Küttner GmbH & Co. KG
Dr. Franz Reufer

State of the art

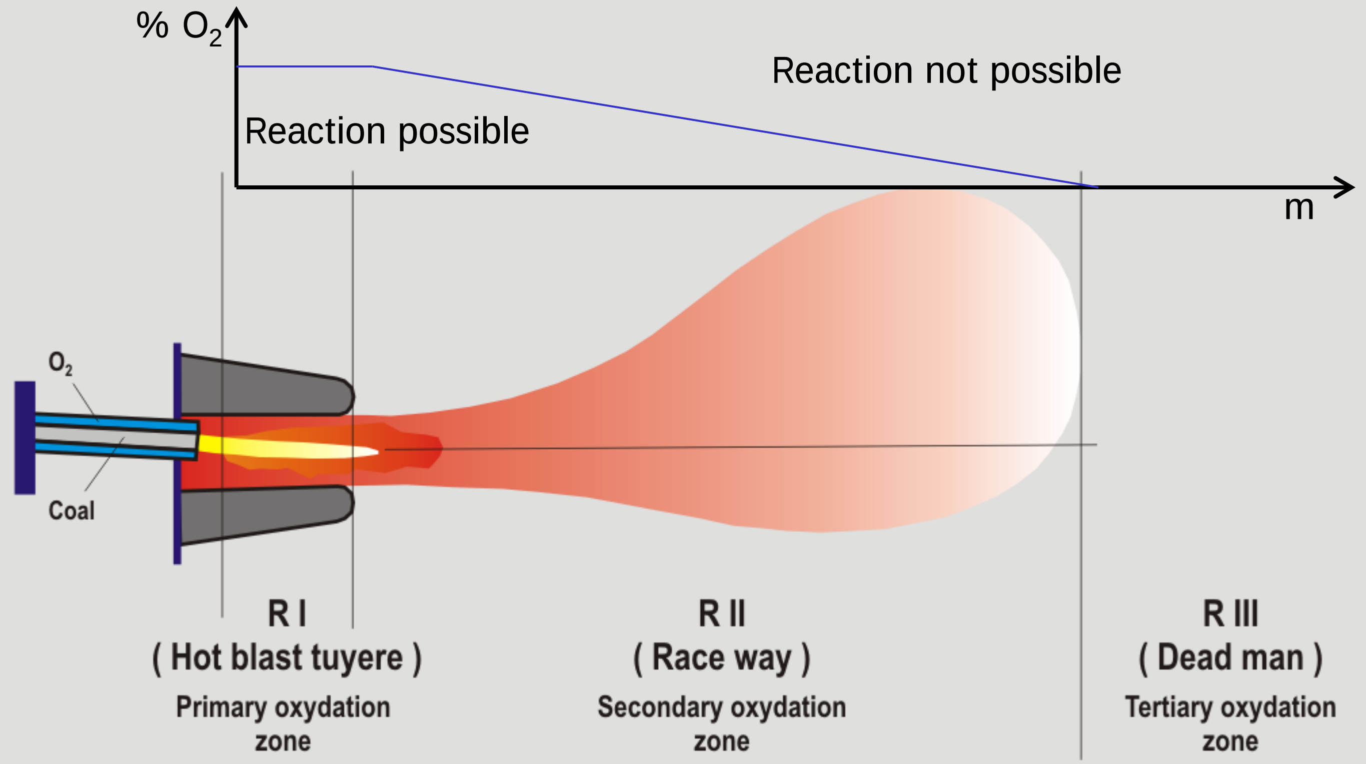
Drying and Grinding plants

and

Pulverized Coal Injection

July, 2016

First steps in dense flow conveying		(1983/84)
Single line control system		(since 1984/85)
Two tuyeres supplied per one line		(1987)
Coarse coal injection (80 wght % < 200 µm)		(1987)
Main pipe conveying system	(pilot plant 1986)	(industrial 1989)
Two single coal lances per tuyere		(1990)
Oxycoal system with coax lances		(1990)
Two coax lances as Oxycoal lances per tuyere		(1993)
Operation with ultra high density / ultra low velocity		(1996/97) (IIPC)
Preheating of coal	(since 1995)	(industrial 1999)
Ceramic control valves		(2000)
One PCI plant feeds independently three blast furnaces		(2002)
Improved nitrogen regulation and fluidisation system		(2003)
KKG/SWR mass flow measurement		(industrial 2003/04)
PCI with 850 m intermediate dense phase conveying and distribution vessel		(2007)
PCI into a fluid bed reducer (nickel production)		(2008)
Upgrading of dilute phase system into Küttner dense phase system		(2009)
Investigation of incrustations in PC conveying pipes		(2009)
Forecast of injection rate rise using Oxycoal based on physical model		(2010)
PCI and ore injection into ULCOS HIsarna-process		(2011)
Two different PC intermediate transport plants feeding one distribution vessel		(2012)
Char coal dense phase recycling for coal gasifier (basic engineering)		(2013)
1800 m intermediate dense phase transport		(2013)



In tuyere the complete gasificatiion should take place

→ Ignition as early as possible

→ Retention time as high as possible

Quelle:ThyssenKrupp Steel

Reaction zones for coal gasification

- **The main target to achieve this is to maximize the retention time in the tuyere. Here the speed of the injected coal has to be reduced to the minimum.**
- **The coal combustion needs the reaction partners Carbon and Oxygen and a large surface that the reaction can take place at as many places simultaneously as possible. So a good mixing of coal and hot blast has to be achieved and in order to create a large surface the coal has to have a small mean diameter.**
- **The ignition temperature of the coal can be influenced by the concentration of Oxygen in the surrounding gas. So the Oxygen level in coal cloud has to be maximized and the influence of the transport gas, which is Nitrogen, has to be minimized.**
- **Last but not least the stability of the injection process is very important without pulsation and an even distribution to all tuyeres of the blast furnace.**

- Using a pulverized coal with a small mean diameter
- Using a blend of coals as the best compromise between ignition point and RAFT
- Using a pulverized coal with a low residual humidity (< 1 % surface humidity)
- Minimizing the cold transport gas
- Producing a cloud of coal in the tuyere with a great surface
- Operation with a low lance outlet velocity
- Adjusting a high concentration of O2 near the coal surface
- Adjusting a stable flame without pulsations
- Produce mixing energy between coal, oxygen and blast
- Adjusting the local and temporary constancy of coal flow also in short time intervals
- Using ultra high density, ultra low velocity injection process

