Implementation of a modern LowNOx firing system for bituminous coal into a new taylor-made boiler concept considering boundary conditions of an existing plant

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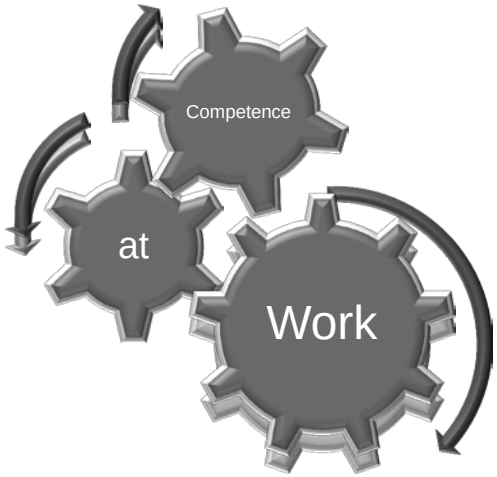


Introduction

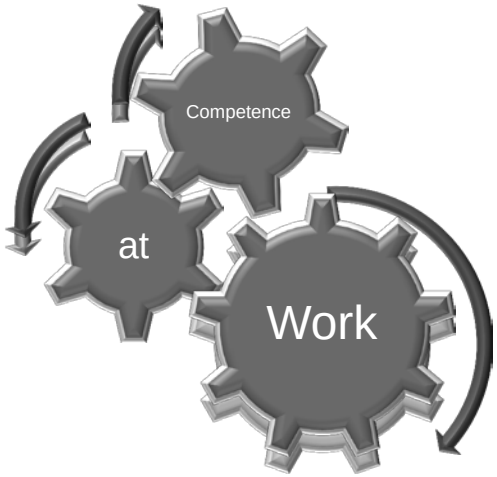
History - Rely on Good Experience

1874 Company foundation of L. & C. Steinmüller (LCS) –
„water tube boiler company“ by Lebrecht and Carl Steinmüller.
Development and supply of firing systems, steam generators and flue gas treatment plants over more than 125 years.

