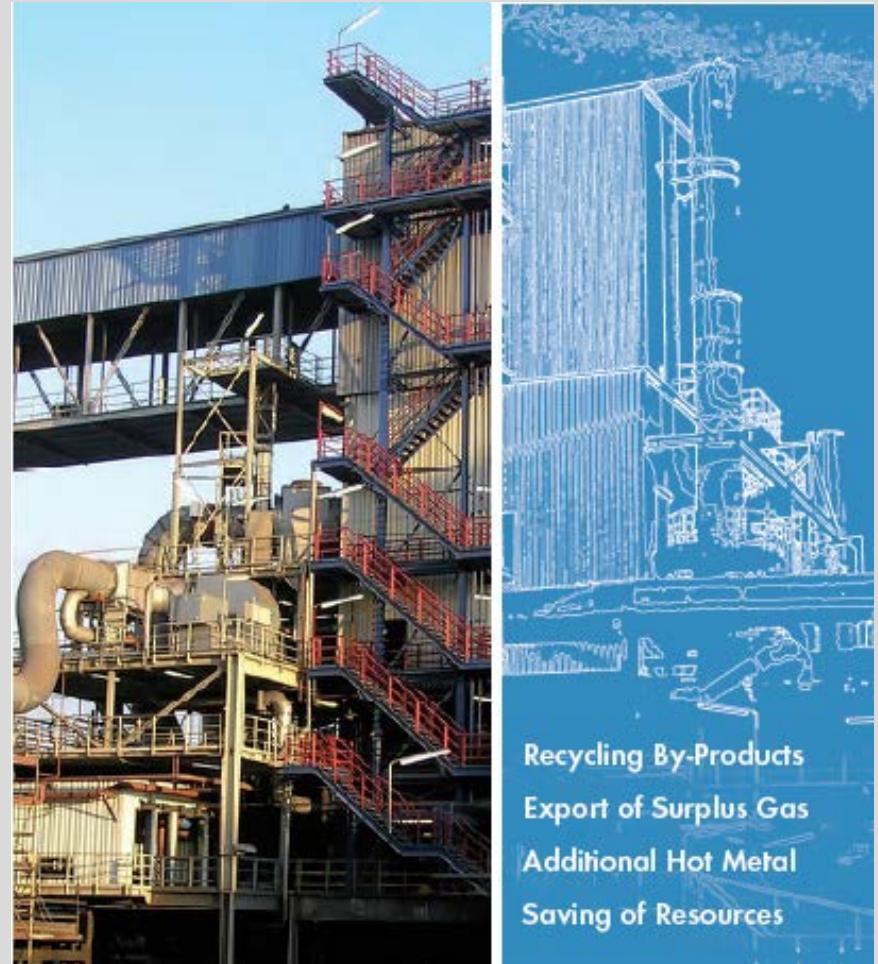


# UTILIZATION OF BY-PRODUCTS BY KÜTTNER'S OXYCUP® SHAFT FURNACE TECHNOLOGY

JULY, 2016



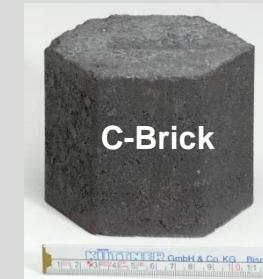
- ▶ OxyCup® Shaft Furnace Process
- ▶ Typical wastes / by-products
- ▶ OxyCup® Annual tonnages example
- ▶ OxyCup® Benefits
- ▶ ThyssenKrupp Steel OxyCup® plant
- ▶ OxyCup® References

# Overview of the OxyCup® process

Küttner GmbH & Co. KG  
Dr. Franz Reufer

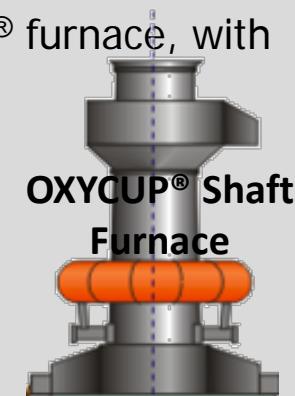
## 1. Make C-bricks

- Using well proven brick making technology to produce Self-Reducing C-Bricks containing:
  - Waste / by-products containing Fe
  - Carbon fines (as reductant)
  - Cement binder and water



## 2. Charge C-bricks into OxyCup® furnace

- OxyCup® furnace based on well proven shaft furnace technology
- Charge self reducing C-bricks into OxyCup® furnace, with
  - Scrap / skulls
  - Coke (as energy source)
  - Oxygen
  - Gravel (control basicity)



