The Si process

DRAWINGS

Thorsteinn Hannesson

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Elkem Iceland

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An electronic version of the drawings is available at the website of Elkem Iceland:

WWW. elkem.is

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INTRODUCTION

Silicon is an element that is in a number of materials around us. Silicon is making aluminium alloys stronger. Silicon is the basis for silicones used in a number of everyday products like pharmaceuticals, cosmetics, water-repellent impregnation and silicone rubbers to mention only a few. As silicon is a semi-conductor, it is also used in all kinds of electrical equipment like e.g. computers. Mixed with iron, silicon is used to a great extent to make high quality steel. The most visible area is the use of silicon in silicon solar cells, which is the largest growing area within silicon based products. The versatile element of silicon is hence used in products all around us to improve the quality of life and to increase the production of renewable energy.

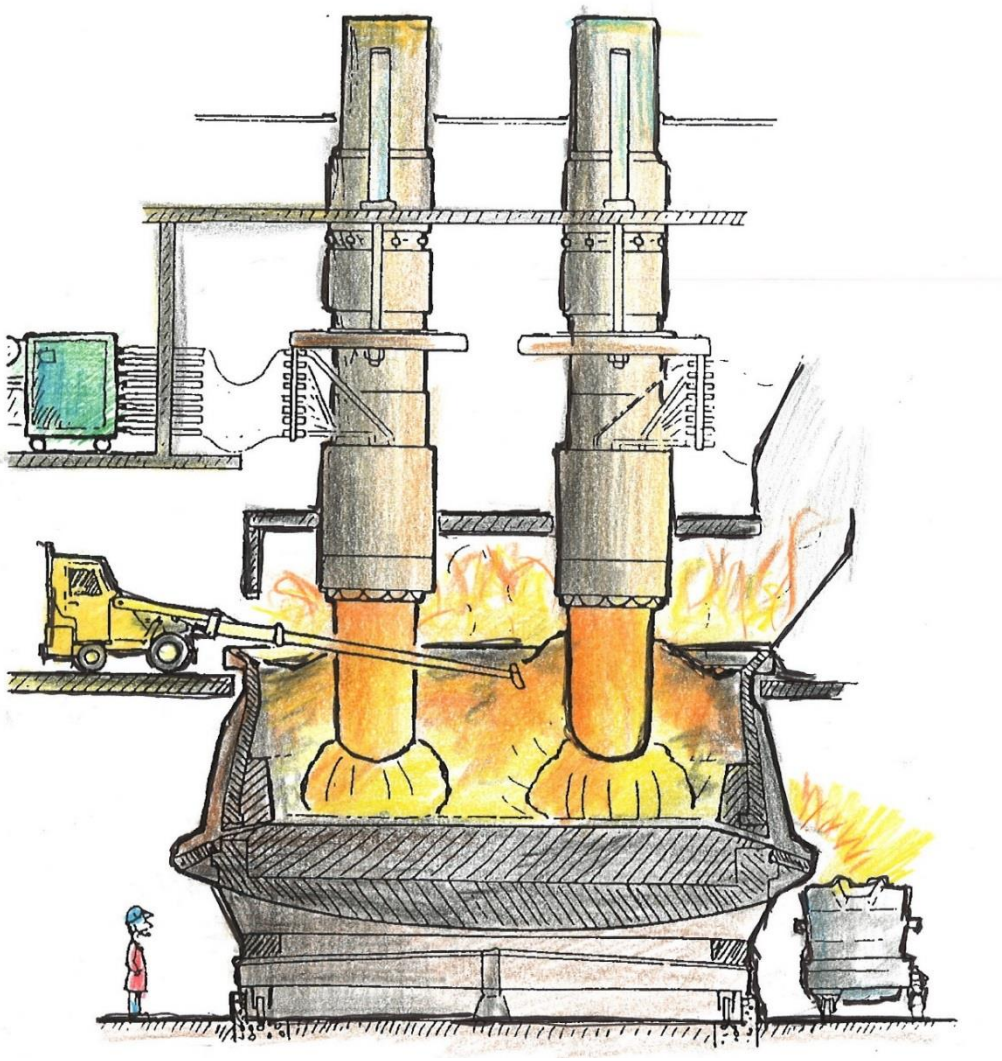
The silicon production process is the starting point for all of these products. Silicon or ferrosilicon is produced in large electrical furnaces from quartz and carbon materials like charcoal and coal. The quartz will be transformed to liquid silicon through a high temperature process of up to 2000 °C. The liquid silicon will then be cooled and solidified, then crushed into suitable size.

Silicon has been produced at Iceland through decades, and during the last years Iceland is coming up as one of the world leading countries regarding silicon production. During many years, Thorsteinn Hannesson, has worked in the silicon producing company Elkem Iceland. His ability to transfer technical knowledge through artistic drawings of the silicon process has both increased the knowledge within the company but also externally. It is hence a happy day for all us fans of silicon and its production process to see the work of Thorsteinn Hannesson collected in this book. This will also give a possibility to transfer the knowledge to the upcoming new generation.

Prof. Merete Tangstad
Norwegian University of Science and Technology

THE FERROSILICON FURNACE

A submerged, three phase electrical arc furnace with self-baking Søderberg electrodes.