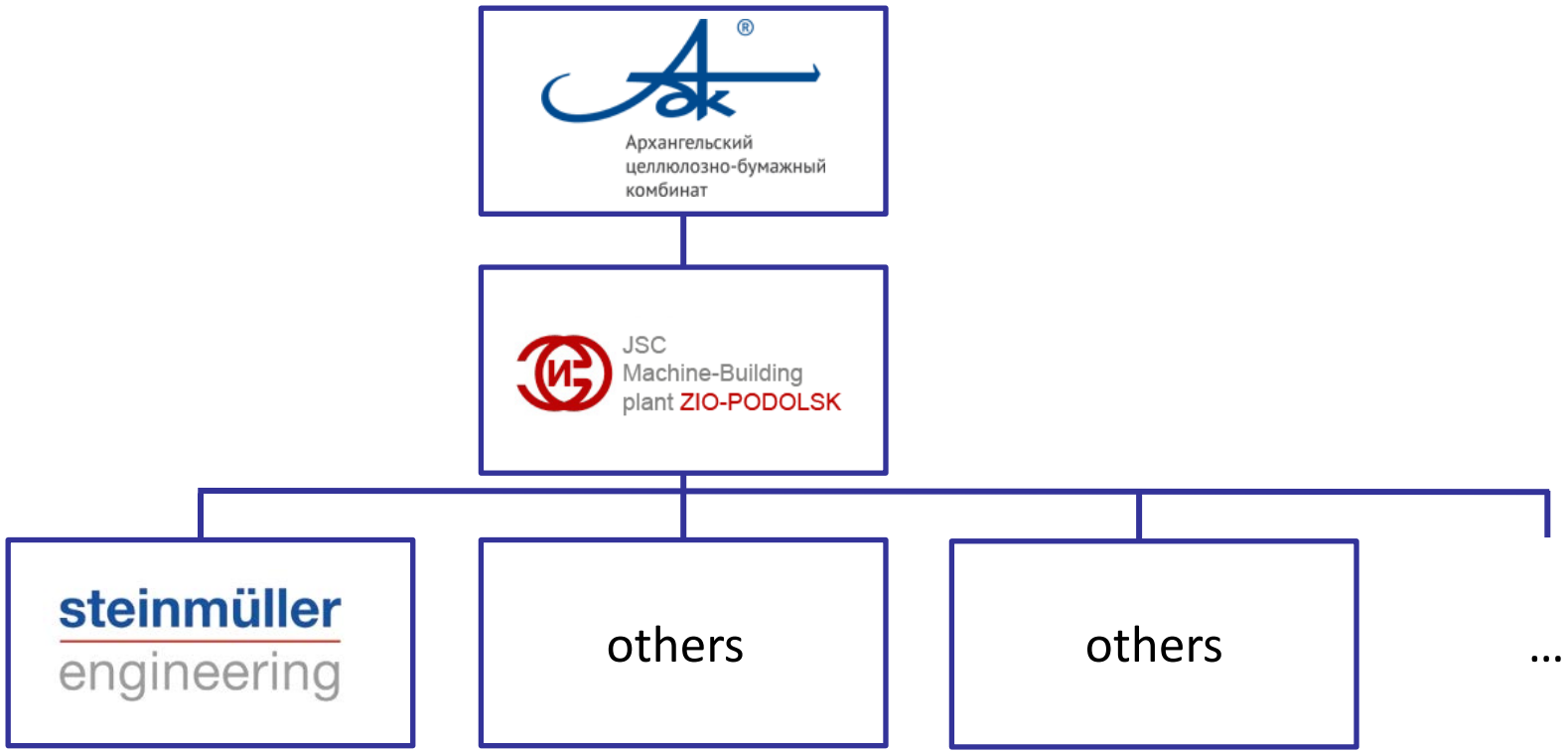
2003 Start of Steinmüller Engineering GmbH (not the legal successor of former LCS) –
Foundation of a new company by a group of experienced LCS engineers.

Providing engineering excellence to the power industry as consultant and a well reputed solution provider for firing systems, steam generators and flue gas treatment plants.

2014 Integration of Steinmüller Engineering GmbH into the IHI Group of Companies.
Continue the expansion into the power industry and generating synergies with one of the strongest knowhow owners in this field of technology.



Project Background


Архангельский
целлюлозно-бумажный
комбинат
JSC
Machine-Building
plant ZIO-PODOLSK
steinmüller
engineering
others
others
...

- Existing boiler house
- Limited floor space and height
- Fuel range (coal from different mines)
- Slagging of coal (problems of existing boilers)
- Compliance with emission values
- Boiler efficiency
- Part load operation (stable boiler operation over the entire load range 40-100%)
- Different suppliers for the steam generator and the firing system (uncompromised and seamless functioning of both firing System and boiler)

