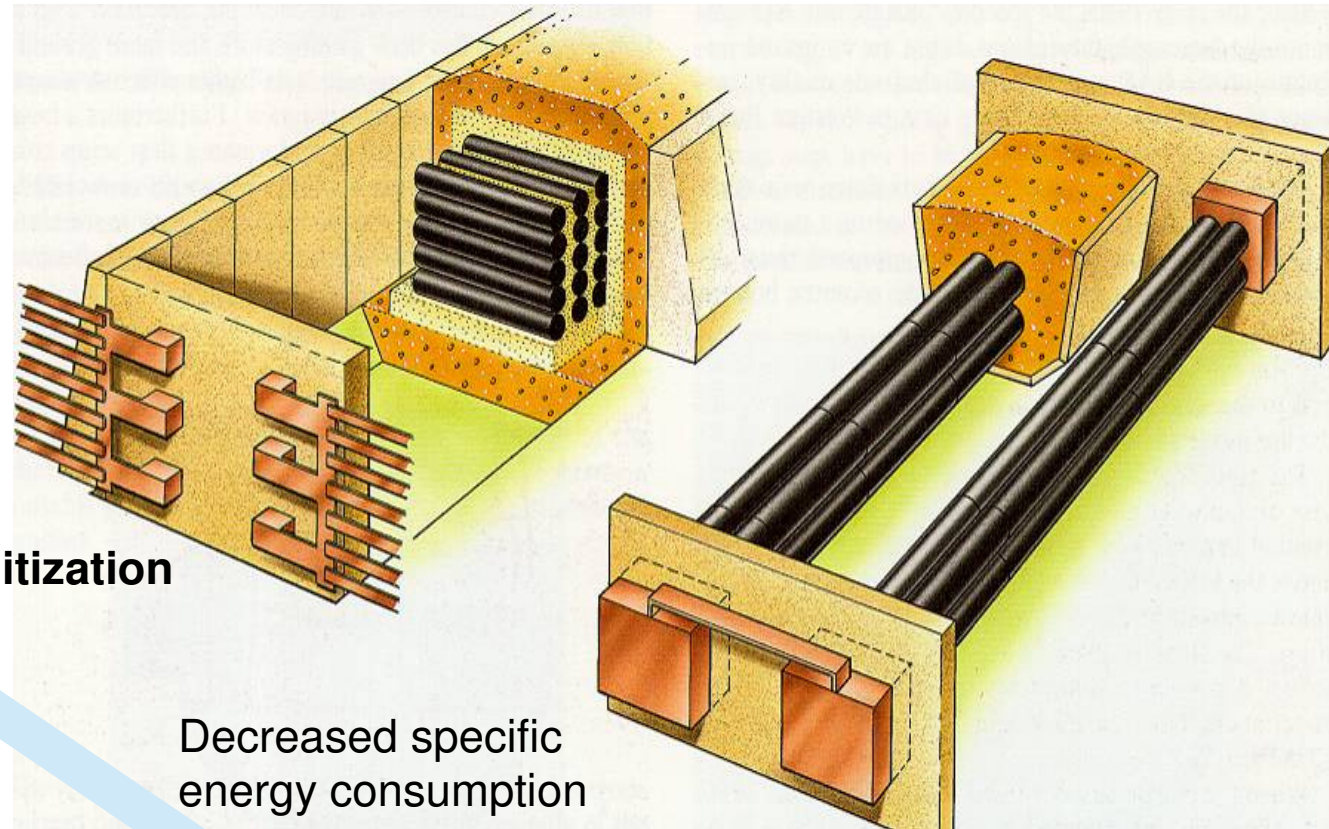
→ Full employment of graphite's anisotropic properties:

- Low resistivity & low CTE in strand direction
- High tensile strength in strand direction
- High bending strength in perpendicular direction