THE MAIN REACTIONS

QUARTZ
SiO_2

CARBON
2 C

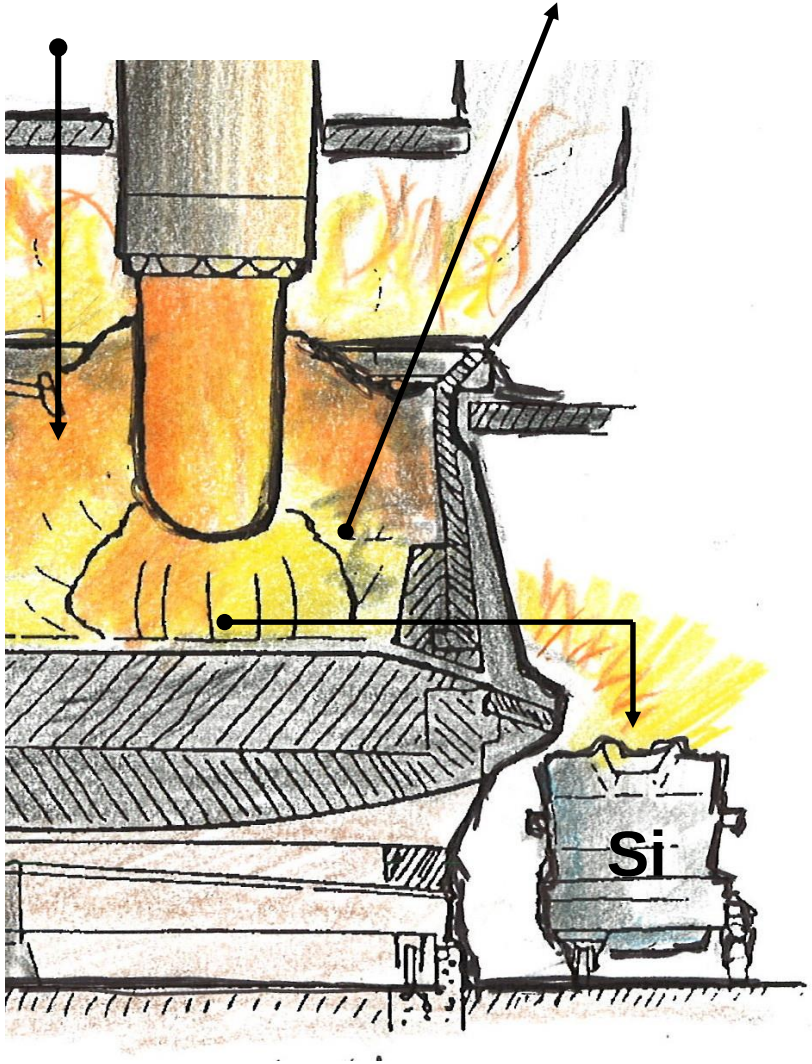
SILICON
Si

CARBON MONOXIDE
2 CO

THE SI PROCESS

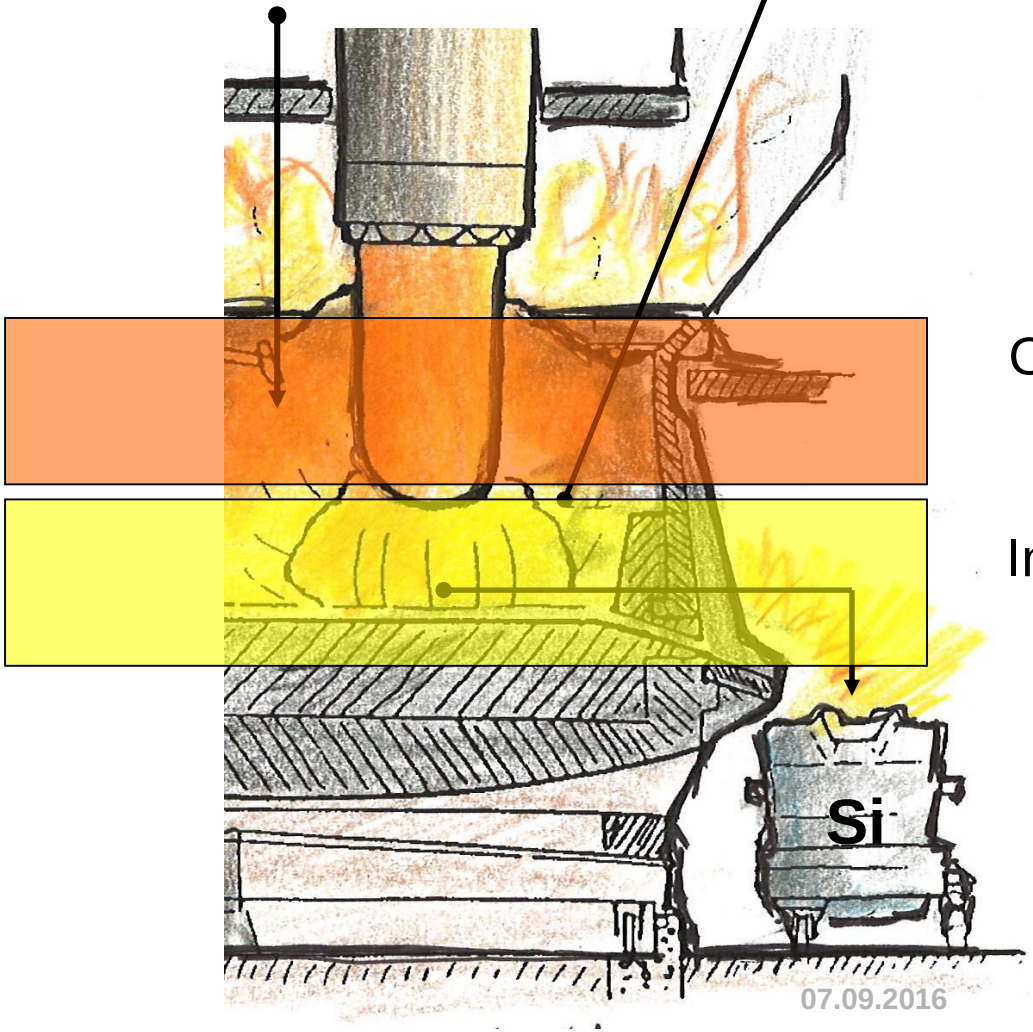
$2\,C + SiO_2$

$2\,CO + O_2 = 2\,CO_2$



THE SI PROCESS

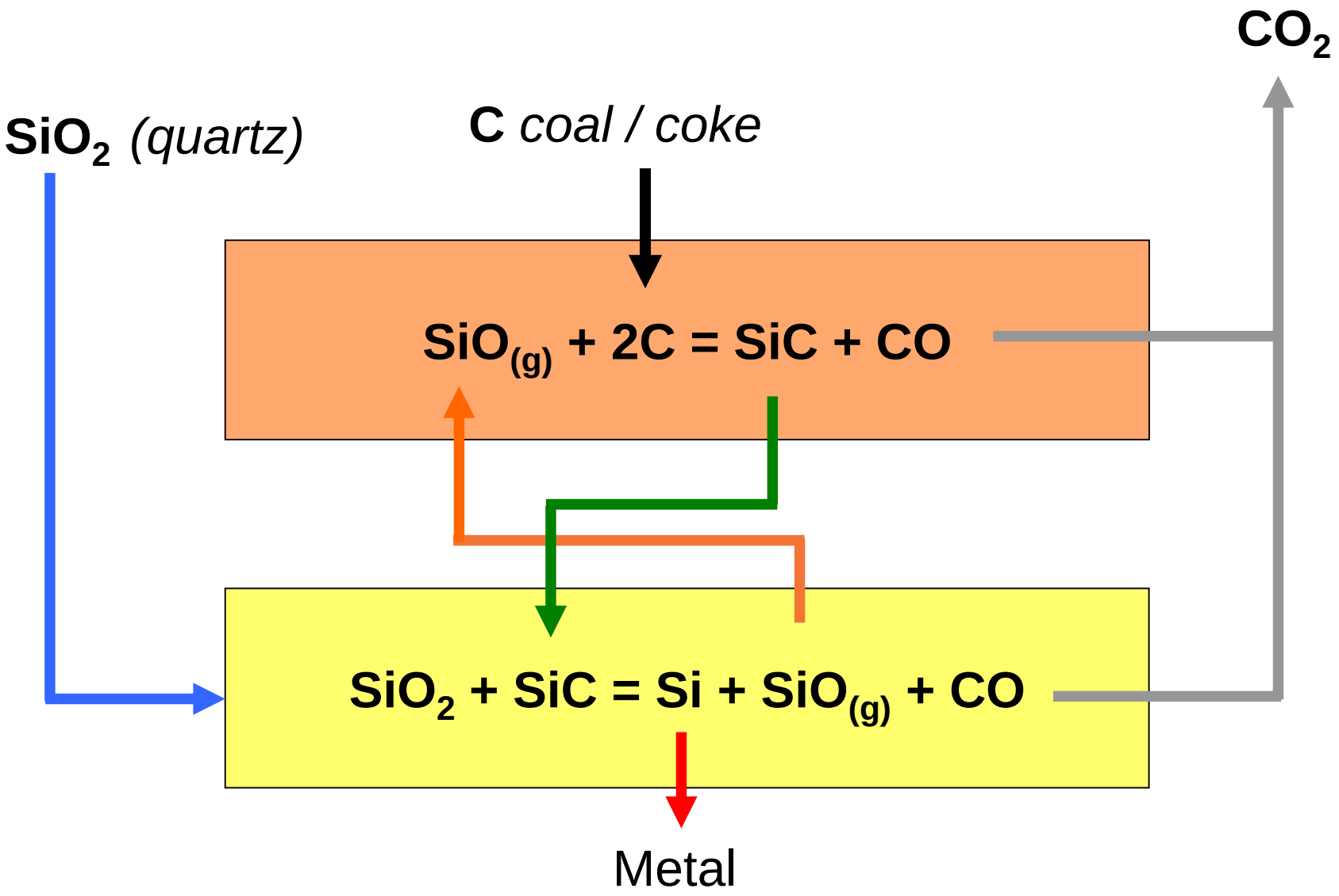
$$2\,C + SiO_2 \qquad 2\,CO + O_2 = 2\,CO_2$$



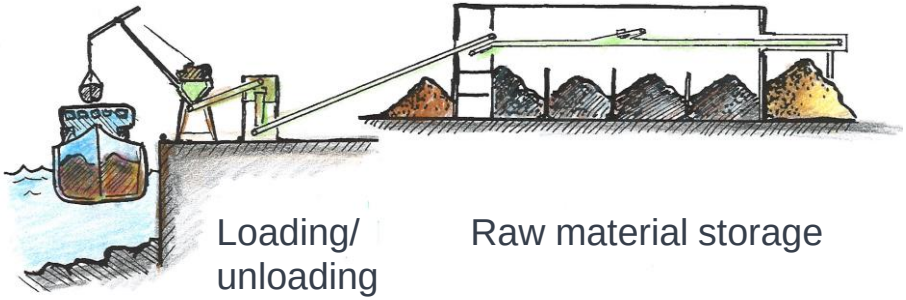
Outer reaction zone
1550 °C

Inner reaction zone
over 1800°C
(crater zone)