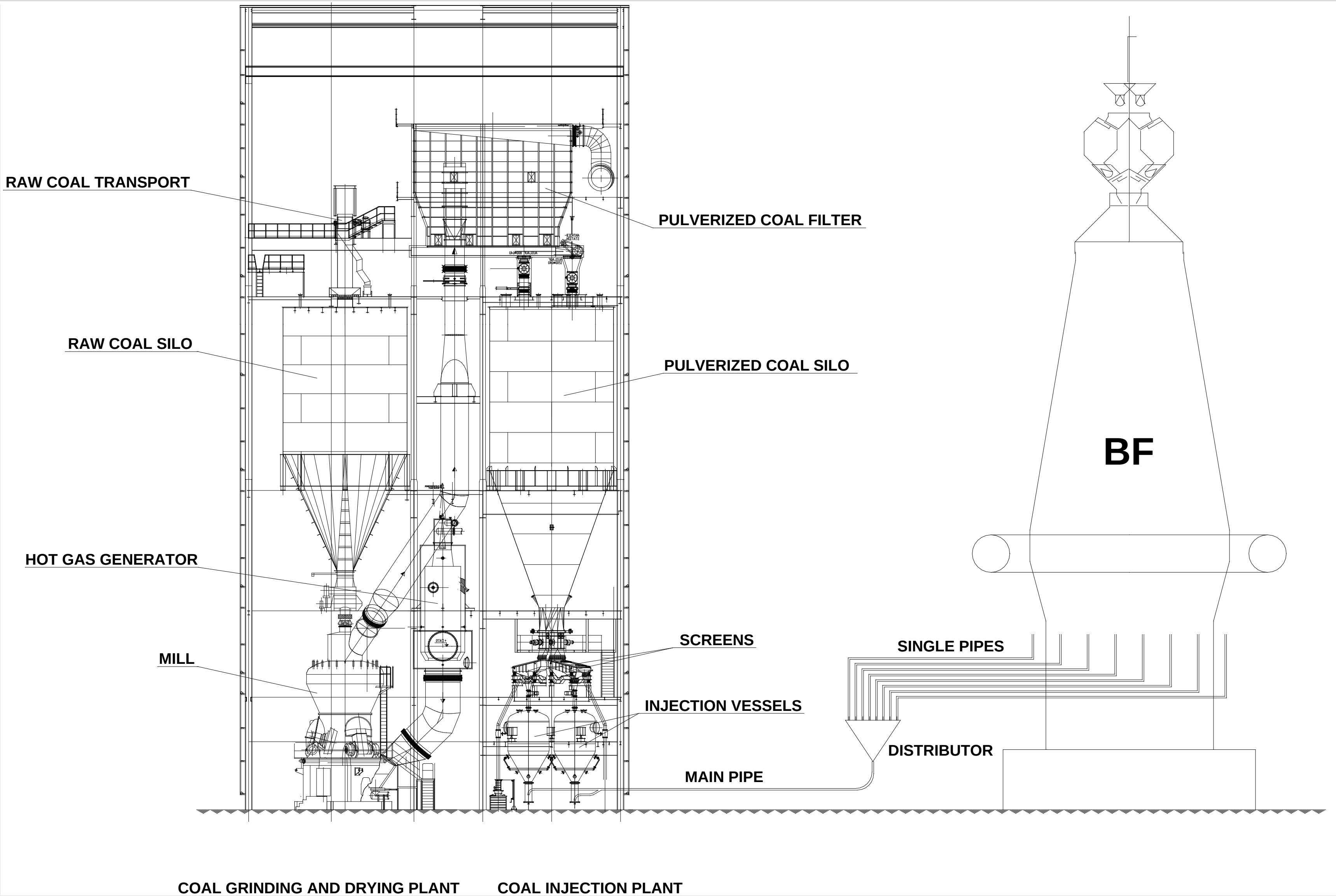
Parameter for fast heating up and a high conversion rate of pulverized coal

Coal Drying and Grinding Plants:

Drying energy: Hot Stove Waste Gas / BF Gas

Using vertical roller mills from various suppliers

Full GAD and PCI plant out of one hand



Coal grinding / drying and PCI plant with main pipe system

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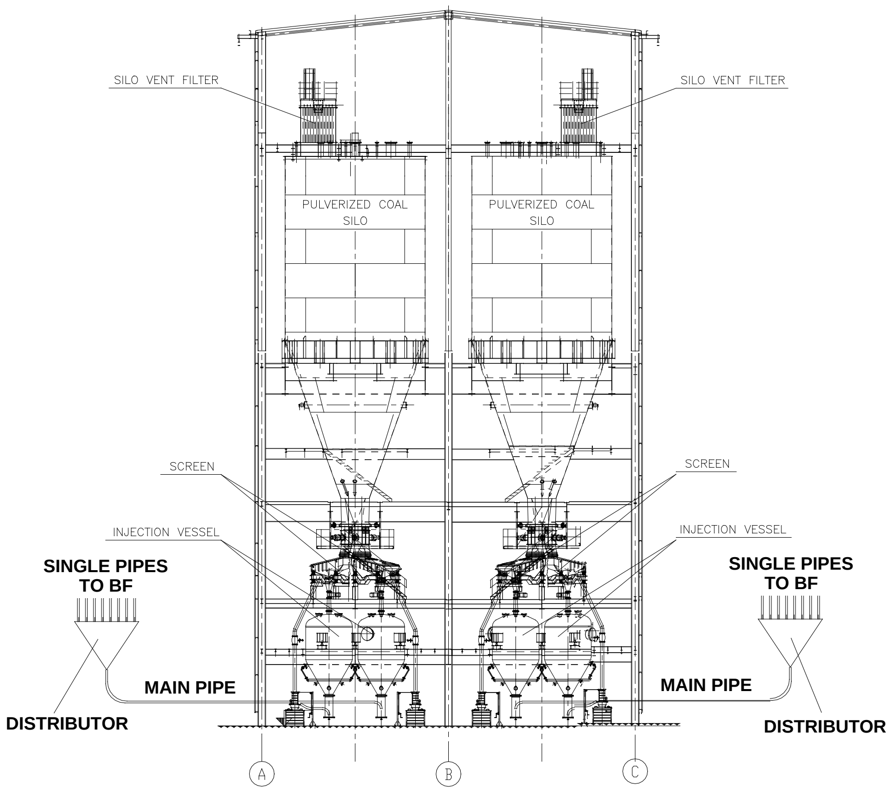
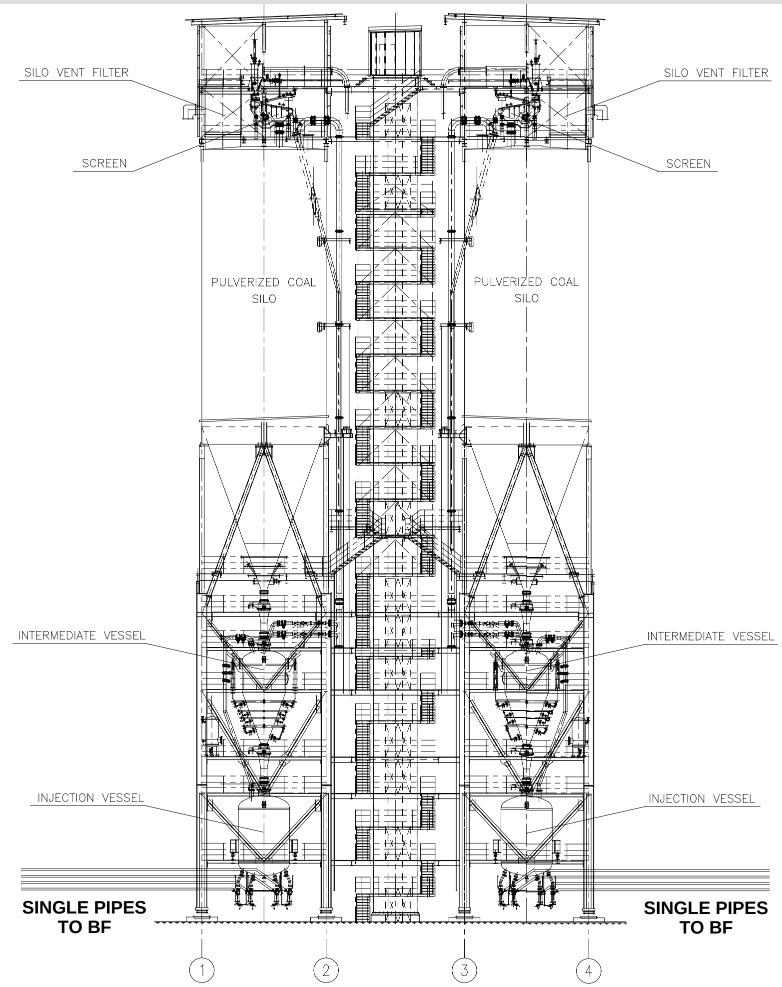