Graphite Electrodes – Major Developments

Graphitization

Acheson graphitization
indirect heating



Decreased specific
energy consumption

Increased
productivity

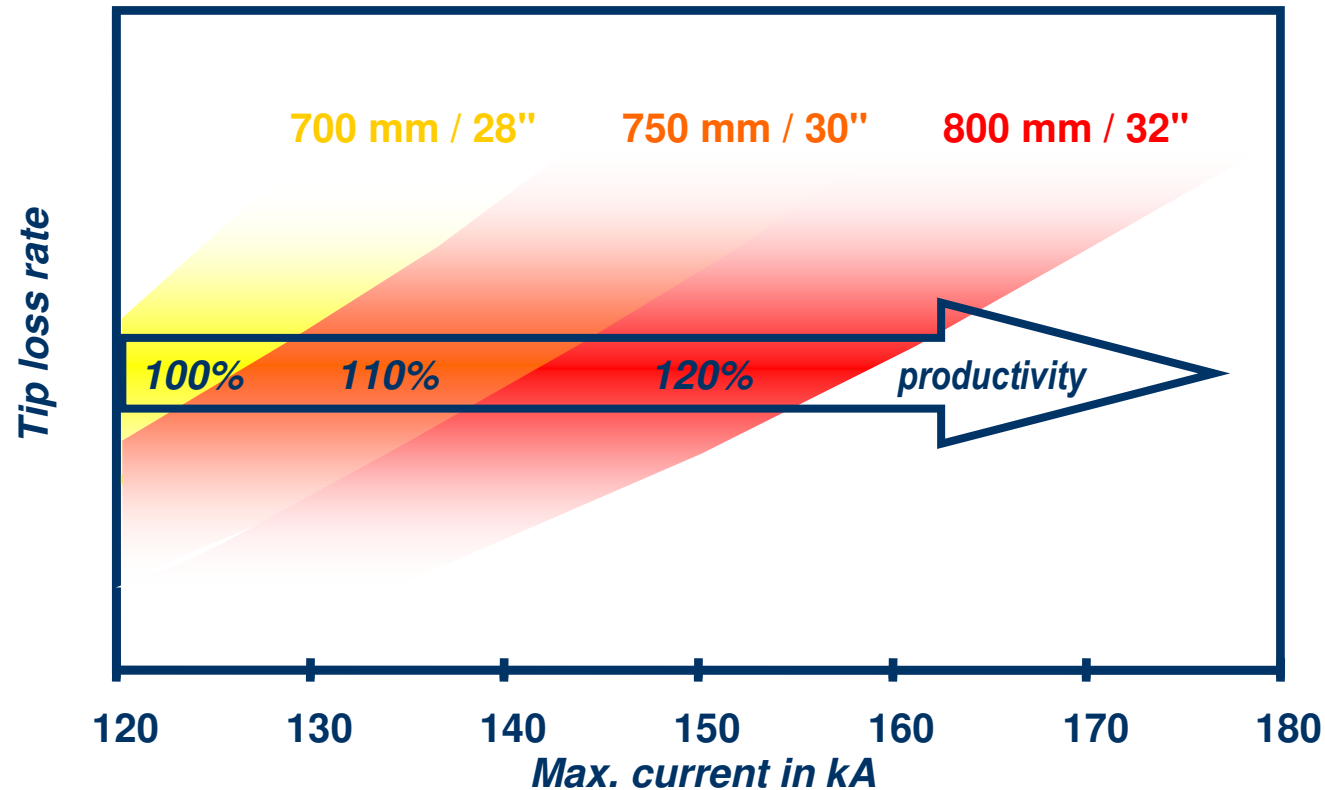
Castner or length-wise graphitization (LWG)
direct heating