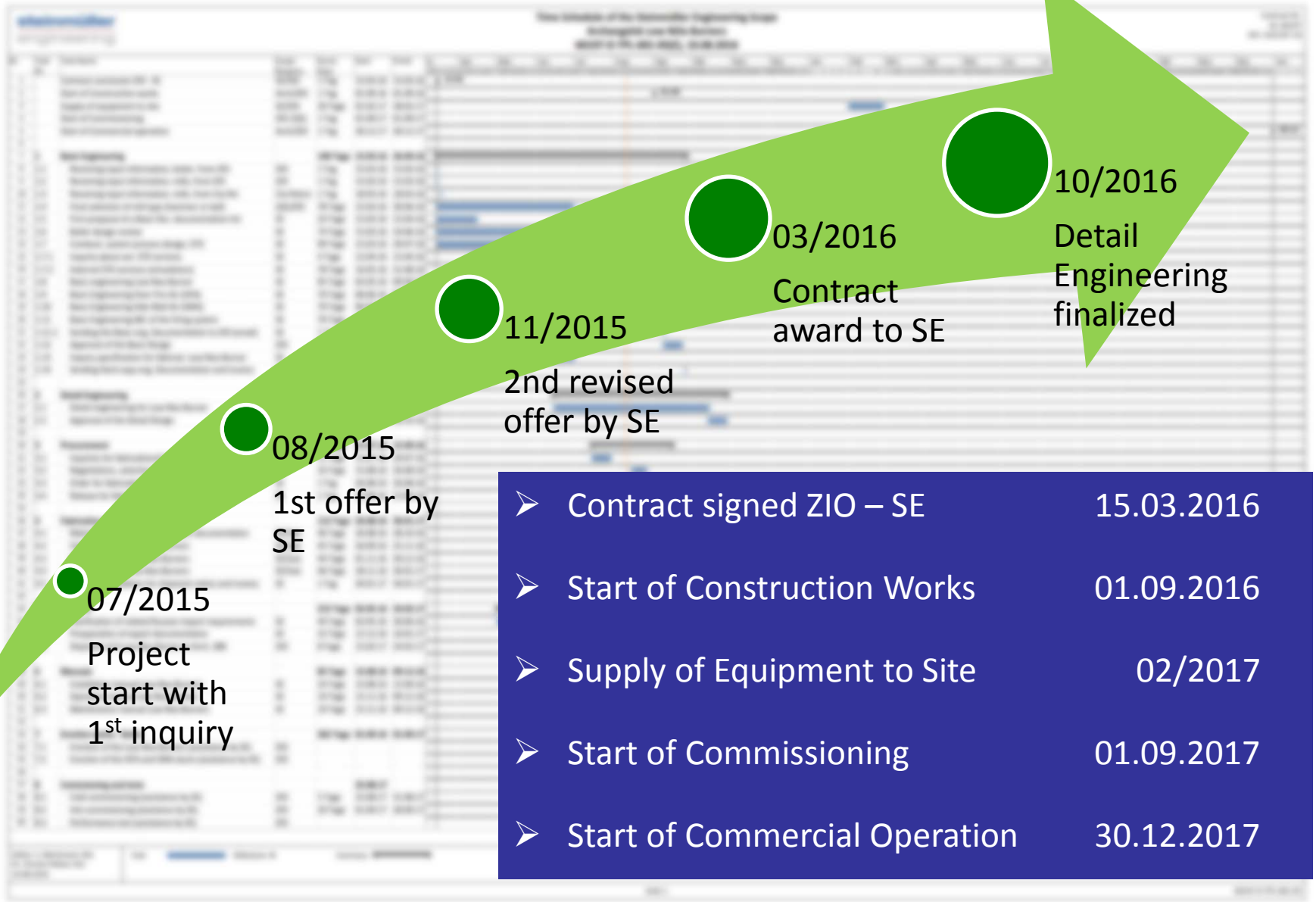
Boiler Data	Value	Unit
Steam capacity	**220**	t/h
Steam pressure	**9.8**	MPa
Steam temperature	**540**	°C
Feed water temperature	**215**	°C
min. Boiler efficiency	**91**	%

Emission Values [mg/Nm³]@6%O_2	Current limits
NOx	**470**
PM	**150**
SO_2	**1200**
HF, HCl	---
Hg [µg/Nm³]	---

Designation	Unit	Main (guaranteed) fuel (mixture 30% «Д» and 70% «ГЖО»)
Working mass content of main and rated fuel (hard coal)		
W_t^r	%	9.0
A^r	%	21.4
S^r	%	1.4
C^r	%	55.5
H^r	%	3.59
N^r	%	1.72
O^r	%	7.39
Total:	%	100
Yield of volatile matter, V^{daf}	%	39.4
Net calorific value, Q^r_i	kcal/kg	5163