THE SI PROCESS

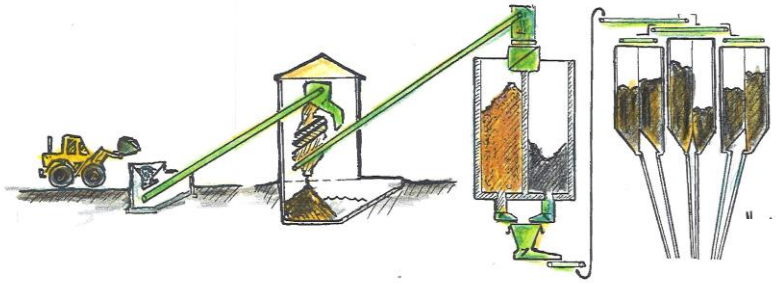


THE PRODUCTION PROCESS

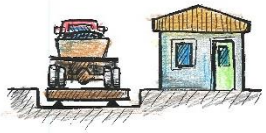


Loading/
unloading

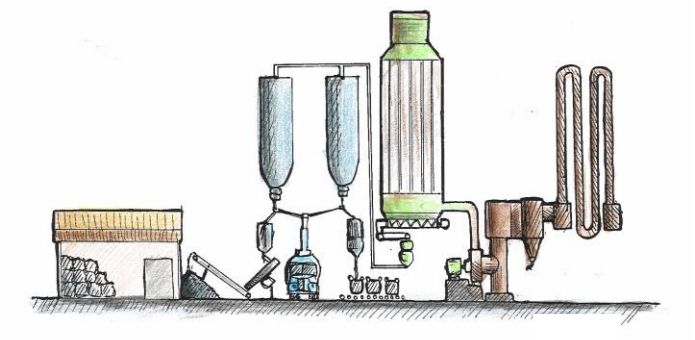
Raw material storage



Transport to furnace bins



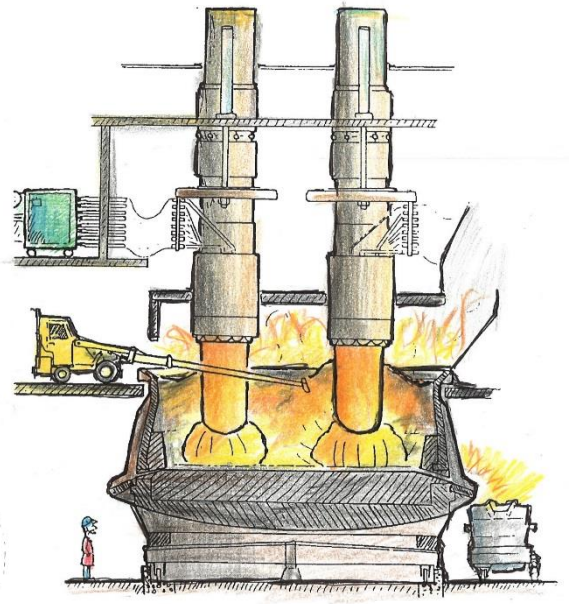
Weigh bridge

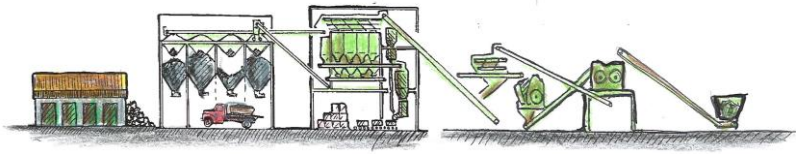


Microsilica® storage

Filter

Coolers

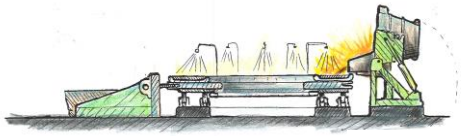




FeSi storage

Screening

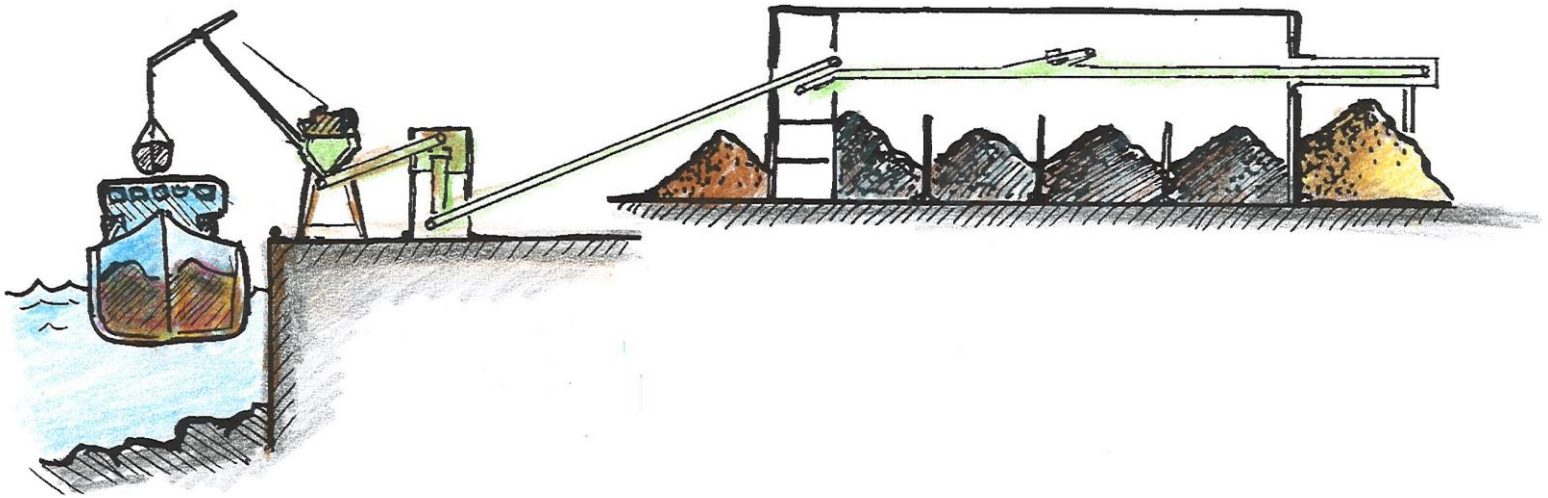
Crushing



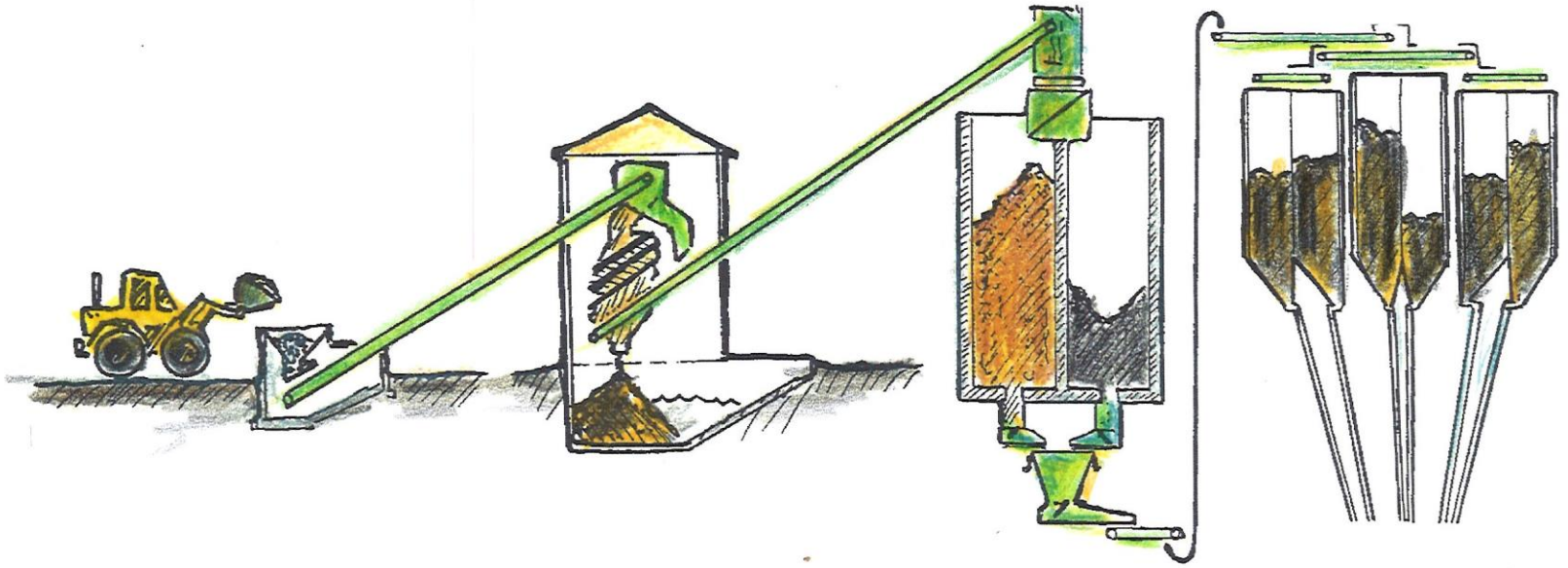
Casting

Furnace

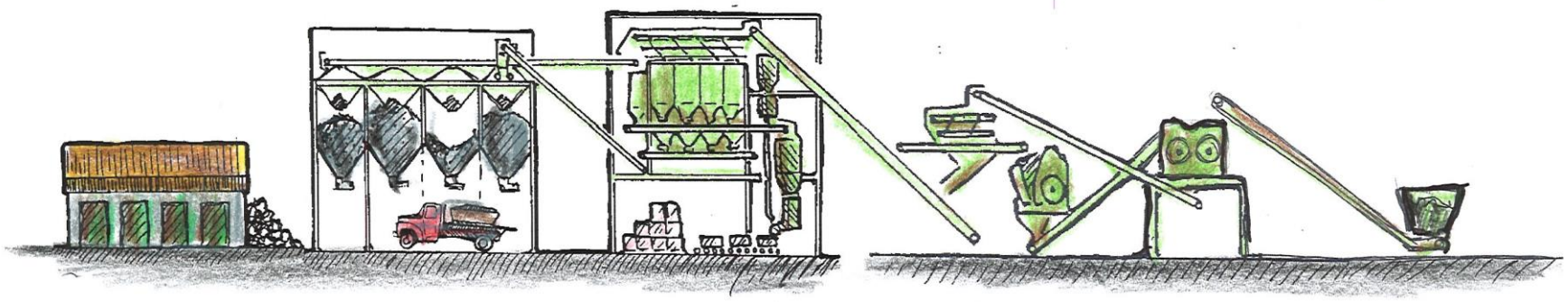
RAW MATERIALS - HANDLING AND STORAGE



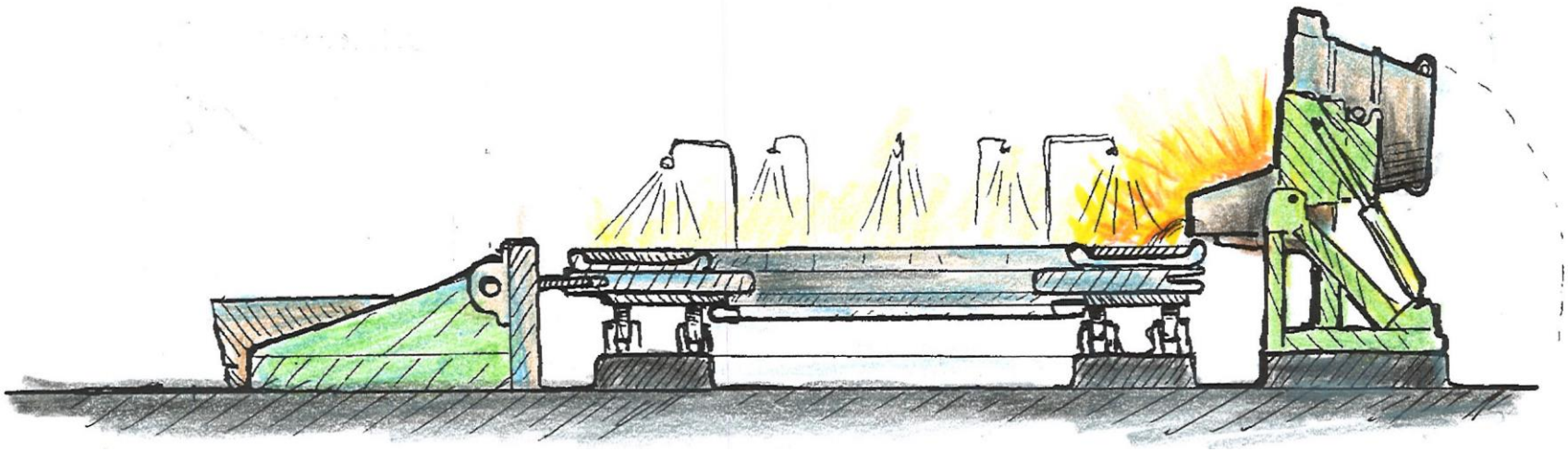
RAW MATERIALS - SCREENING AND TRANSPORTATION TO FURNACE BINS