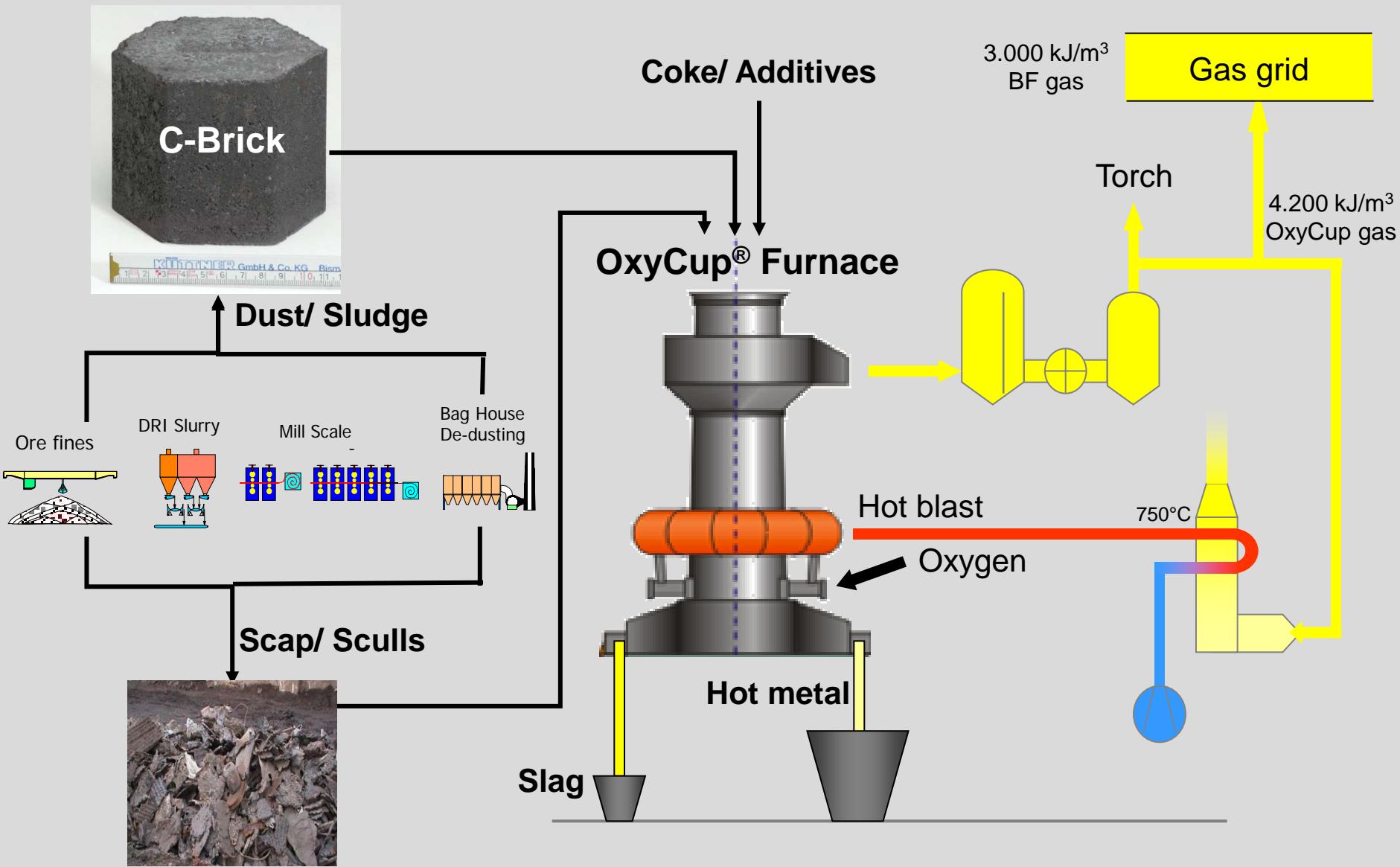
## 3. Produce Liquid Iron

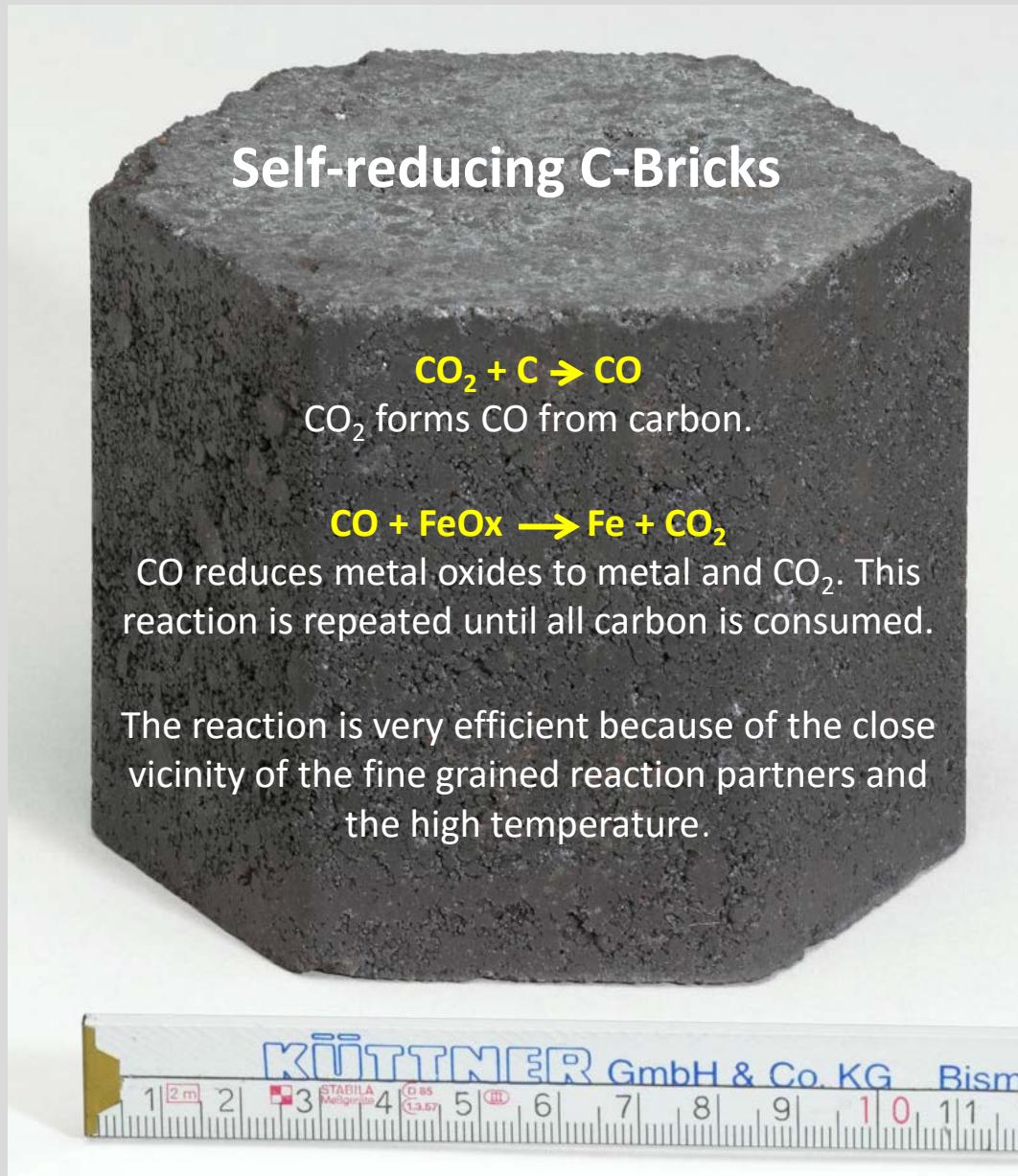
- Smelting with coke
- Fast reduction in self-reducing C-Bricks
- Products of BF-Quality Hot metal, slag & gas