SYSTEM MAIN PIPE



SYSTEM SINGLE PIPES

Systems of coal injection plants

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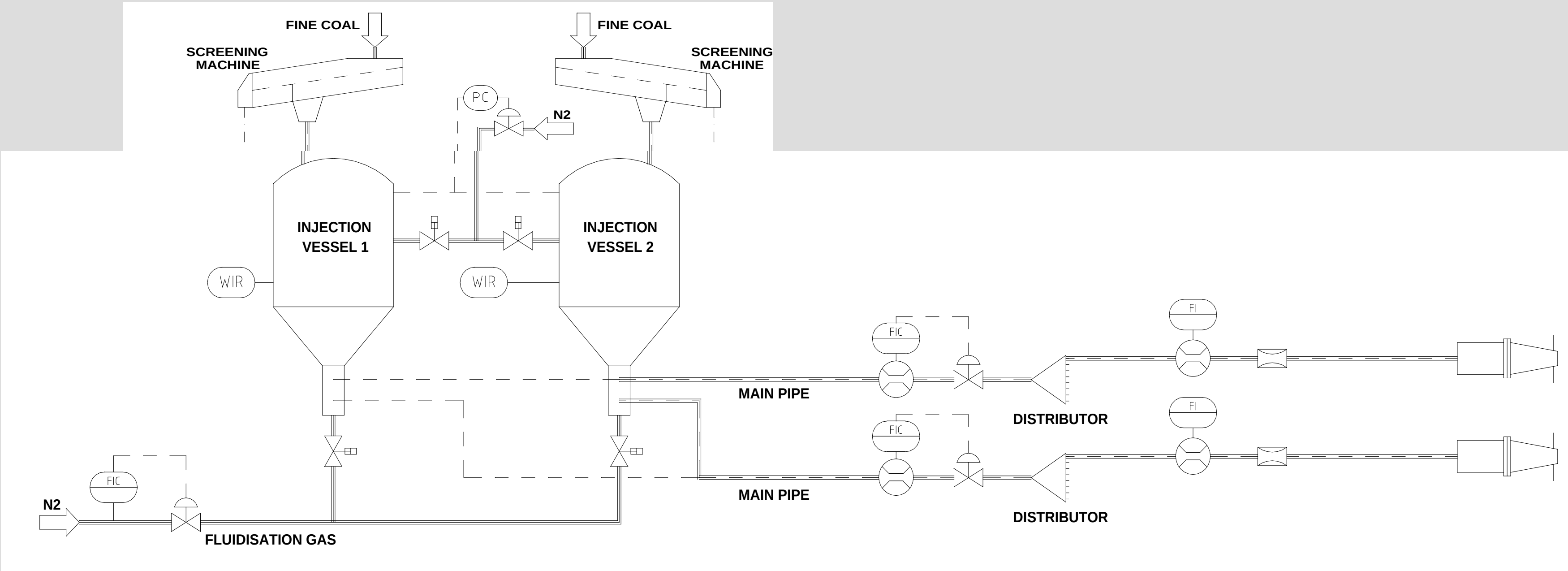
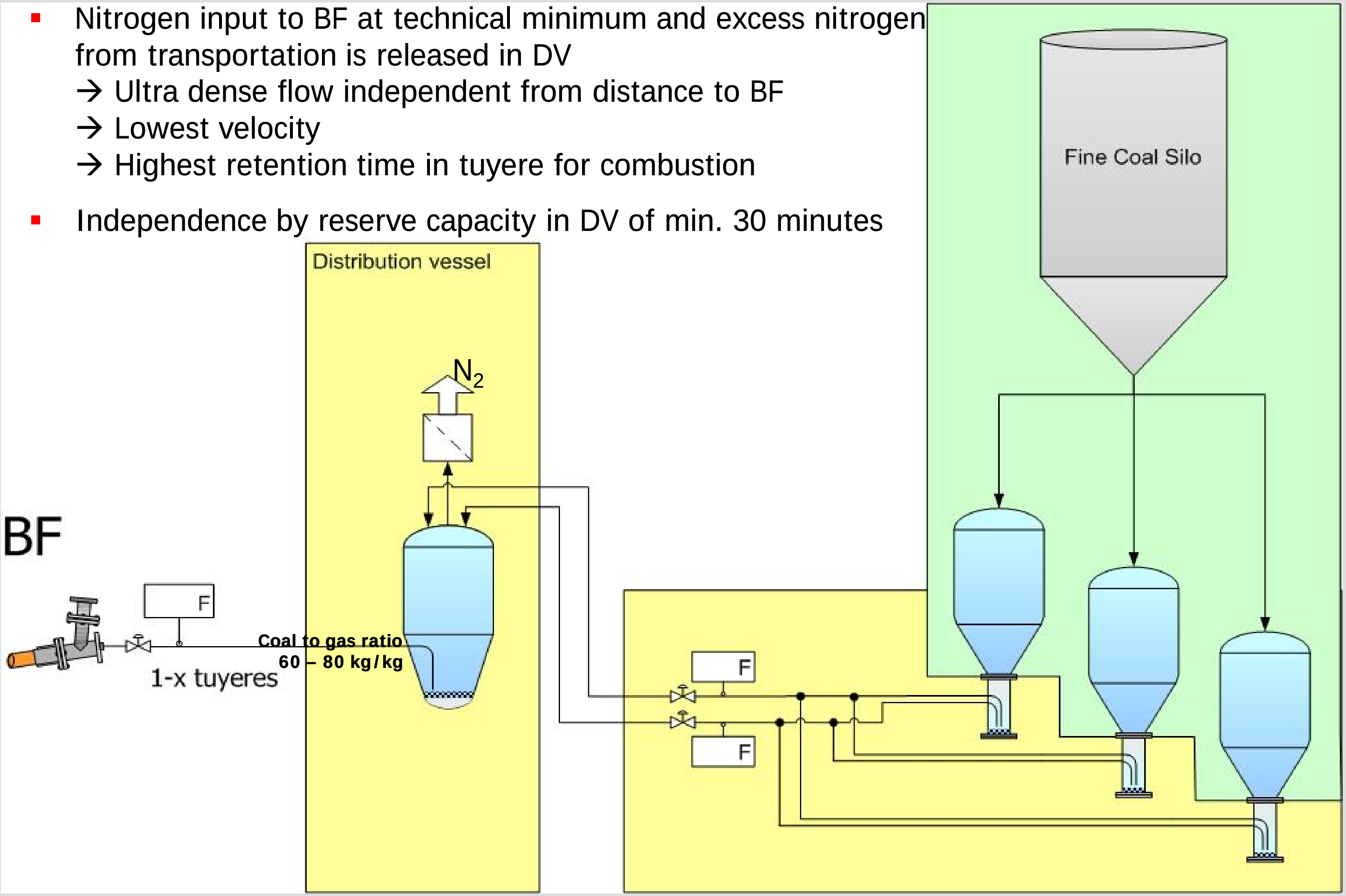