Graphite Electrodes – Major Developments

Diameter Increase - Break-through for a new generation of high-power EAFs



Productivity increase at constant tip loss rate



SGL Group 1st to present 800 mm GE in 2000

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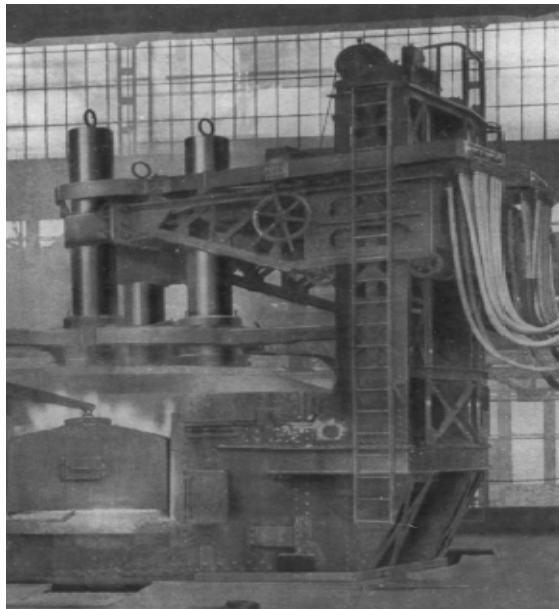
Improvements in Furnace Technology - Some Examples -

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Improvements in Furnace Technology

Major Developments

~ 1920



Slag foaming

UHP ($U > 1000 \text{ V}$, $i > \sim 25 \text{ A/cm}^2$)

Water spraying

Oxygen lances

Electrode diameter

Taping weight

2010



Improvements in Furnace Technology

Ultimate Furnace (300 mt)

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SIMETAL^{CIS} ULTIMATE 300t EAF
At COMMISSIONING

SIEMENS
V A I 



AC-Furnace at Çolakoğlu/TR

Page 15

Date 20.11.07

Author Michel HUCK

SIMETAL^{CIS} Ultimate and RCB – ATS VDEH

I&S / MT / TT

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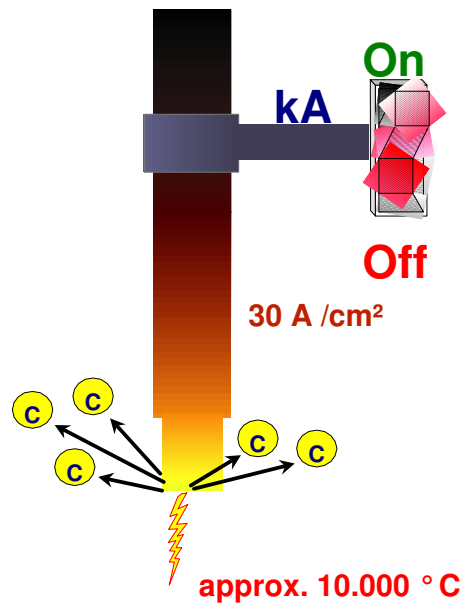
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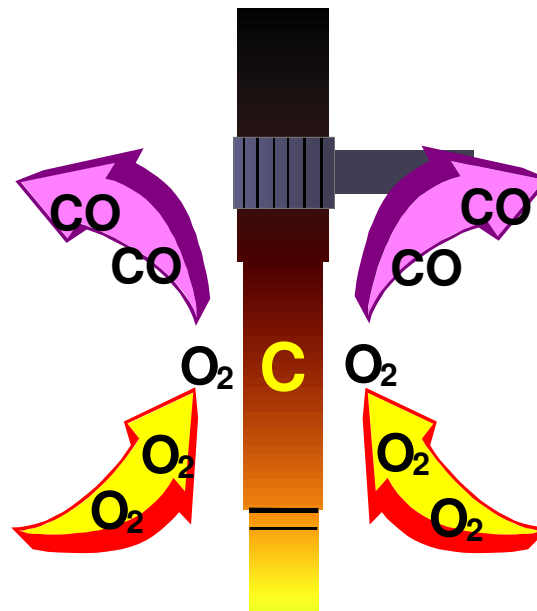
Technology Improvements in Furnace Technology