**KÜTTNER**

# OxyCup® Process

Küttner GmbH & Co. KG  
Dr. Franz Reufer



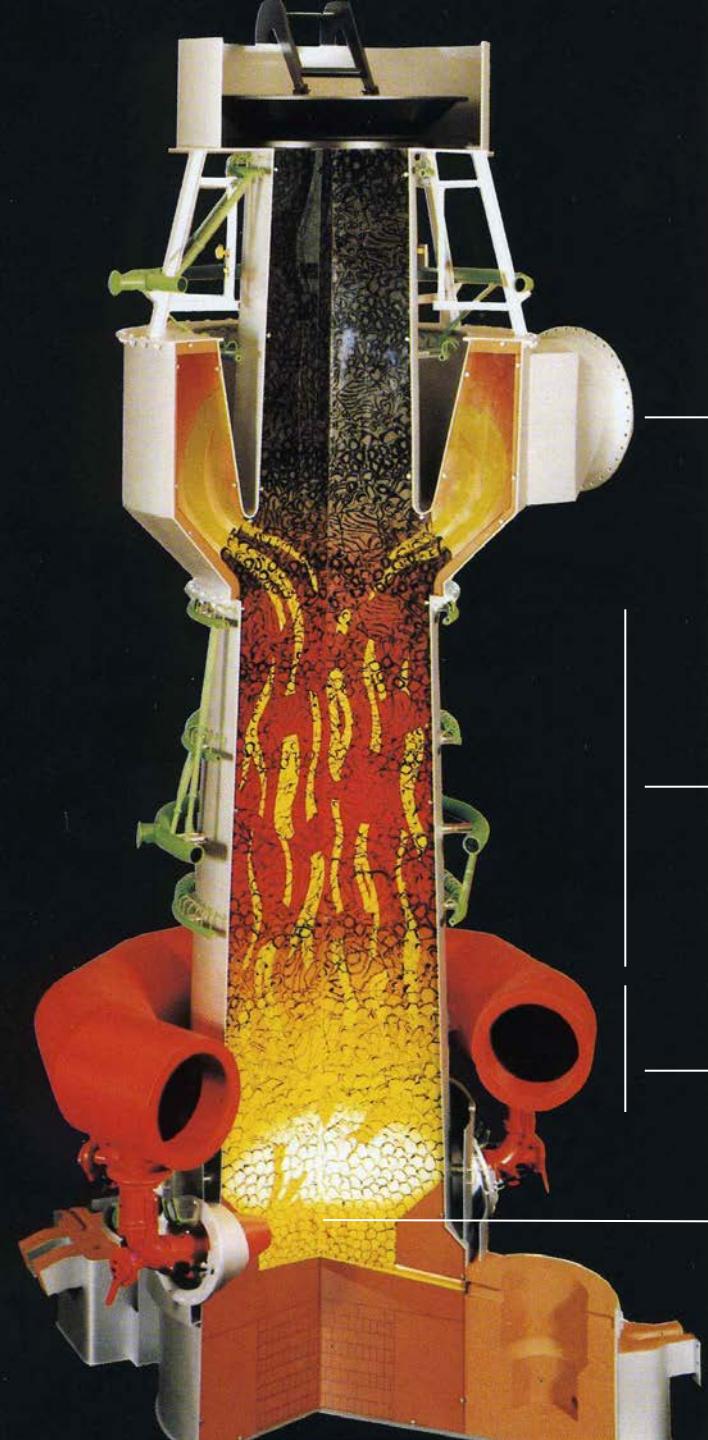


## Composition

- Oxide Fines
  - DR Slurry
  - Mill scale ( can be oily)
  - Bag House Dust
- 
- Carbon fines
  - Binder

# OXYCUP® Shaft Furnace

Küttner GmbH & Co. KG  
Dr. Franz Reufer



Gas take-off

Preheating zone

Reduction and  
Melting zone

Superheating  
carbon pick-up

- Smelting with coke
- Raw material flexibility from agglomerated fines to low grade scrap
- Fast reduction in self-reducing C-Bricks
- Products of BF-Quality Hot metal, slag & gas
- Proven Technology
  - Over 300 Shaft Furnace References



**KÜTTNER**

- ▶ OxyCup® Shaft Furnace Process
- ▶ Typical wastes / by-products
- ▶ OxyCup® Annual tonnages example
- ▶ OxyCup® Benefits
- ▶ ThyssenKrupp Steel OxyCup® plant
- ▶ OxyCup® References

# Typical waste / by-products processed by OxyCup®

Küttner GmbH & Co. KG  
Dr. Franz Reufer

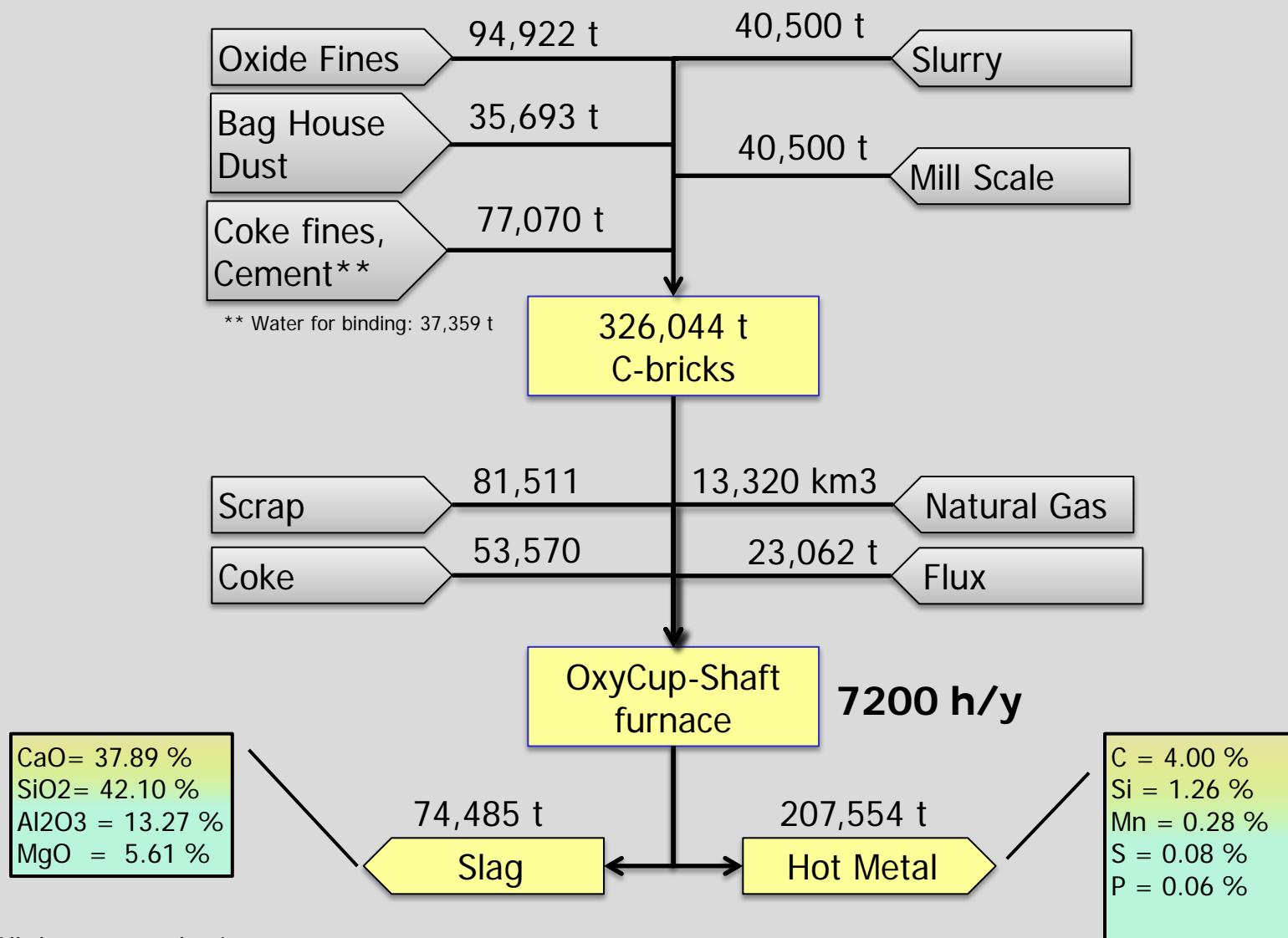
Solid waste/by-product	Unit	Amount	Fe total [%]	C total [%]	Zn [%]	Na/K [%]
Dry filter dust coal & coke	[kg/t coke]	2-3		90		
Dust sinter process gas cleaning	[kg/t sinter]	15-25	35-36	1,5-10	0,05-0,4	1,9
Dust sinter secondary dedusting	[kg/t sinter]	0,5-1,0	1,4-1,8	20,3-25,2	0,02	3,7-4,2
Coarse flue dust from BF	[kg/t liq. steel]	10-30	24-40	29	0,2	0,74
sludge from BF gas treatment	[kg/t liq. steel]	25-35	25-35	23	4,2	0,2
Dust from BF cast house	[kg/t liq. steel]	0,5-1,5	46,2	4,1	0,038	0,1
HM desulphurization slag	[kg/t liq. steel]	3-20	20-42	0	0,009	0,27
BOF slag	[kg/t liq. steel]	120-150	16	0	-	-
Coarse dusts and sludge	[kg/t liq. steel]	5-8	55-72	n.a.	0,1-0,9	0,054
Fine dusts and sludge	[kg/t liq. steel]	9-12	54-62	n.a.	1,4-3,2	0,38
Dust from secondary dedusting	[kg/t liq. steel]	0,5-1,0	58	15	n.a.	n.a.
BOF sludge	[kg/t liq. steel]	15-20	67	n.a.	0,006	0,006
BOF spittings	[kg/t liq. steel]	4-5	23,5-28,3	0	0,063	0,05
Slag from secondary metallurgy	[kg/t liq. steel]	2-16	<1	0	-	-
Torch cutting slag from cont. casting	[kg/t CC]	4-5	71	0,26	n.a.	1,5
Scale from continuous casting	[kg/t CC]	1,2 - 6	70	0,9	0,02	0,1
Scale hot rolling (flat products)	[kg/t Product]	20-30	65-70	0,2	-	-
Scale hot rolling (long products)	[kg/t Product]	5-10	72	n.a.	-	0,09
Scale/sludge from hot rolling	[kg/t Product]	3-15	64	7,6	-	-