Screening machines above injectors for enhanced fluidization

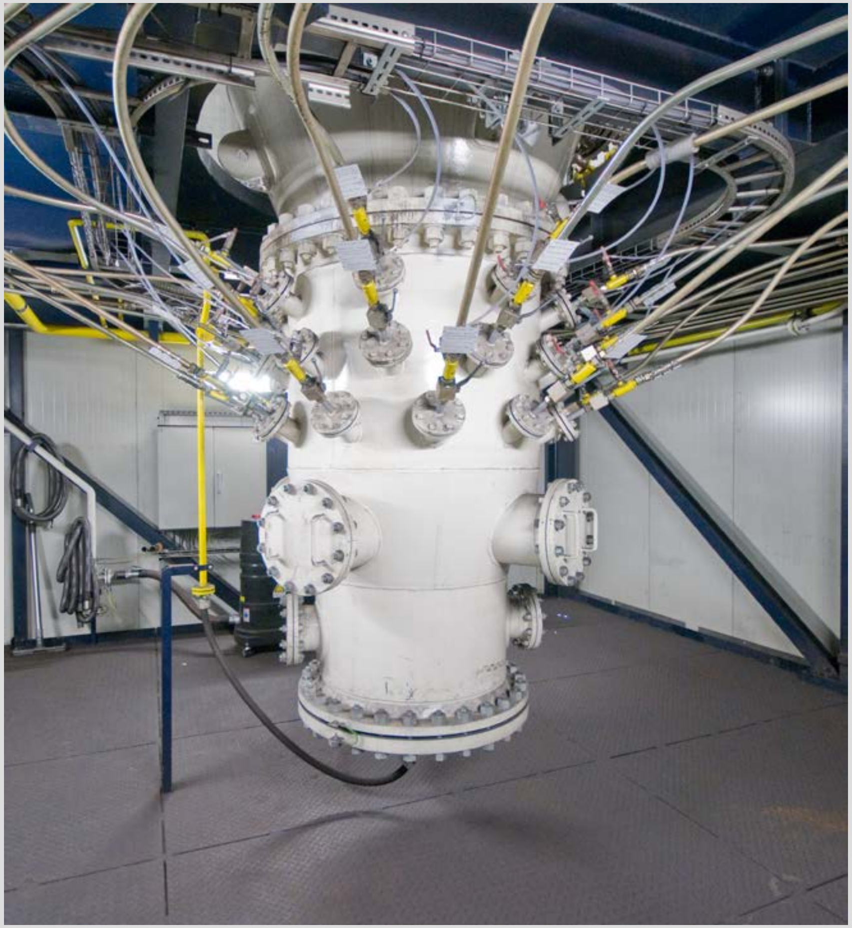
Two different blast furnaces are fed by one PCI plant by ceramic control valve and mass flow measurement

- Nitrogen input to BF at technical minimum and excess nitrogen from transportation is released in DV
  → Ultra dense flow independent from distance to BF
  → Lowest velocity
  → Highest retention time in tuyere for combustion
- Independence by reserve capacity in DV of min. 30 minutes