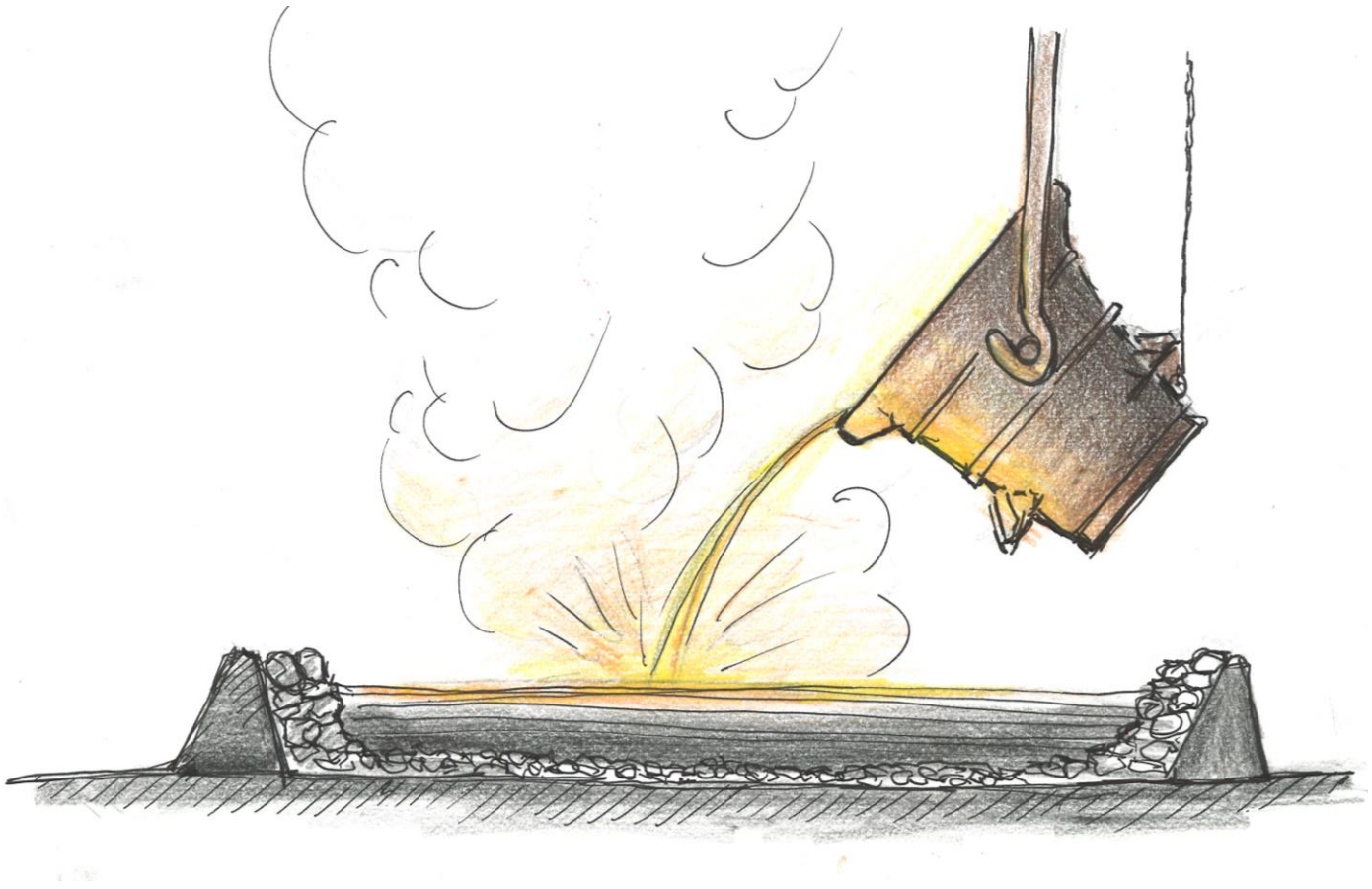
CRUSHING SCREENING AND STORAGE



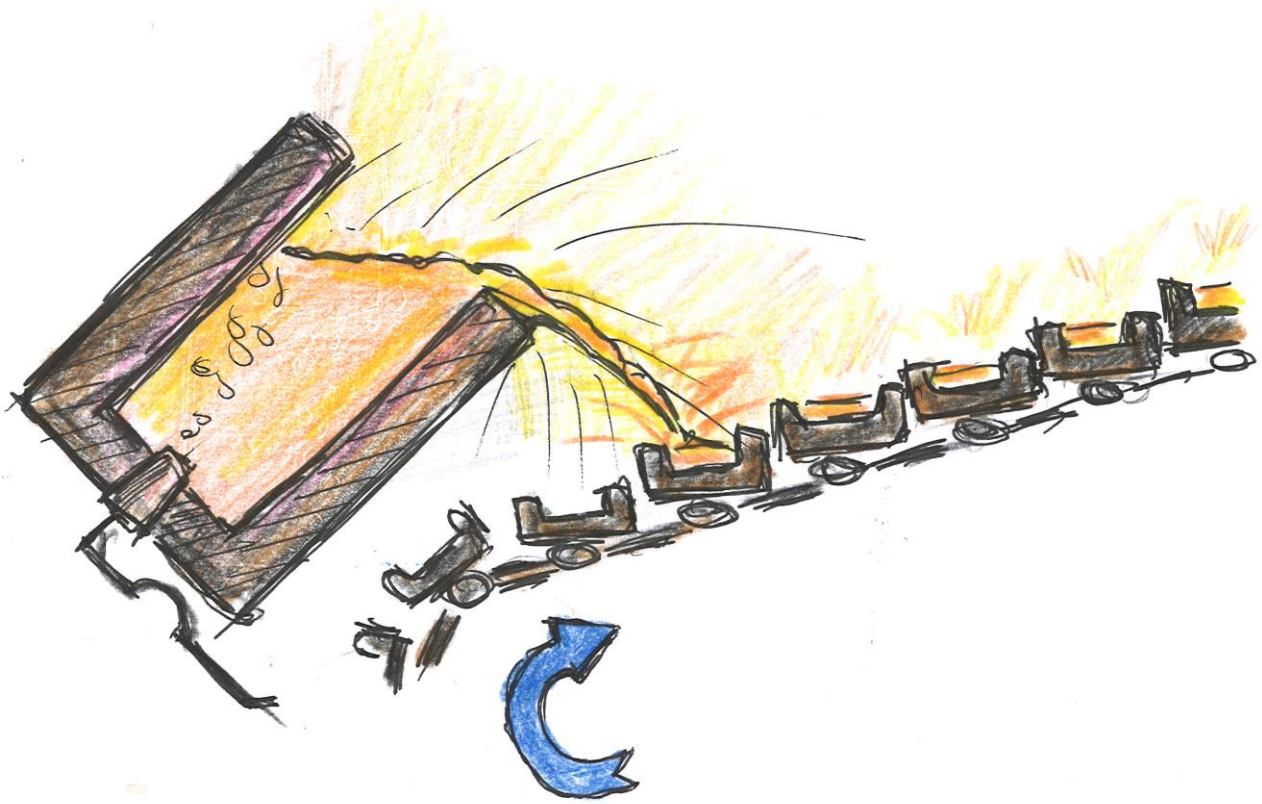
CASTING IN CAST IRON MOLDS



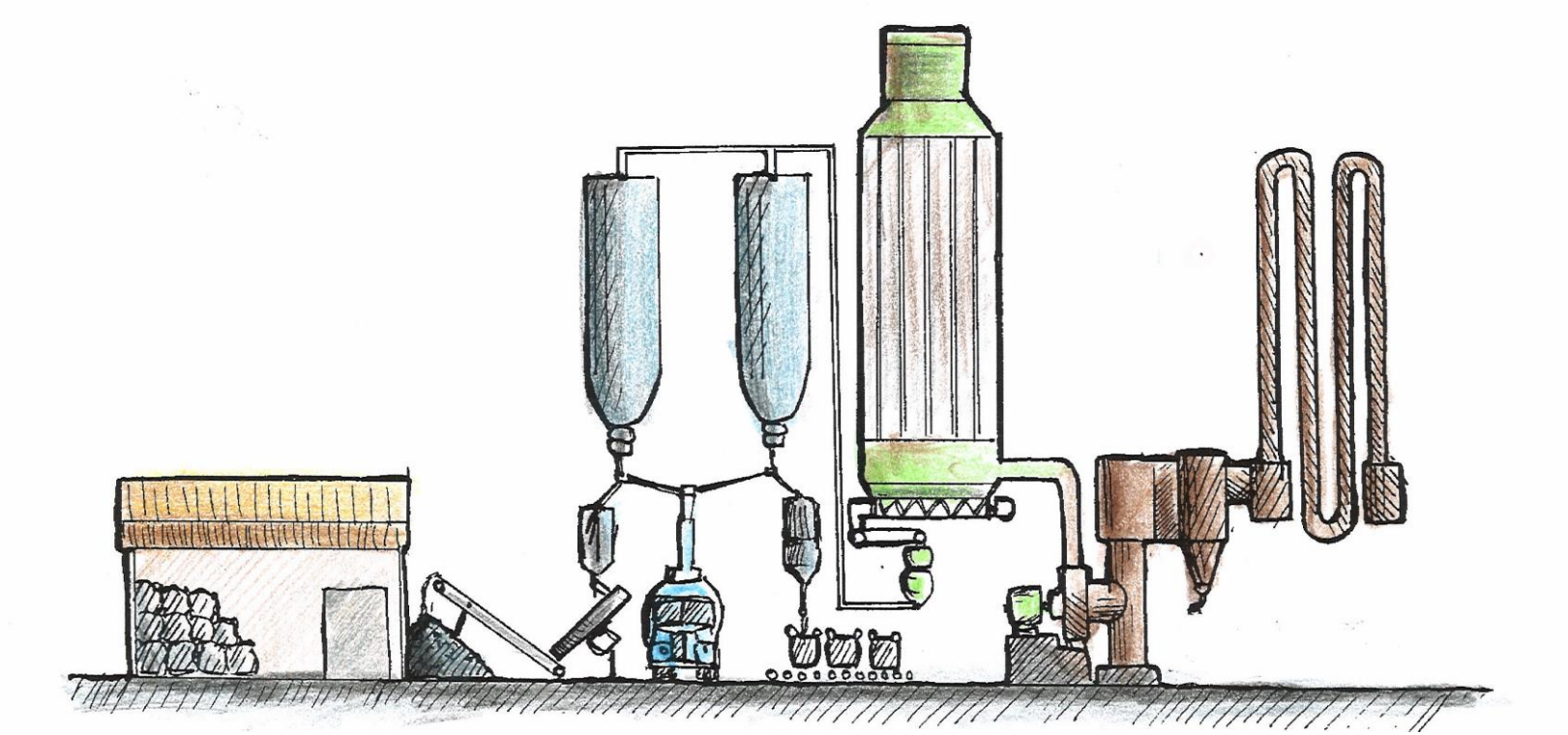
BED CASTING