**KÜTTNER**

- ▶ OxyCup® Shaft Furnace Process
- ▶ Typical wastes / by-products
- ▶ OxyCup® Annual tonnages example
- ▶ OxyCup® Benefits
- ▶ ThyssenKrupp Steel OxyCup® plant
- ▶ OxyCup® References

# Example: Single OxyCup® Shaft Furnace Annual Tonnages

Küttner GmbH & Co. KG  
Dr. Franz Reufer



\* All data on wet basis

**KÜTTNER**

- ▶ OxyCup® Shaft Furnace Process
- ▶ Typical wastes / by-products
- ▶ OxyCup® Annual tonnages example
- ▶ OxyCup® Benefits
- ▶ ThyssenKrupp Steel OxyCup® plant
- ▶ OxyCup® References

- Processing of all wastes from the main processes; Oxide Fines, DR Slurry, Mill Scale, Bag House Dust
  - Waste / by product dusts and scale
  - Metallic revert materials of unknown composition
  - Steel plant skulls
  - Metal from slag processing
  - Metal from de-sulphurization of hot metal
  - Plated pig iron, salamander etc.
- Avoids the need to process contaminated products (skulls / scrap etc)
  - Higher direct tapping rates and less down-grading and return melts
- Higher Fe yield
- High flexibility by varying the processed materials

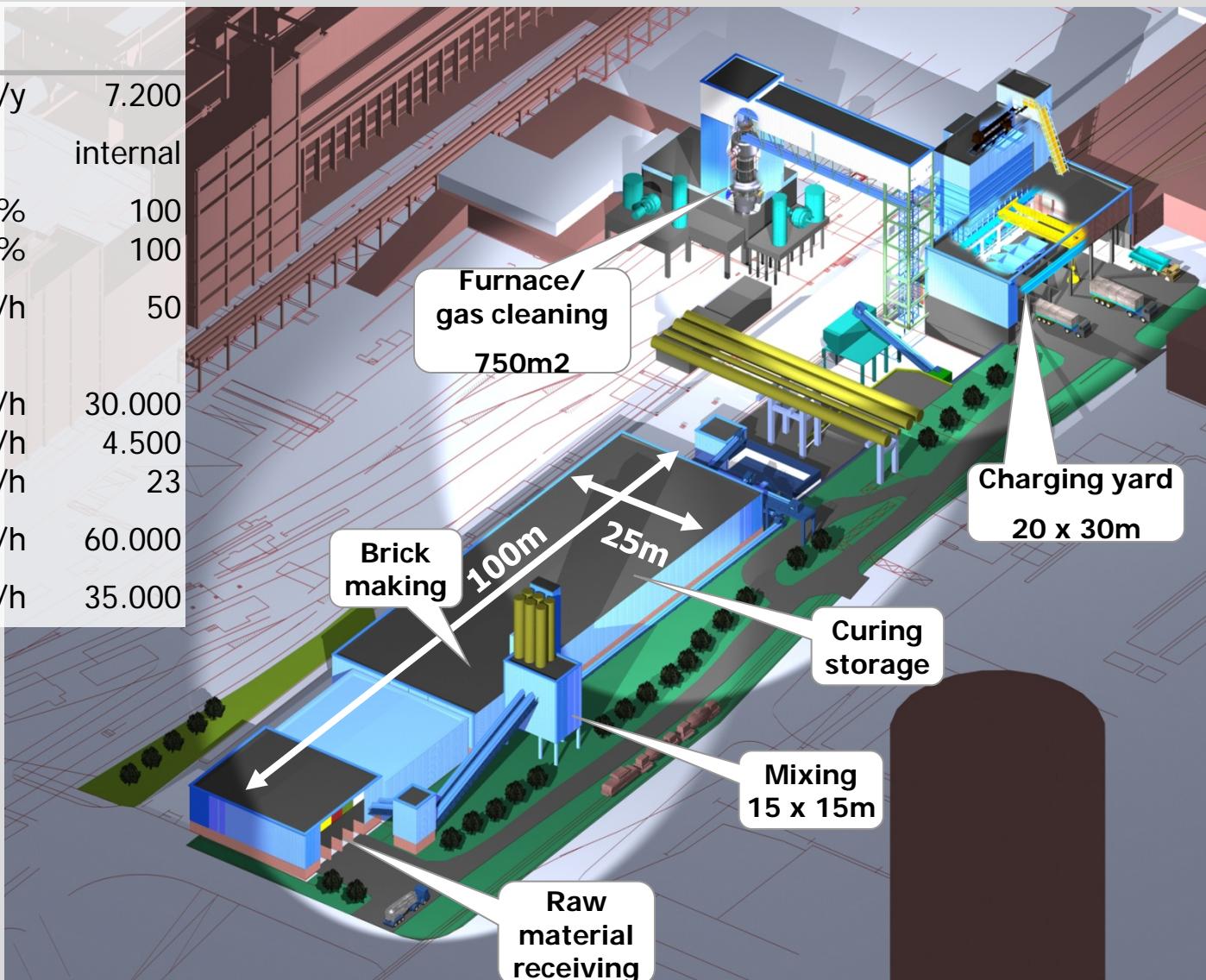
- ▶ OxyCup® Shaft Furnace Process
- ▶ Typical wastes / by-products
- ▶ OxyCup® Annual tonnages example
- ▶ OxyCup® Benefits
- ▶ ThyssenKrupp Steel OxyCup® plant
- ▶ OxyCup® References