PCI+® set up with distributor vessel and single line control

Blending and Storage, Central remote Coal Grinding Plant

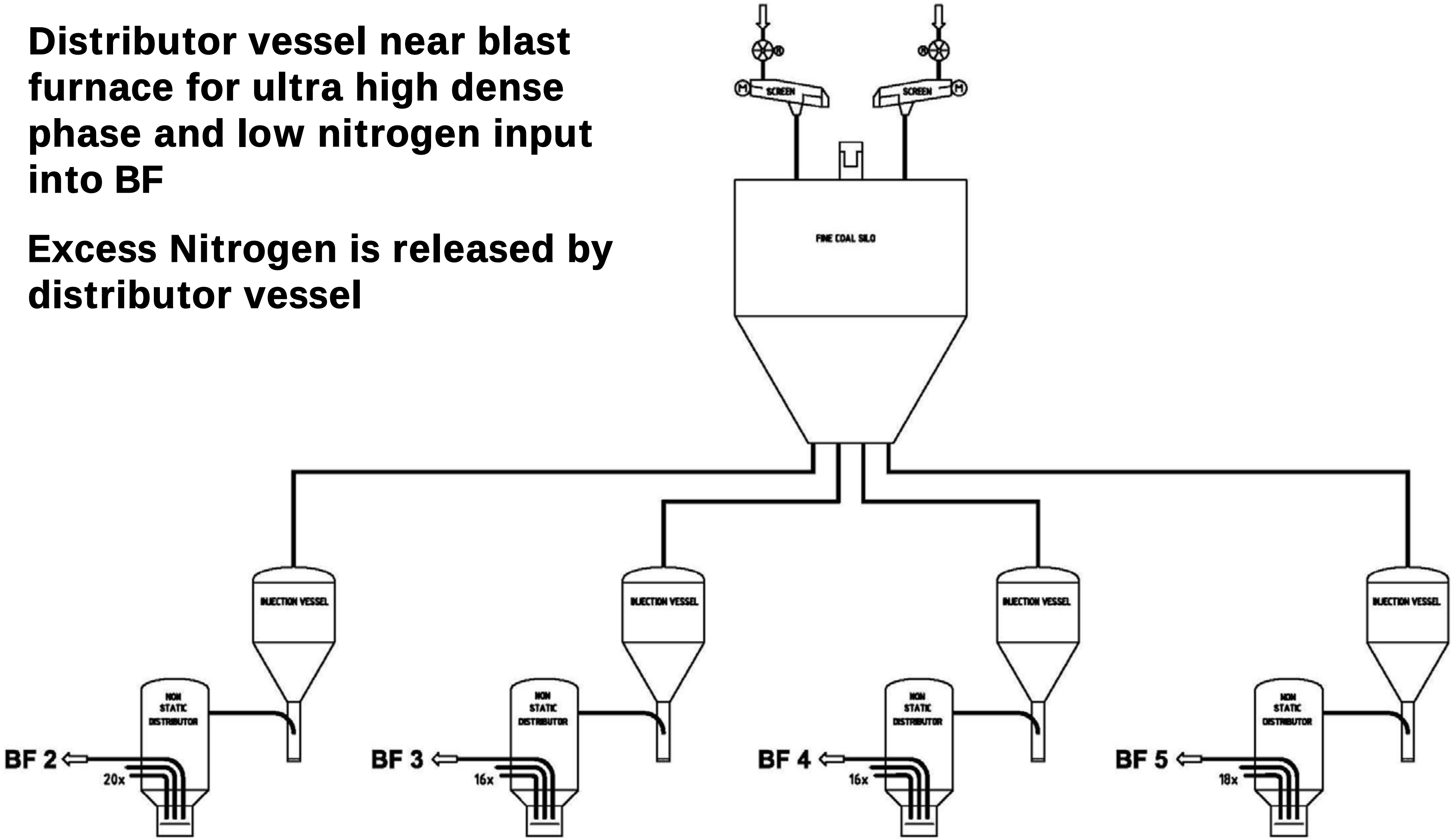


Distributor Vessel for Ultra Dense phase conveying in the entire system

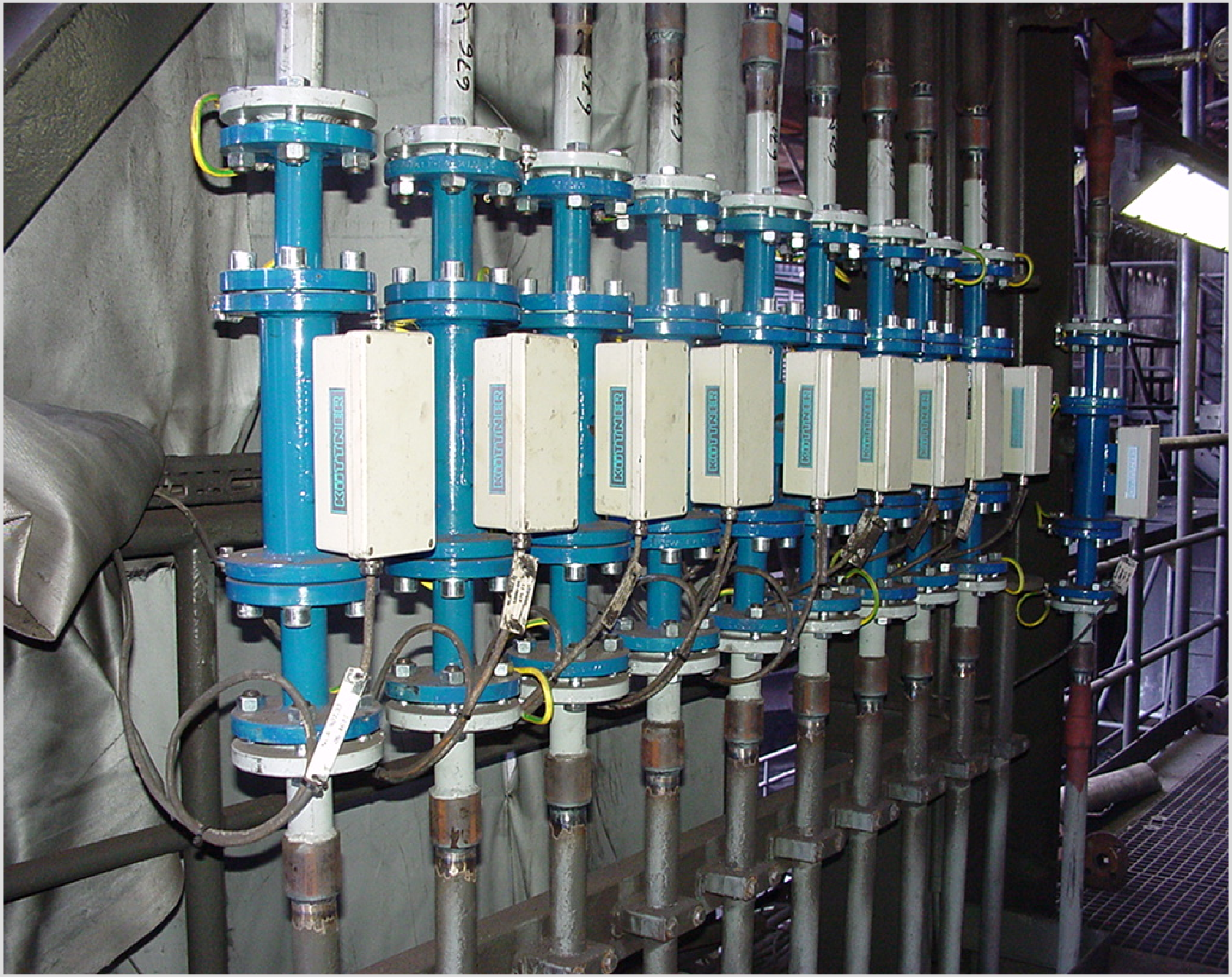
PCI Voestalpine Stahl, Linz, 1,8 km Transport length

Distributor vessel near blast furnace for ultra high dense phase and low nitrogen input into BF

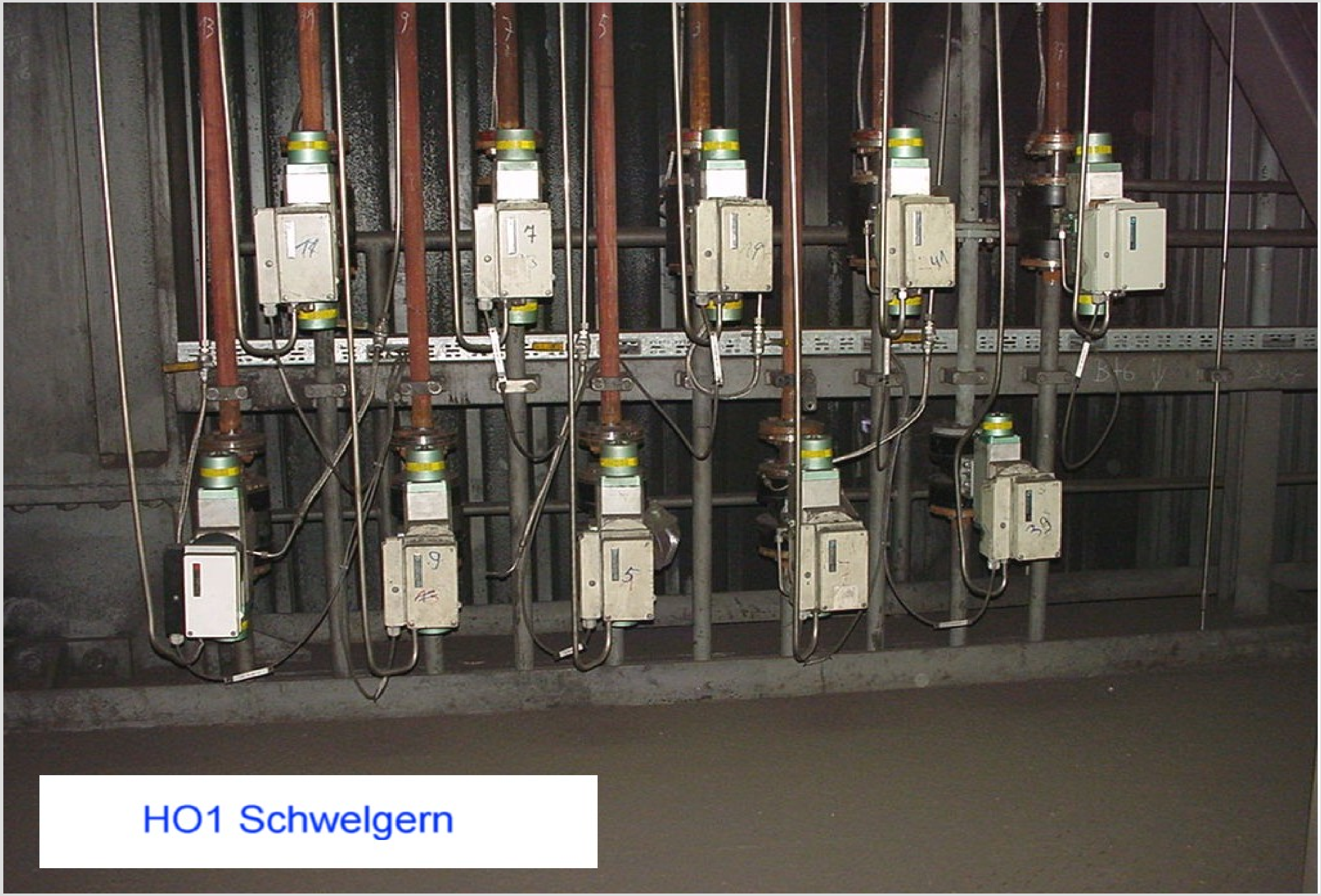
Excess Nitrogen is released by distributor vessel