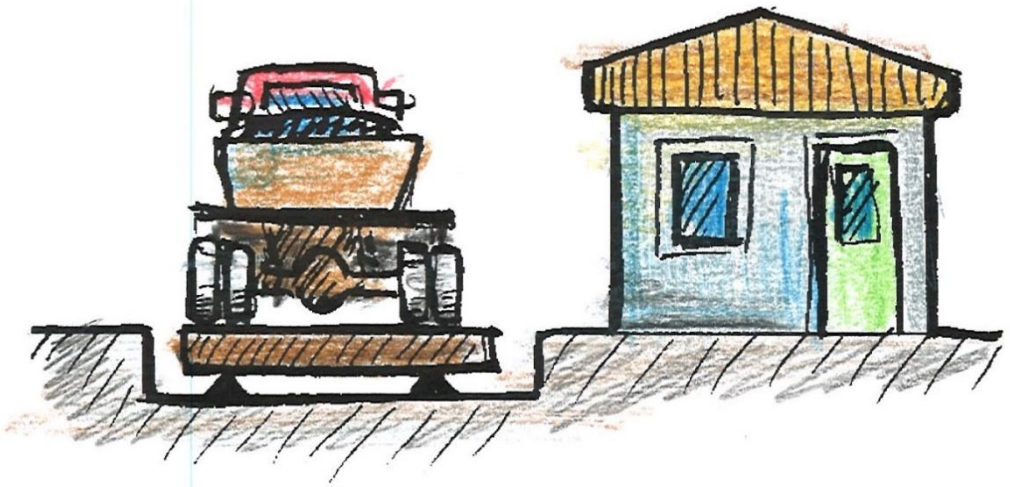
BELT CASTING



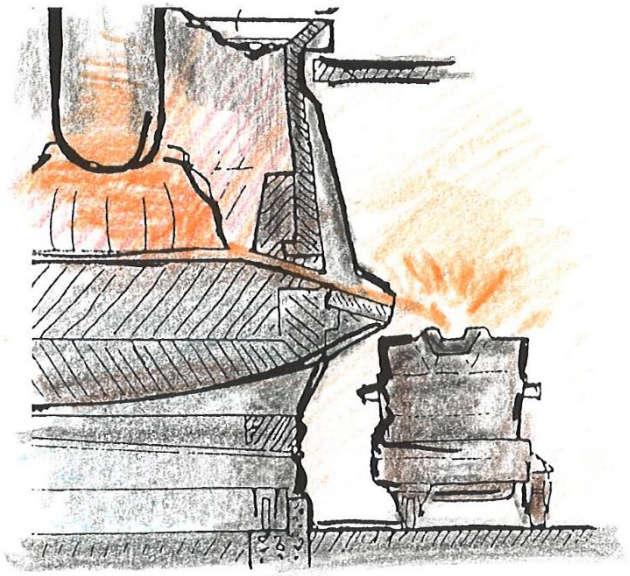
COOLERS AND BAG HOUSE FILTER



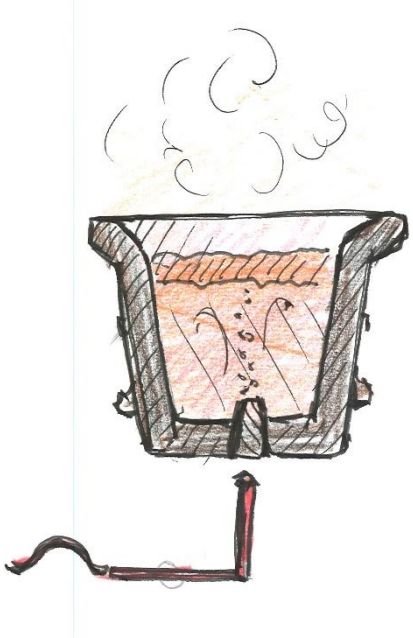
WEIGHING OF THE FINAL PRODUCT - SHIPPING