# Basic data of commercial plant at ThyssenKrupp Steel

Küttner GmbH & Co. KG  
Dr. Franz Reufer

## Basic data

Operation time	h/y	7.200
Brick making facility		internal
Skulls	max-%	100
Bricks	max-%	100
Charging facility	t/h	50
Capacity		
- Blast capacity	Nm <sup>3</sup> /h	30.000
- Oxygen capacity	Nm <sup>3</sup> /h	4.500
- Hot metal (70%-bricks)	t/h	23
Gas cleaning	Nm <sup>3</sup> /h	60.000
Gas export	Nm <sup>3</sup> /h	35.000





## Raw materials

- Limitations for charge material
  - size 700 mm
  - fines max. 10 %

## Equipment data

- |                   |         |    |
|-------------------|---------|----|
| ■ Scrap hopper    | 3 x 12  | m3 |
| ■ Brick hopper    | 1 x 40  | m3 |
| ■ Coke hopper     | 2 x 500 | m3 |
| ■ Additive hopper | 2 x 200 | m3 |

# OxyCup® can process various metallic charges

Küttner GmbH & Co. KG  
Dr. Franz Reufer



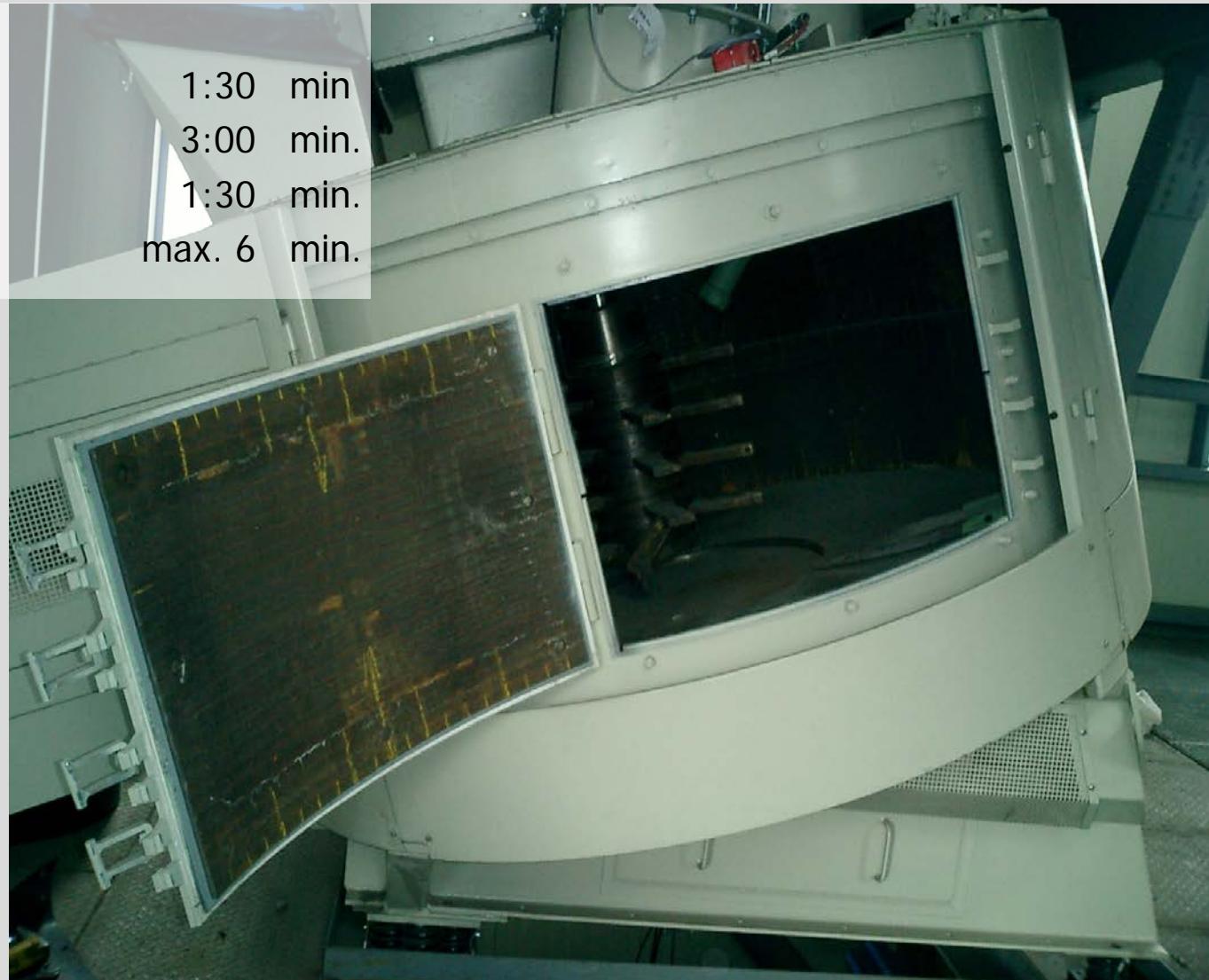
# Raw material preparation: Mixing

Küttner GmbH & Co. KG  
Dr. Franz Reufer

## Mixing times

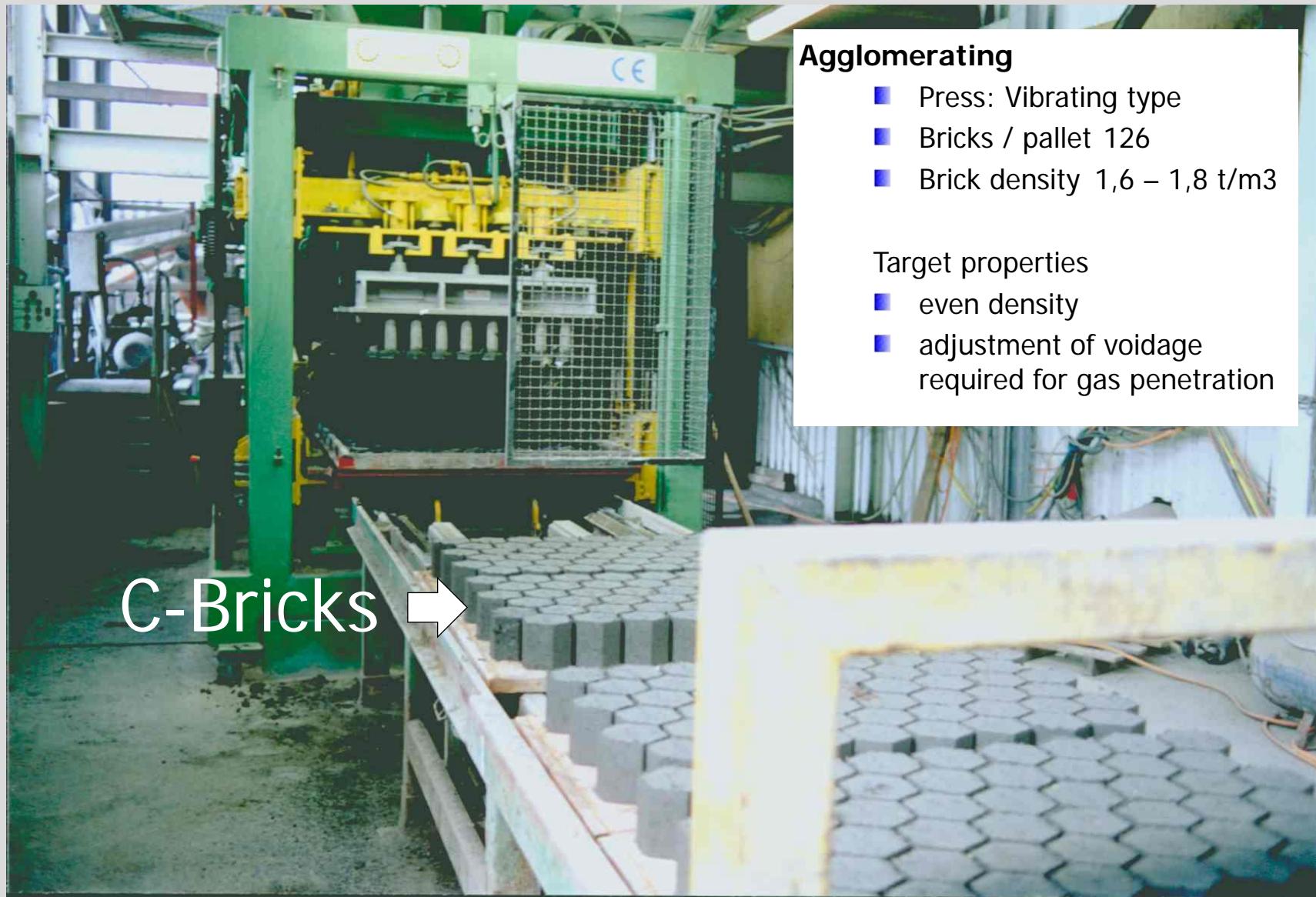
- Charging
- Mixing
- Emptying
- Total cycle time

1:30 min  
3:00 min.  
1:30 min.  
max. 6 min.



# Raw material preparation: C-Brick Press

Küttner GmbH & Co. KG  
Dr. Franz Reufer



# C-Bricks ready for use

Küttner GmbH & Co. KG  
Dr. Franz Reufer



**KÜTTNER**

# OxyCup® Commercial plant at ThyssenKrupp Steel

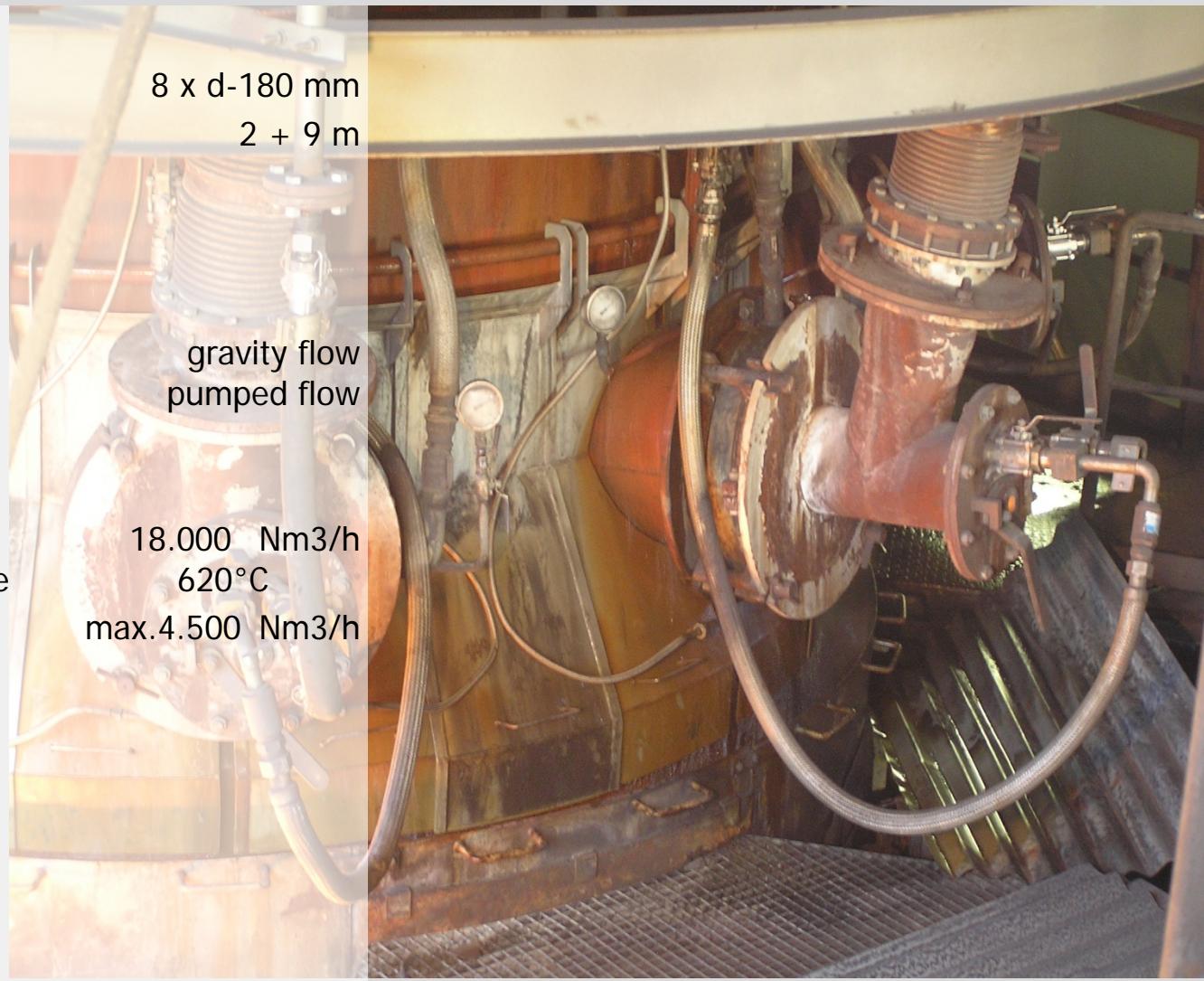
Küttner GmbH & Co. KG  
Dr. Franz Reufer



**KÜTTNER**

## Furnace

- Tuyeres
- Effective height
- Refractories
  - hearth
  - shell
- Cooling method
  - shell
  - tuyeres