Electrode Consumption Mechanisms

Continuous

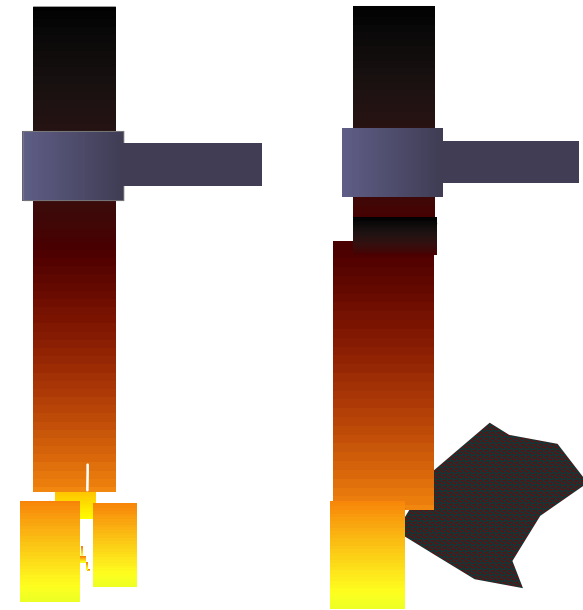


Tip sublimation



Surface oxidation

Discontinuous



Stub end losses

Breaks



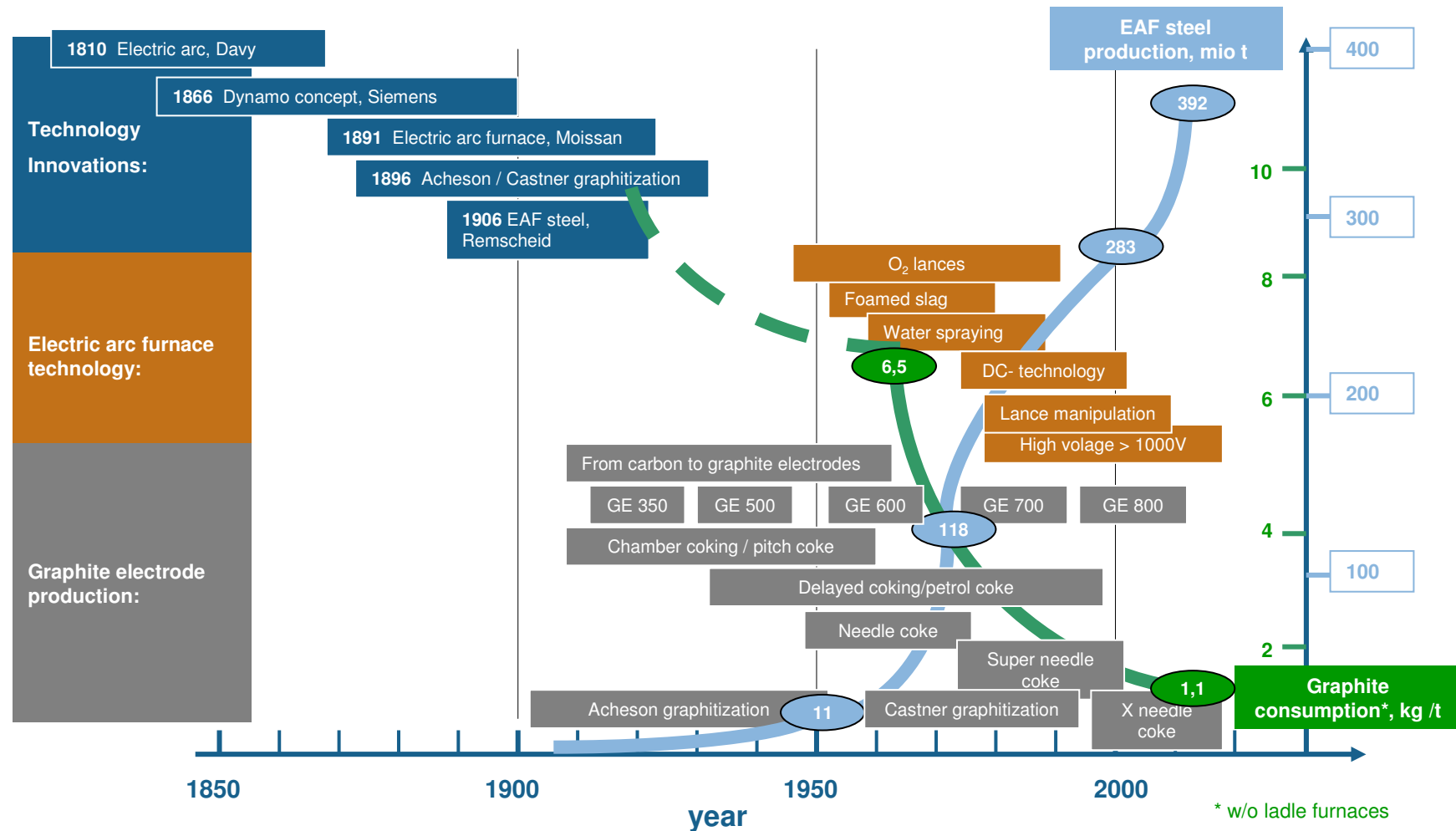
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Summary