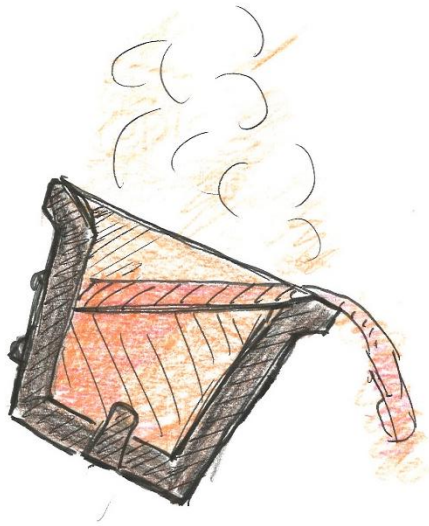
REFINING OF METAL



Tapping



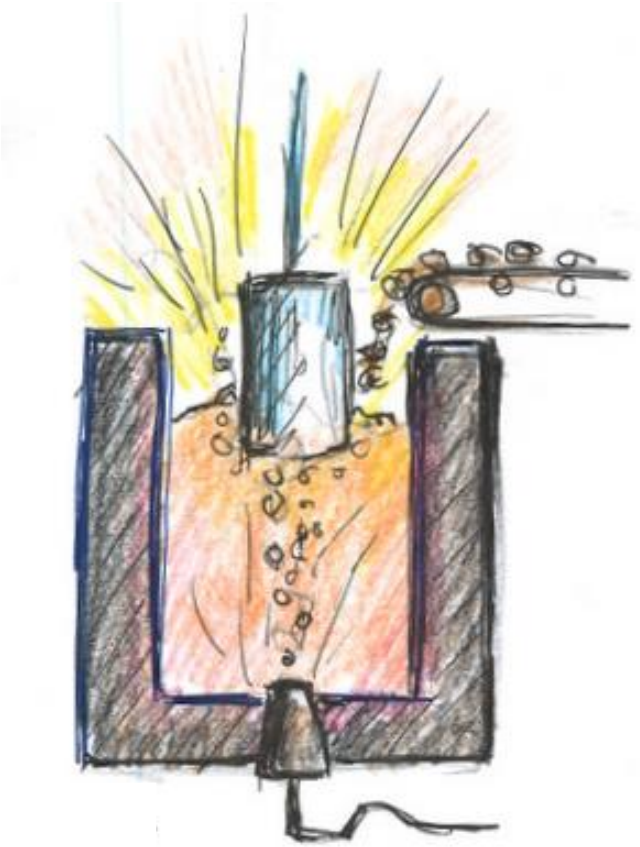
Slag refining
stirring



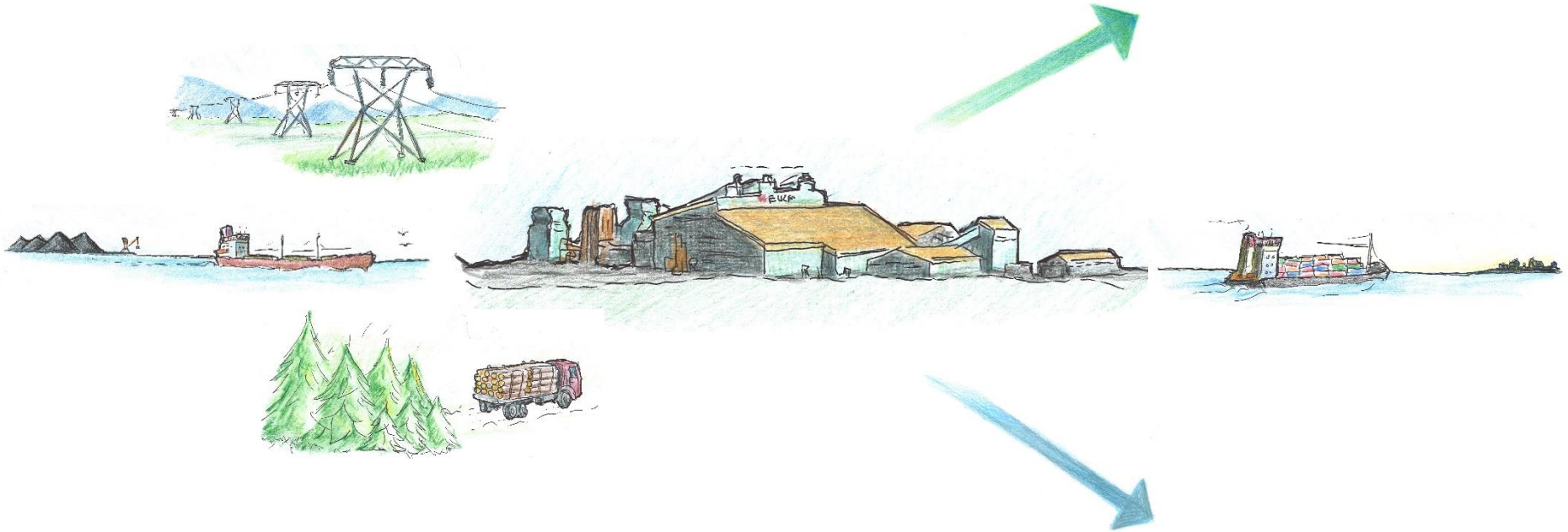
Slag skimming

ALLOYING

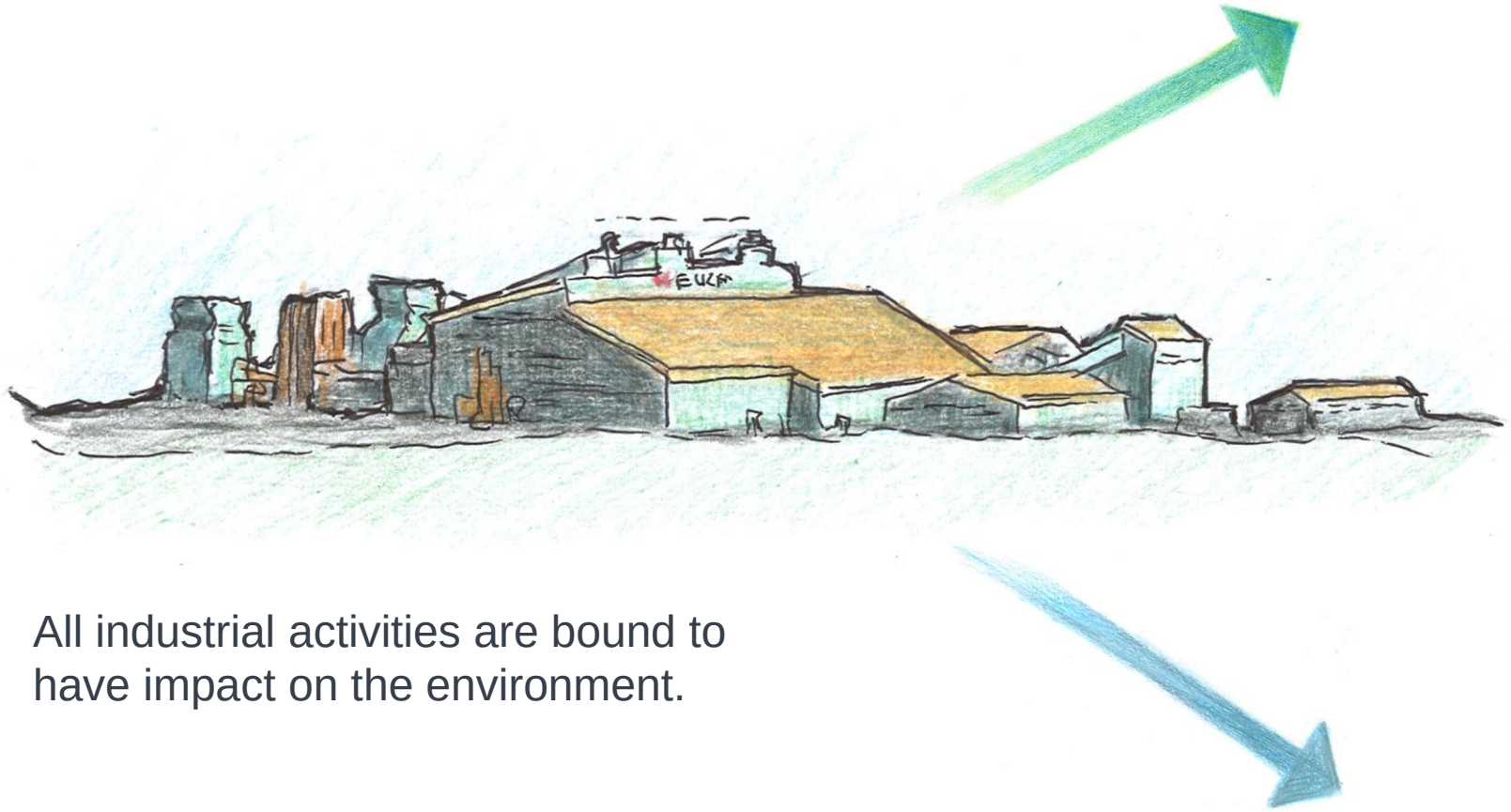
Alloying is done by adding alloying elements to the molten metal and stirring the melt by e.g. nitrogen purging.