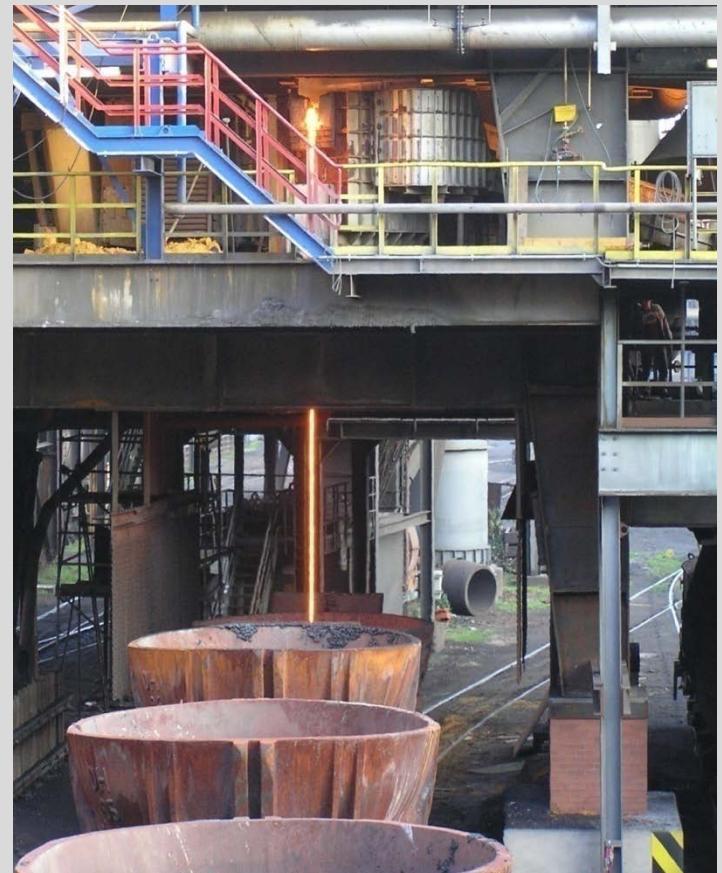


## Process data

- Blast volume
- Blast Temperature
- Oxygen volume,

# OxyCup® plant: Iron and Slag tapping

Küttner GmbH & Co. KG  
Dr. Franz Reufer



- A tilting runner passes the hot metal to two positions for Torpedo cars
- Slag is directly tapped into slag pots

**KÜTTNER**



## Gas cleaning

- Lines                            2 x 30.000 Nm<sup>3</sup>/h
- Gas export                    max. 35.000 Nm<sup>3</sup>/h

- ▶ OxyCup® Shaft Furnace Process
- ▶ Typical wastes / by-products
- ▶ OxyCup® Annual tonnages example
- ▶ OxyCup® Benefits
- ▶ ThyssenKrupp Steel OxyCup® plant
- ▶ OxyCup® References

# OxyCup® Reference Plants

Küttner GmbH & Co. KG  
Dr. Franz Reufer

Company	Country	Melting rate	Metallic input	Year
Sicartsa (AM Las Truchas)	Mexico	80 t/h	Scrap HBI, C-bricks tests	1998
TKS	Germany	52 – 50 t/h	pit scrap, C-bricks	2004
Nippon Steel	Japan	60 t/h Shuttle furnace	scrap, C-pellets	2005
JFE	Japan	80 t/h	scrap	2008
TISCO	China	2(3) x 20(45)t/h twin line	scrap, C-Bricks	2011

# ARCELOR MITTAL, L.C., MEX

HIGH RAW MATERIAL FLEXIBILITY



Special features:

Raw materials

- Heavy metal scrap  
Shredder
- DRI/ HBI

Ready for C-Bricks from  
waste oxides, pellet  
and ore fines

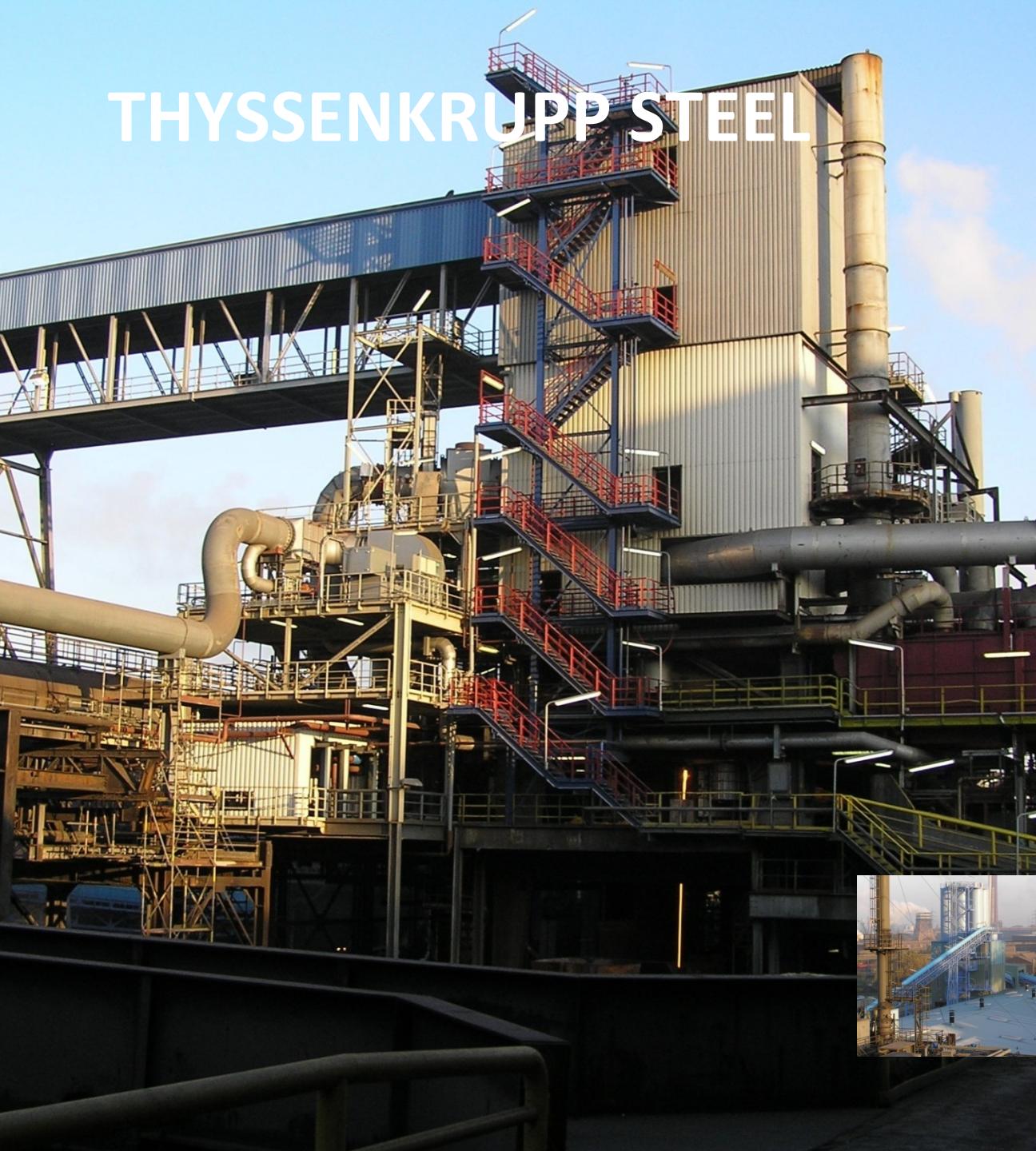
Coke

- Foundry / BF-coke  
Total ratio 155 kg/t
  - Coke breeze  
Injection ratio 20 kg/t
- Hot metal 80 t/h