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Steel Recycling with Graphite Electrodes

An Industrial Success Story



Steel Recycling with Graphite Electrodes

An Industrial Success Story



Thank you for your attention!

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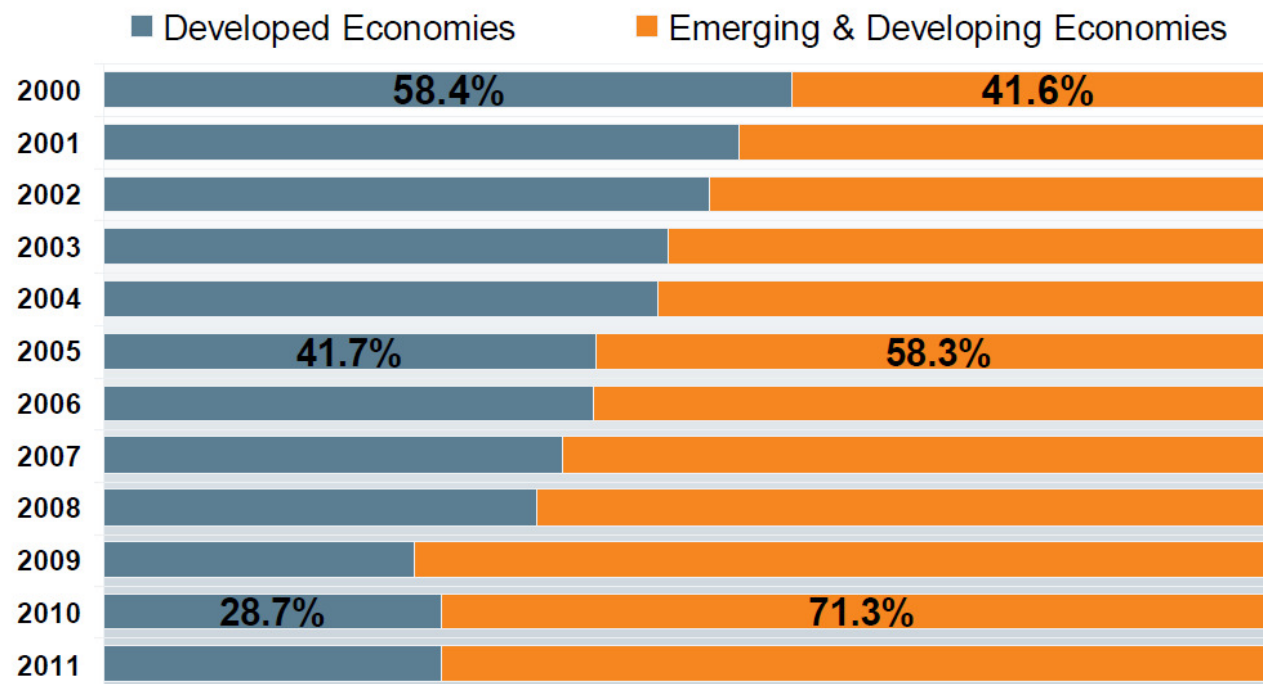
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Backup

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Steel Recycling with Graphite Electrodes