THE USE OF NATURAL RESOURCES - ENVIRONMENTAL IMPACT

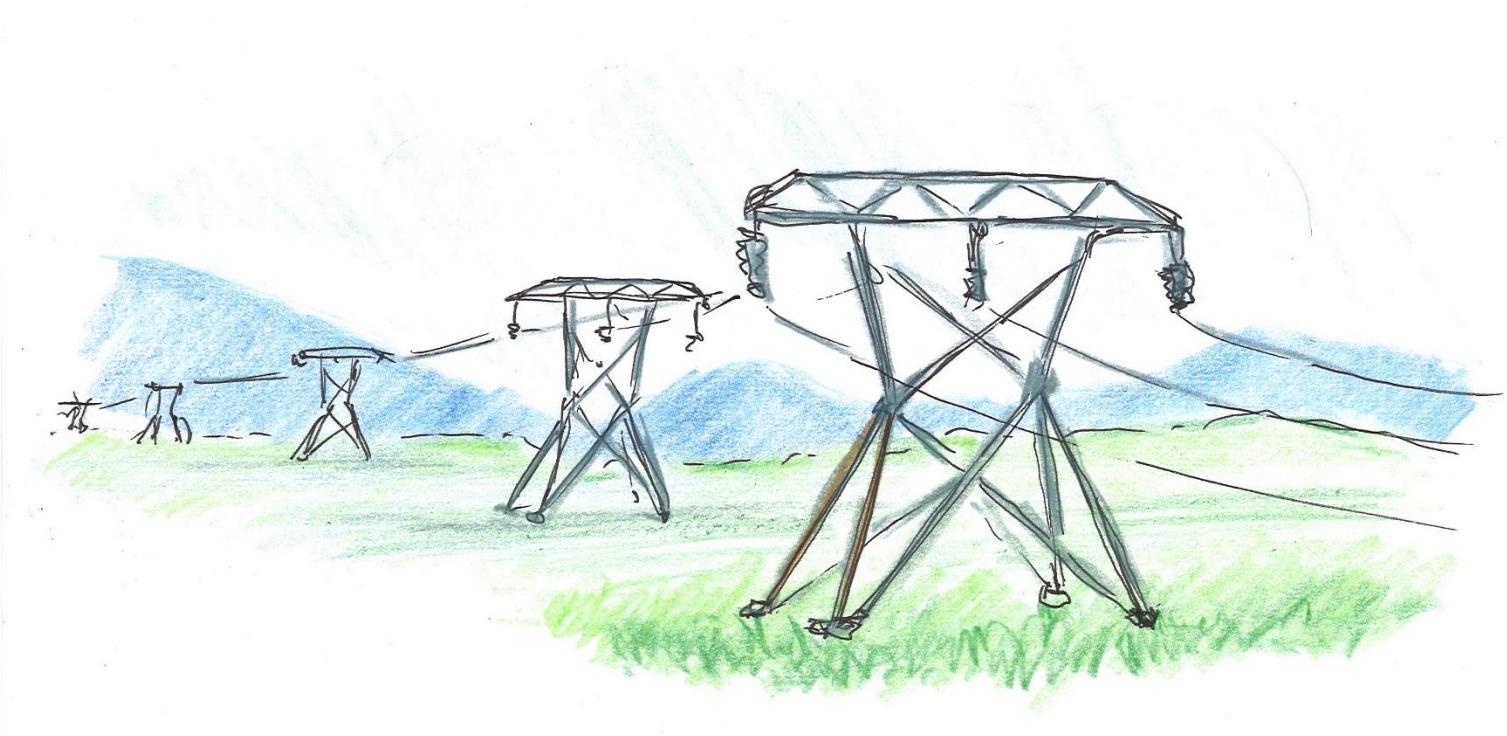


THE USE OF NATURAL RESOURCES - ENVIRONMENTAL IMPACT



All industrial activities are bound to have impact on the environment.

THE USE OF NATURAL RESOURCES - ENVIRONMENTAL IMPACT



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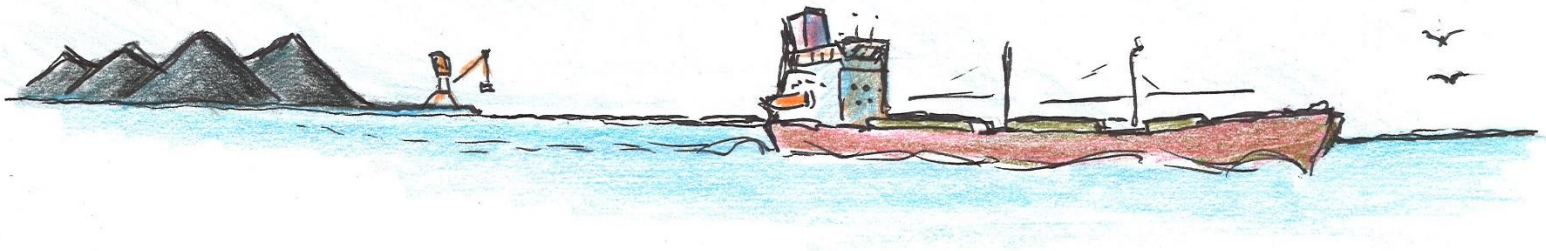

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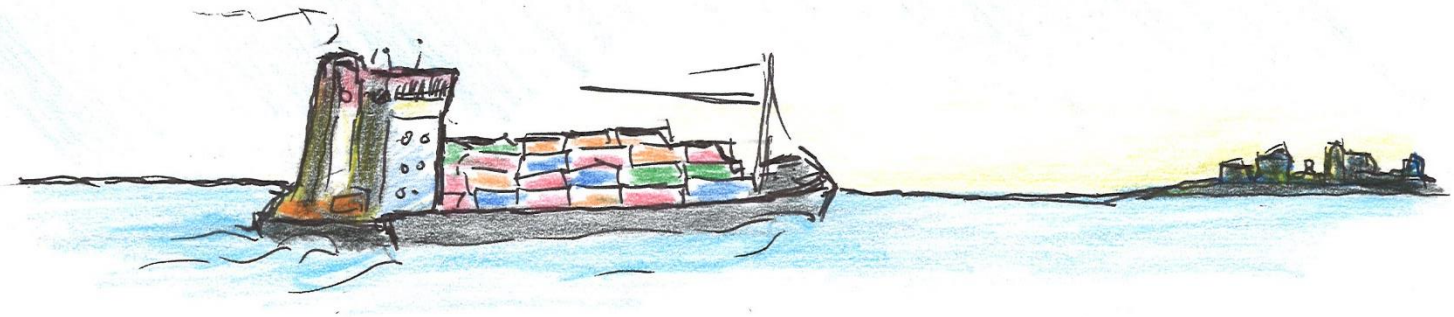
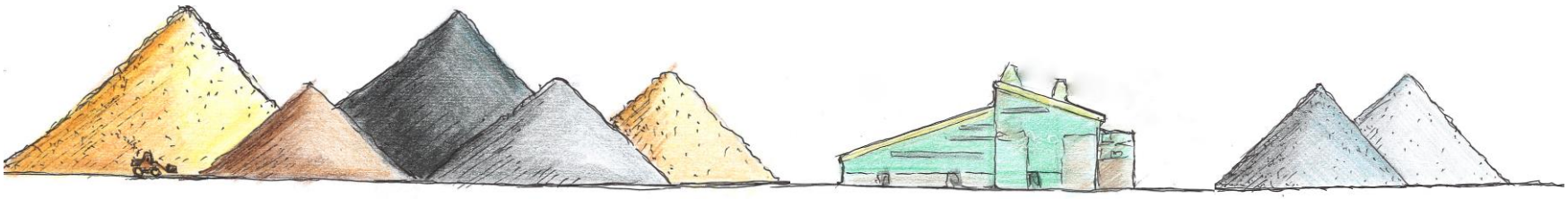


THE USE OF NATURAL RESOURCES

The production of 120.000 MT/year of FeSi 75

Annual usage of raw materials and production in correct proportions. The highest stock pile is 52 m high.