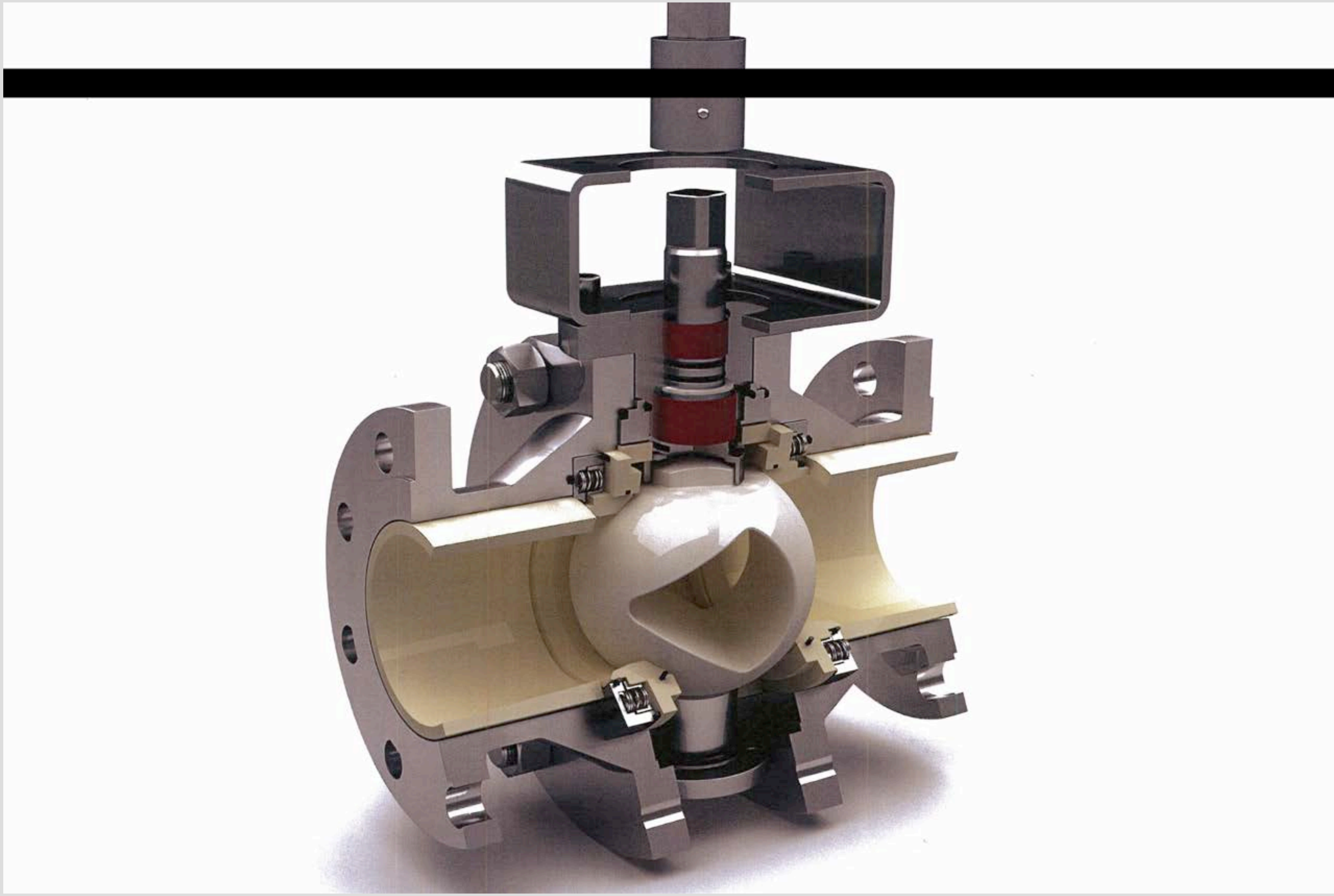
System with distributor vessel (E.S.C.H. type)



KKG/SWR Measurements TKS HO1

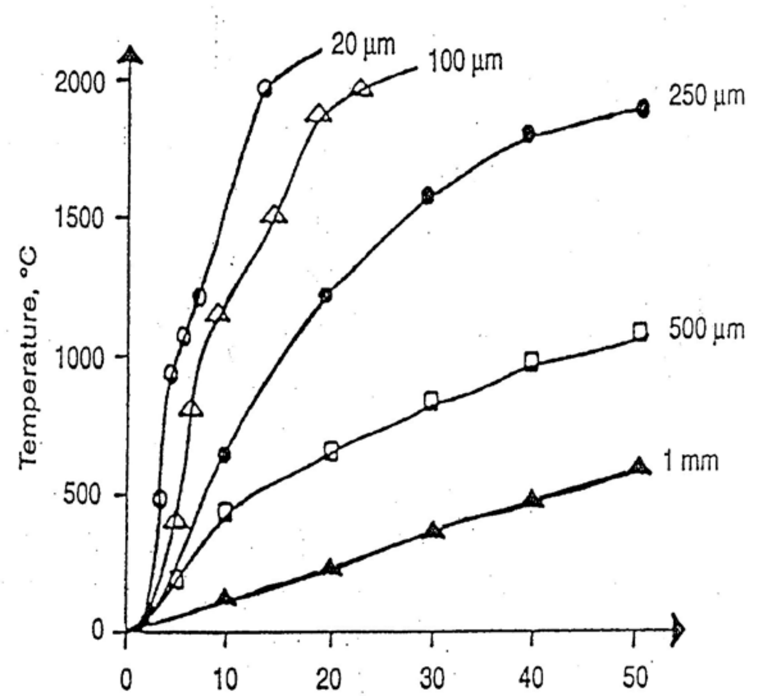


Ceramic control valves
HO1 TKS Schwelgern



Coalflow regulation Valve

Ignition temperature	in oxygen	in air	
lignite	135-240	410-520	°C
high volatile coal	214-230	460-510	°C
rich coal	243- 248	510-590	°C
lean coal	260	670	°C
low volatile coal	339	690	°C
anthracite	485	850	°C