**KÜTTNER**

# THYSSENKRUPP STEEL



## Special features

- Iron recovery from all kind of wastes, incl. lumpy skulls and fine grained dusts/ sludges
- Slag is used for cement, road and water way construction
- Gas recovery and used in power plant



**KÜTTNER**

# NSC, NAGOYA WORKS (JP)

## CAR SHREDDER RECYCLING



### Special features

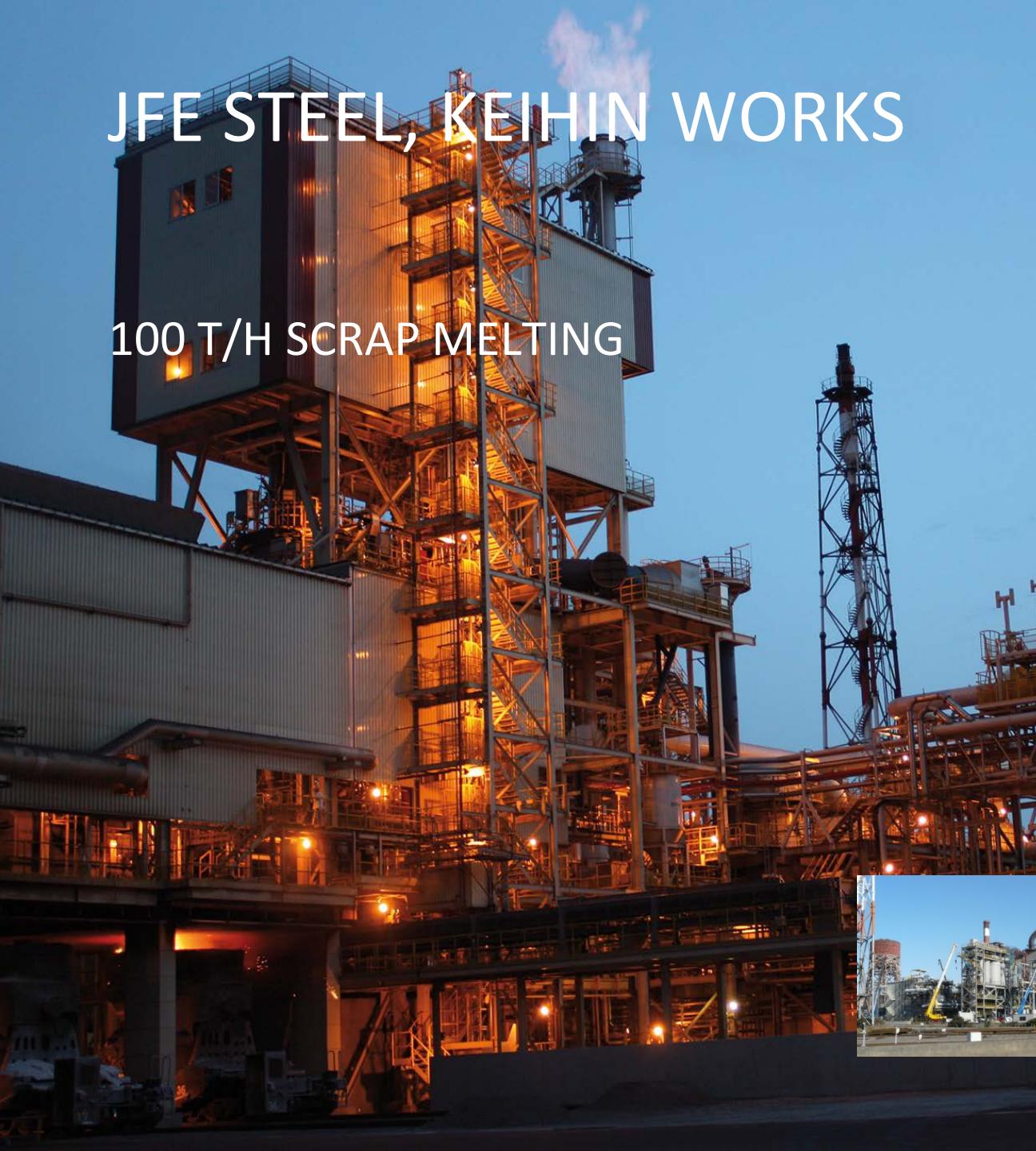
- 60t/h Shuttle type furnace for high availability
- Divided Blast technology for energy saving
- Wet gas cleaning and gas export for electrical power generation



**KÜTTNER**

# JFE STEEL, KEIHIN WORKS

100 T/H SCRAP MELTING



## JFE concept

- Additional steel making capacity at specific low CO<sub>2</sub>-Emission for scrap based production, even compared with EAF
- Gas export for power generation
- Ready for C-Brick operation
- Succesfull test of 100% HBI-melting



**KÜTTNER**

# TAIYUAN IRON & STEEL, CHINA

ALSO FOR CR, NI BEARING WASTE OXIDES



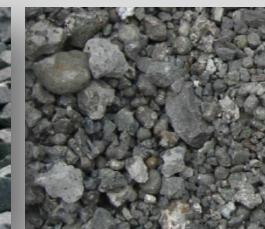
Special feature:

Cr and Ni Recovery

- Twin line furnaces
- 800°C hot blast

- 20 t/h hot metal from 45 t/h C-bricks

- Actual recovery rates:  
90% Cr-recovery rate  
98% Ni-recovery rate



**KÜTTNER**



Furnace C, OxyCup Plant – TISCO Taiyuan

- ▶ OxyCup® Process based on proven technology:
  - ▶ Brick making process is well established
  - ▶ Küttner has over 300 shaft furnace references
- ▶ OxyCup® Shaft Furnace can process:
  - ▶ Steelworks wastes / by-products dust and scale
  - ▶ Metallic revert materials of unknown composition
  - ▶ Steel plant skulls
  - ▶ Metal from slag processing
  - ▶ Metal from de-sulphurisation of hot metal
- ▶ Wastes / by-products are contained in C-Brick with carbon
  - ▶ Direct reduction process
  - ▶ CO reduces metal oxides to metal and CO<sub>2</sub>.
  - ▶ The reaction is very efficient because of the close vicinity of the fine grained reaction partners and the high temperature
- ▶ Hot metal and slag produced is similar quality to blast furnace

# General Time Schedule

Küttner GmbH & Co. KG  
Dr. Franz Reufer