Global Steel Use



Source: worldsteel, SRO

worldsteel

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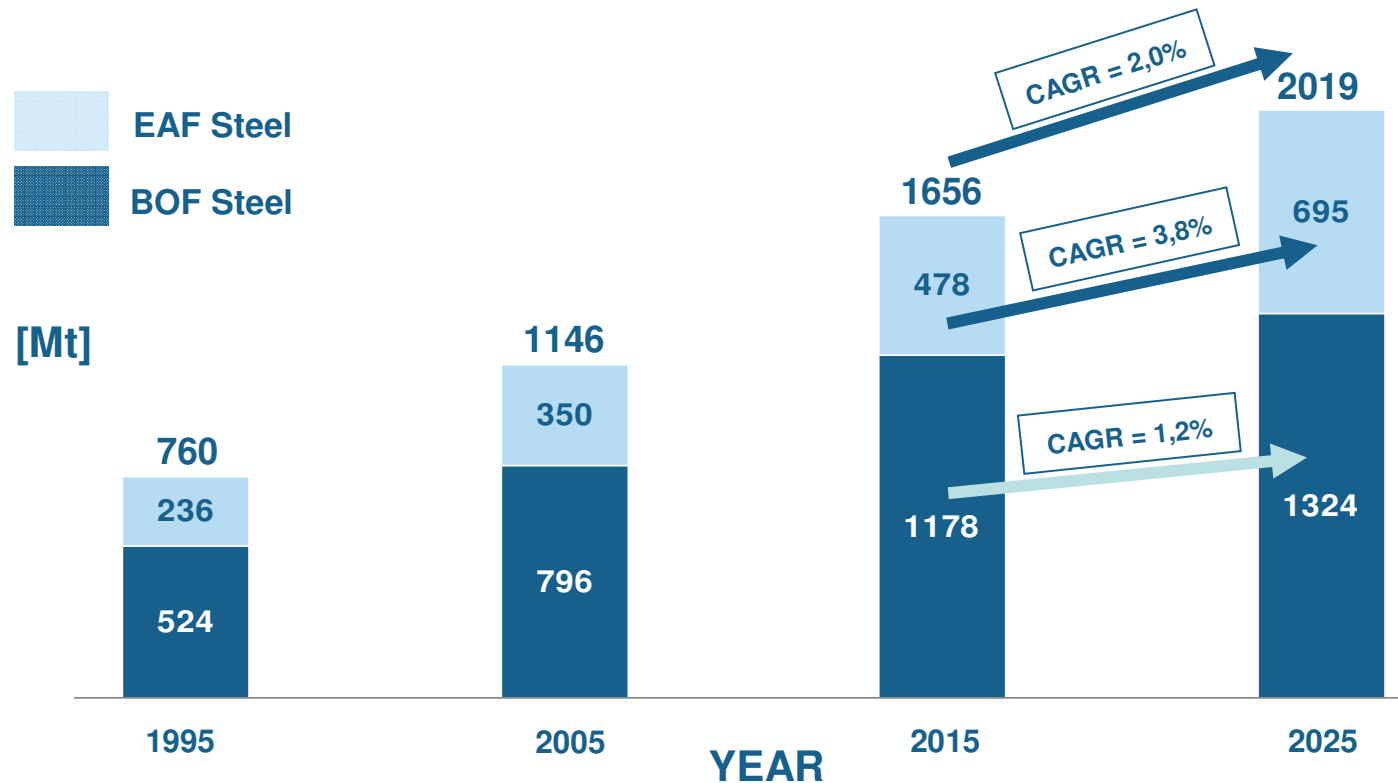
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Steel Recycling with Graphite Electrodes

Crude Steel Production 1995 to 2025

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- Steel Production will further demonstrate a sound Growth.
- EAF Steel will grow stronger than BOF.
- Areas of EAF Growth will be Asia, Near & Middle East, and Africa.