Heating up of coal particles

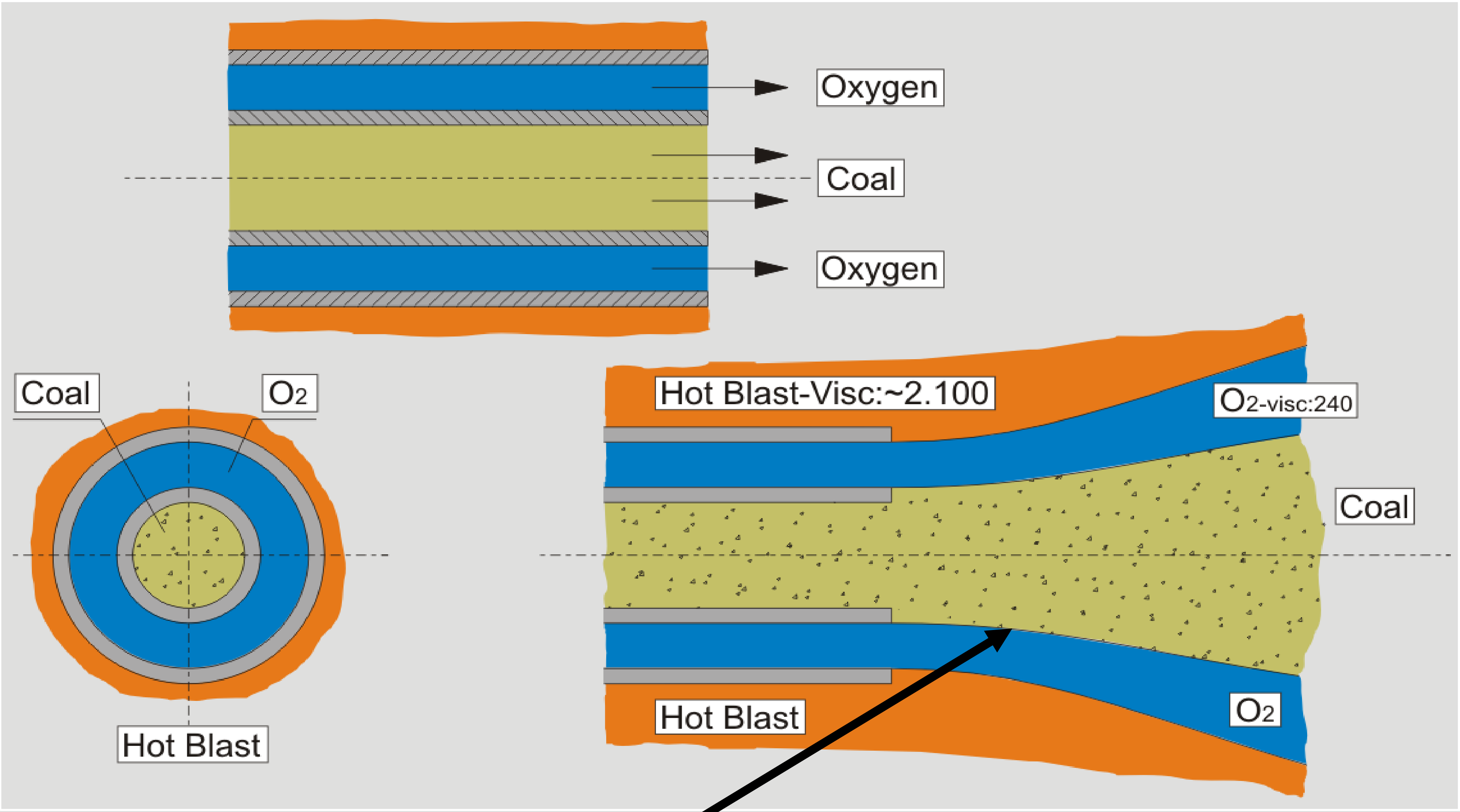
In oxygen the ignition temperature of coal is significantly lower

→ earlier ignition

At smaller grain size the reaction surface is higher and there is more contact between Oxygen and coal