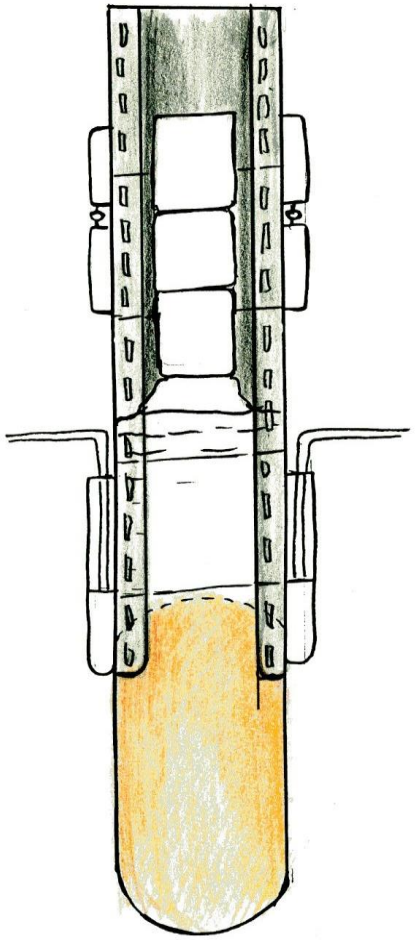


Quartz Iron Coal Coke Woodchips FeSi Microsilica®

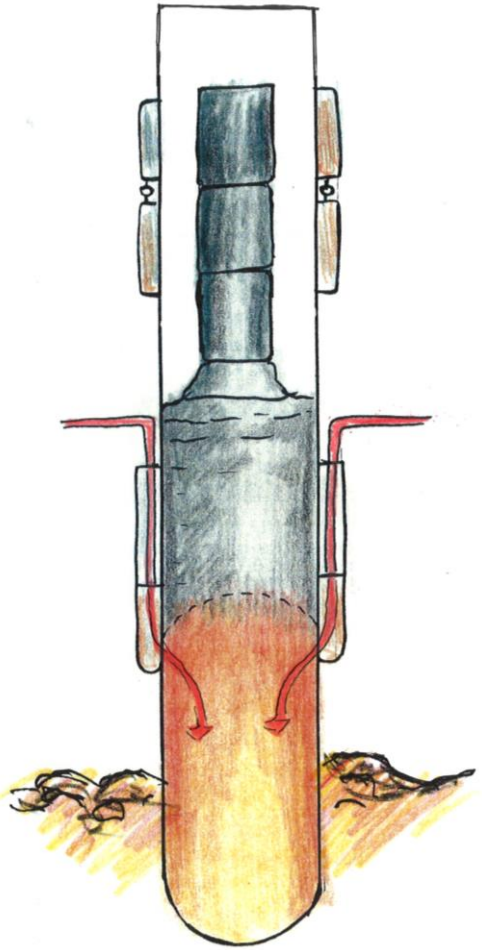
RAW MATERIALS

Raw materials are costly so those should be handled with care.

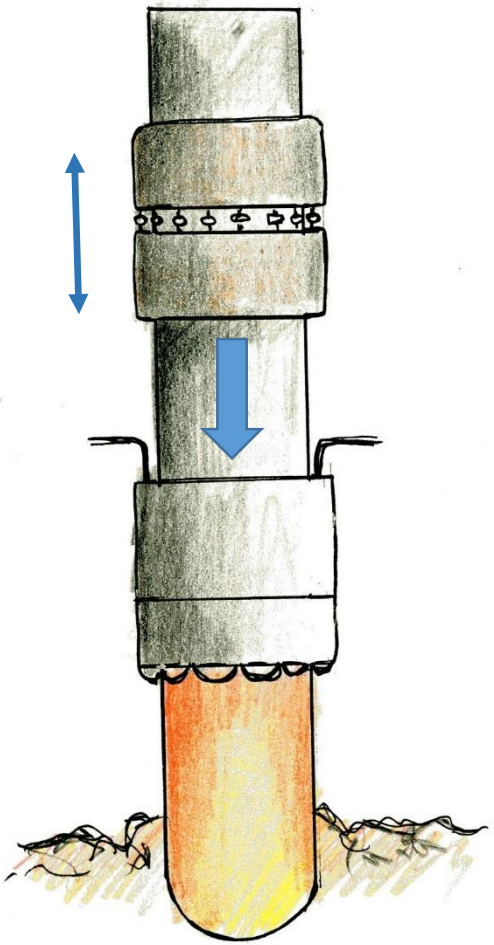
THE SØDERBERG ELECTRODE



Cross section

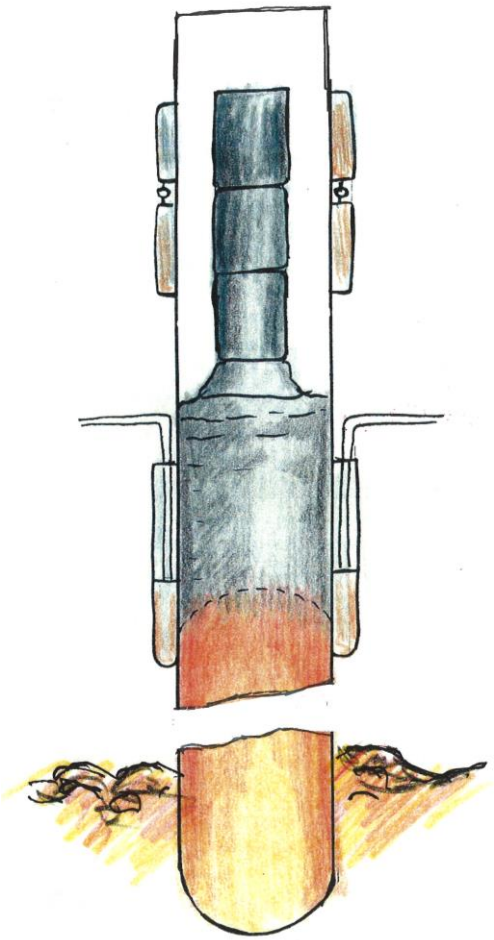


Current paths

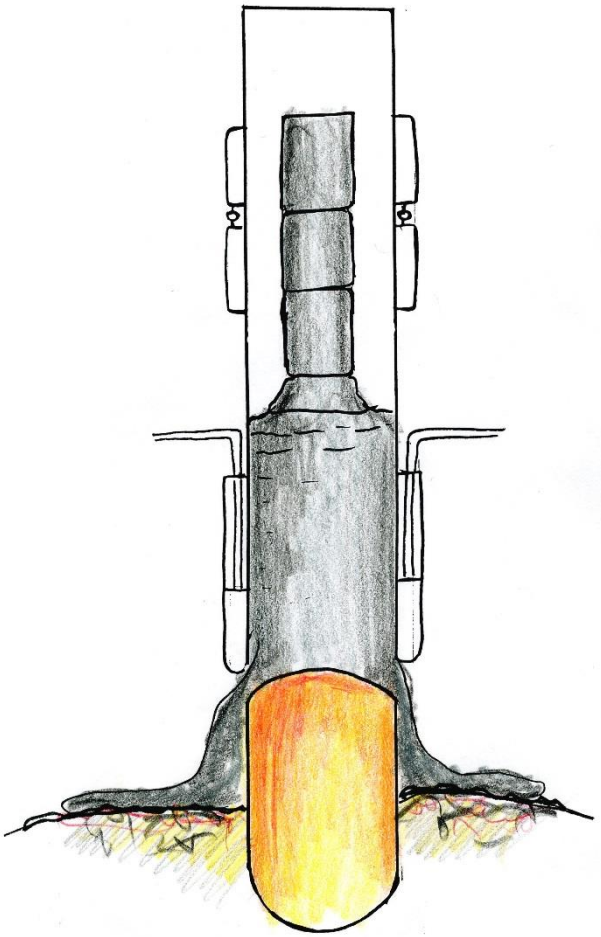


Slipping

THE SØDERBERG ELECTRODE - ELECTRODE BREAKAGES

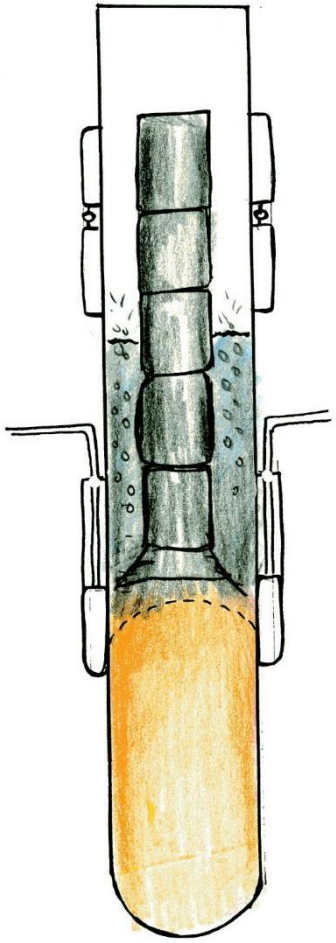


Hard break



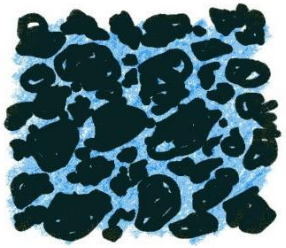
Soft break - paste leakage

THE SØDERBERG ELECTRODE - SEGREGATION IN THE LIQUID PASTE



Segregation in the electrode column

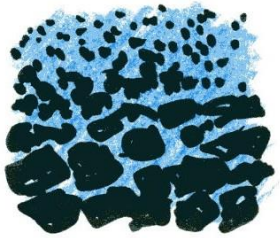
Normal paste



Binder

Aggregate

Segregated paste



THE USE OF FERROSILICON

Ferrosilicon is mostly used as a deoxidizing agent, as an additive in the production of steel and as nodulizer and inoculant in iron foundries.

The author

Thorsteinn Hannesson war born in Reykjavik, Iceland. He finished his BS in Chemistry from the University of Iceland and PhD in Physical Chemistry from the University of Michigan. He works at Elkem Iceland as a Senior Specialist.

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Credits and acknowledgements

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Thorsteinn Hannesson