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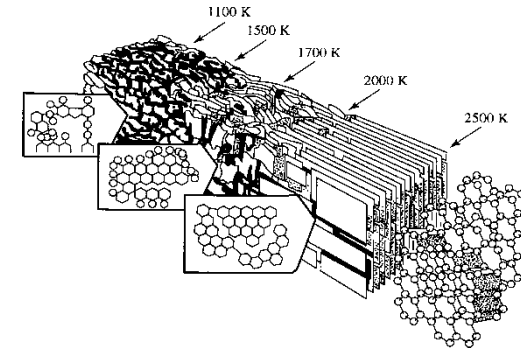
Steel Recycling with Graphite Electrodes

Effects of Graphitization



Graphitization = crystal development (from amorphous to polycrystalline material)

→ change of physical material properties:



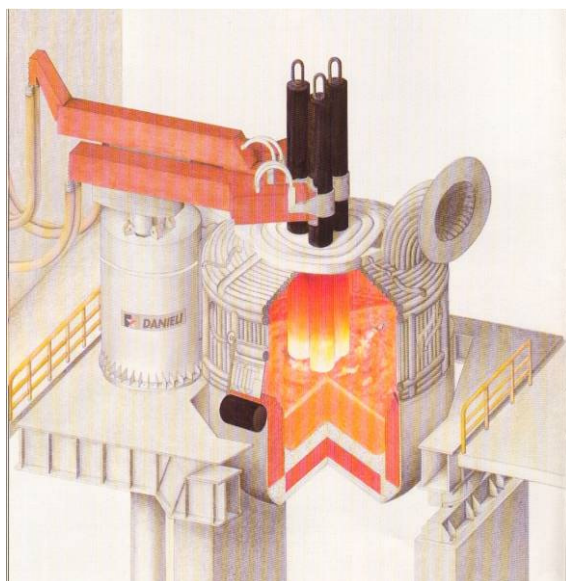
Property	Increase	Decrease	Impact on Application in EAF
Electrical Conductivity	X		very good
Thermal Conductivity	X		very good
Flexural Strength		X	worse, but ...
CTE		X	good
Young's Modulus		X	good - indifferent
Volume		X	no direct impact
Weight		X	no direct impact
Porosity	X		no direct impact
Apparent Density		X	no direct impact

additionally → material gets softer and easier to machine

Steel Recycling with Graphite Electrodes

AC vs. DC Furnace Technology

AC - Furnace



Some Pros

← Lower capital cost

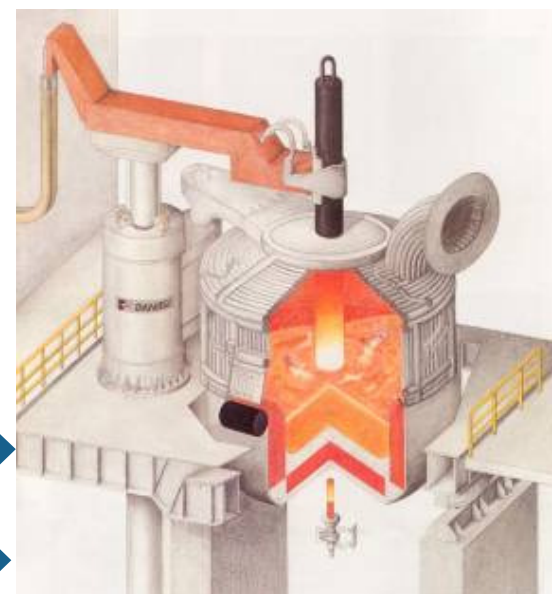
← Lower maintenance cost

← Higher operation reliability

→ Less impact on the electrical grid

→ Less oxidation

DC - Furnace



Steel Recycling with Graphite Electrodes

Typical Figures for an AC Furnace with 600 mm Electrodes



● Shell diameter	6 - 8 m
● Secondary current	50 - 70 kA
● Secondary voltage	600 - 1500 V
● Column length	6 - 8 m (3 electrodes)
● Tapping weight	80 - 130 t
● Tapping temperature	1620 - 1680 °C
● Tap to tap time	50 - 80 min
● Power on time	42 - 75 min
● Electric energy consumption	350 - 550 kWh/t
● Total energy consumption	600 – 700 kWh/t
● Oxygen consumption	15 - 45 Nm ³ /t
● Electrode consumption	1.2 - 2.8 kg/t