→ Faster heating up
→ More complete gasification

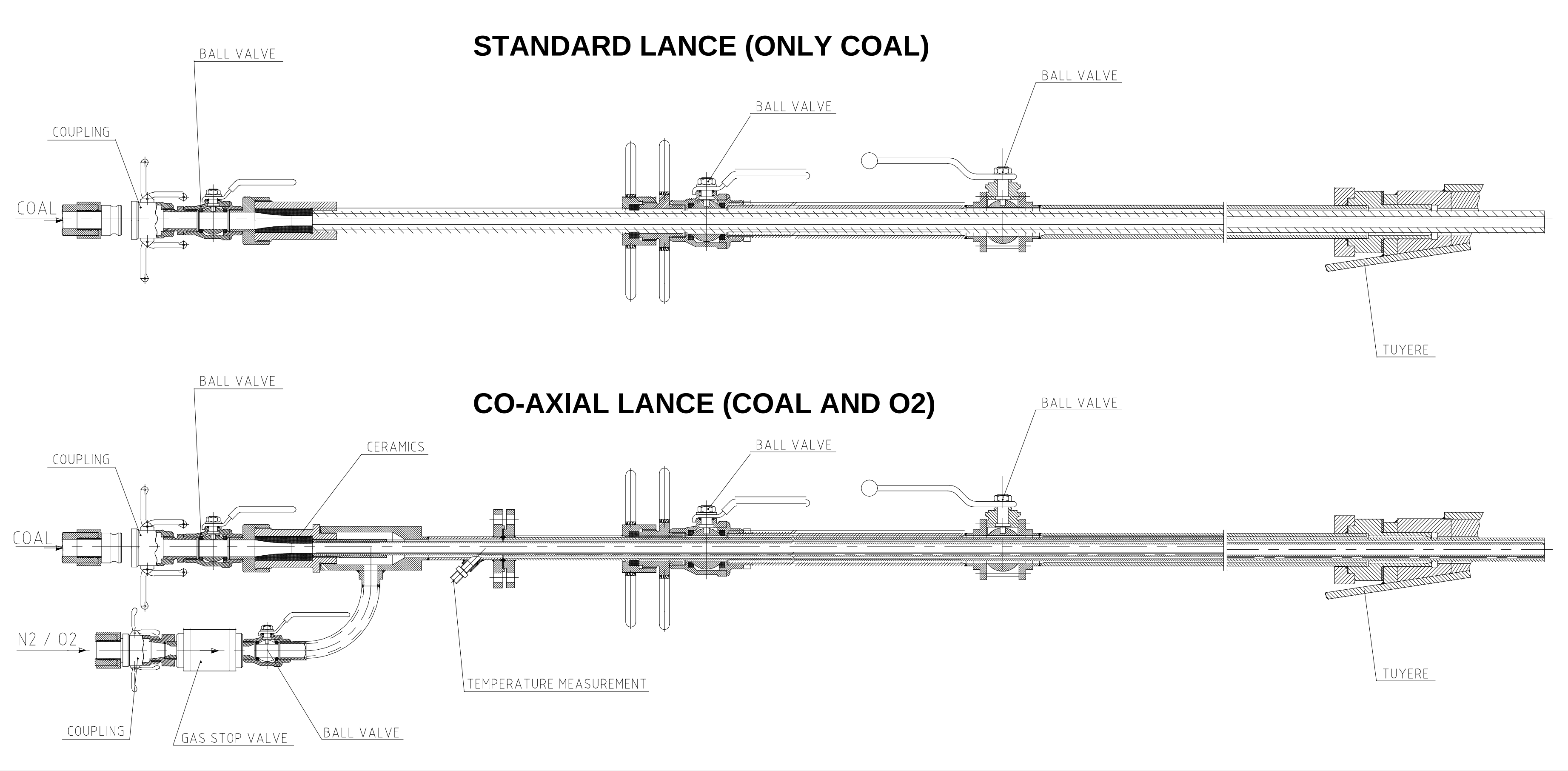
Measures for earlier combustion

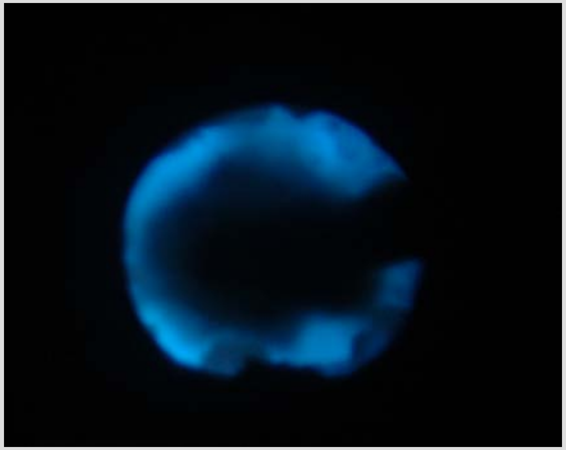


Intensive contact between Oxygen and Coal

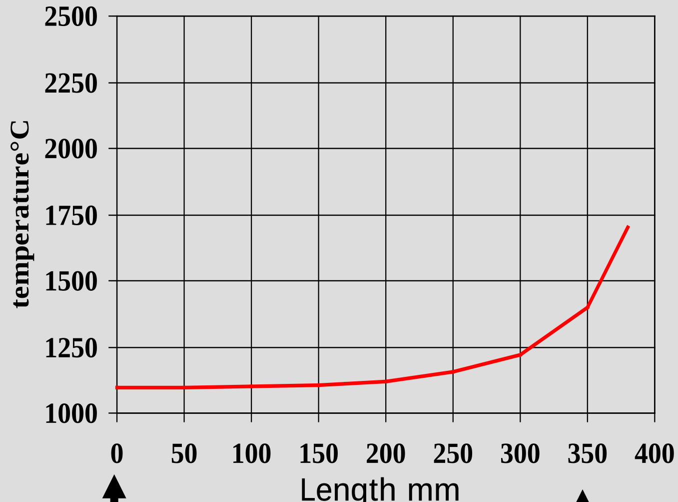
Source: ThyssenKrupp Steel

OxyCoal +® Co-axial lance for Coal and Oxygen


STANDARD LANCE (ONLY COAL)
BALL VALVE
COUPLING
COAL
BALL VALVE
BALL VALVE
TUYERE
CO-AXIAL LANCE (COAL AND O2)
BALL VALVE
COUPLING
CERAMICS
COAL
BALL VALVE
BALL VALVE
N2 / O2
TEMPERATURE MEASUREMENT
TUYERE
COUPLING
GAS STOP VALVE
BALL VALVE

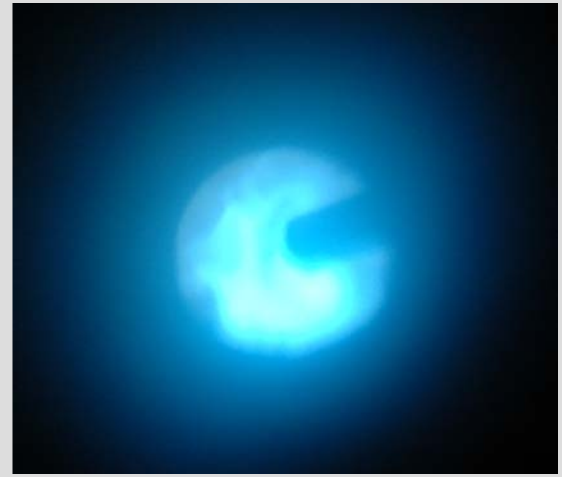


Conventional injection process

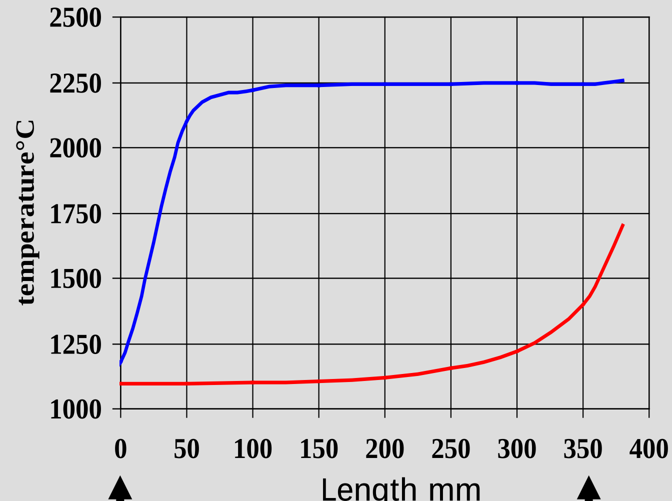


Tip of lance

Tip of tuyeres



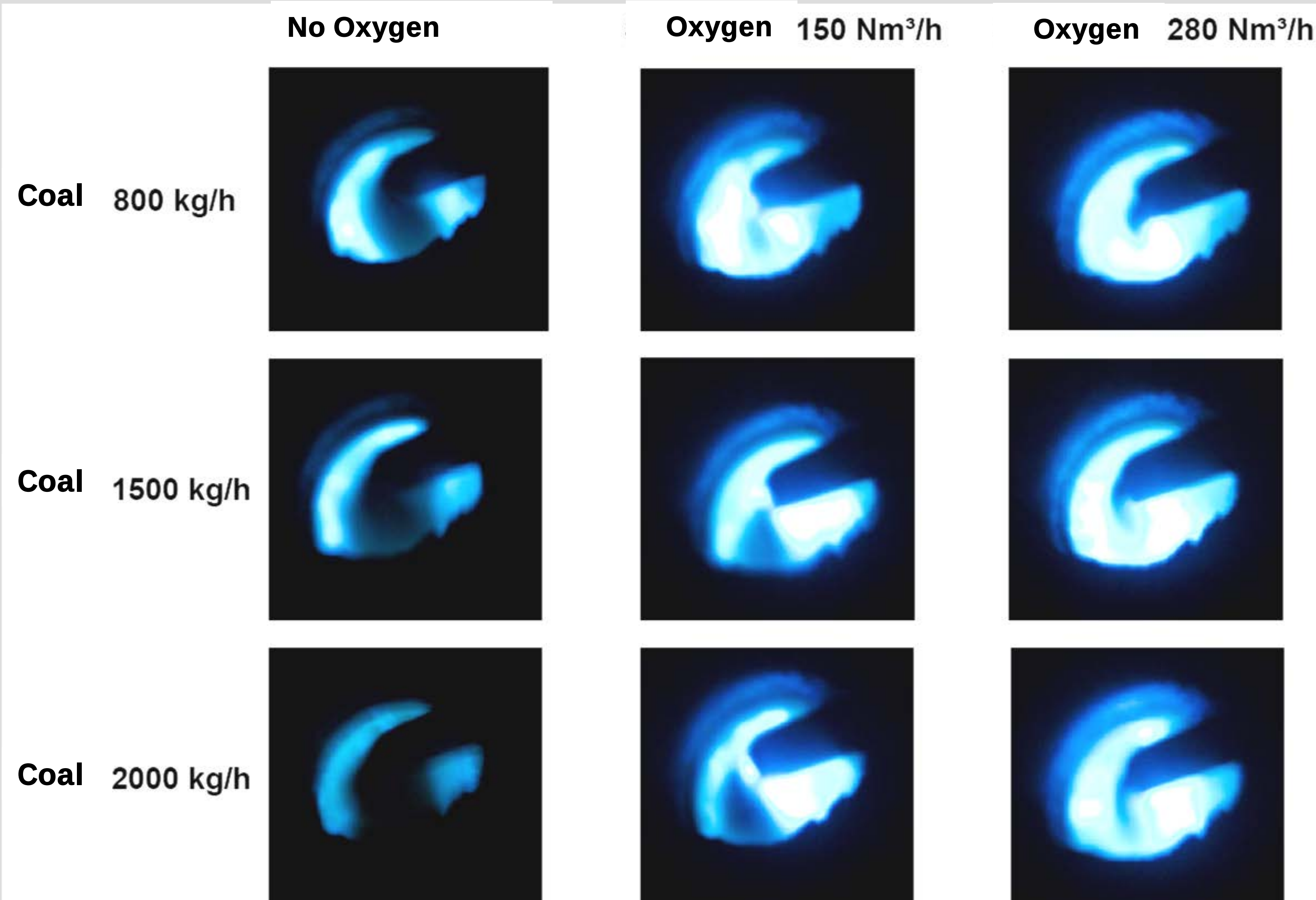
PCI+® Oxycoal+® injection process



Tip of lance

Tip of tuyere

Temperature development in tuyere


No Oxygen
Oxygen 150 Nm³/h
Oxygen 280 Nm³/h
Coal 800 kg/h
Coal 1500 kg/h
Coal 2000 kg/h

Coaxial lance in operation