Project Background

-Milestones-



07/2015
Project start with 1st inquiry

08/2015
1st offer by SE

11/2015
2nd revised offer by SE

03/2016
Contract award to SE

10/2016
Detail Engineering finalized

➢ Contract signed ZIO – SE	15.03.2016
➢ Start of Construction Works	01.09.2016
➢ Supply of Equipment to Site	02/2017
➢ Start of Commissioning	01.09.2017
➢ Start of Commercial Operation	30.12.2017

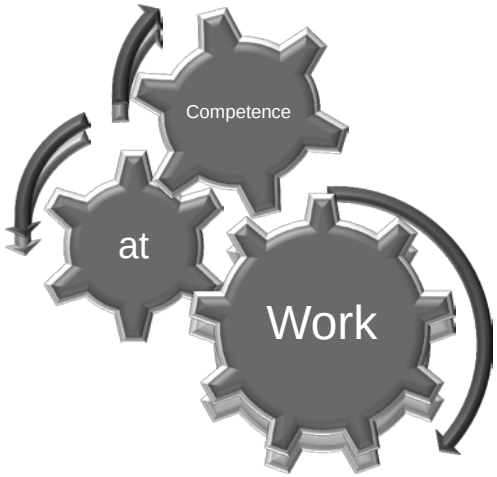
Prerequisites for Performance and Guarantee

- Furnace dimensions are according SE guideline approx. 6,5m x 8,5m x 14,6m (height from above hopper)
- 100% boiler load is given with 3 mills in operation
- Uniformity of dust distribution is max. +/- 10% (deviation from mean value)
- Air distribution takes place evenly among all burners and other air intakes
- The fuel of the lighting-up burner is fuel oil EL
- For the coal fineness:
  The value R_{90} = 10% (+/- 1.0%) or R_{200} = 0.2% (+/- 0.1%) is required for the screen residue

Performance Guarantee Values

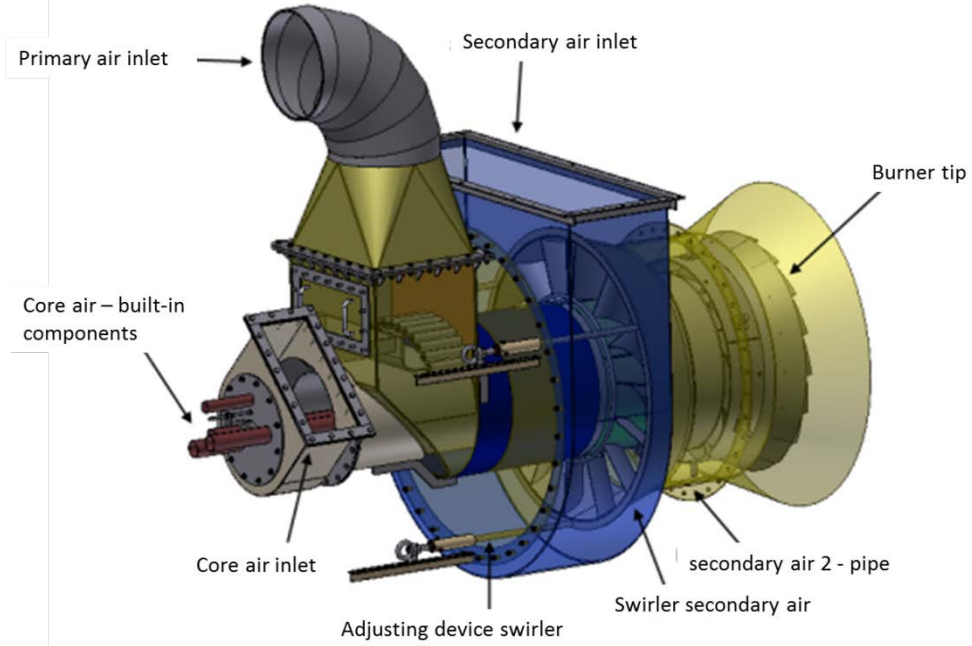
For boiler load at normal conditions of 100% <u>without</u> support firing and with specified coal Workuta and Khahasiya, the scope of supply for the firing system will meet the guarantees (hourly average values) as follows:

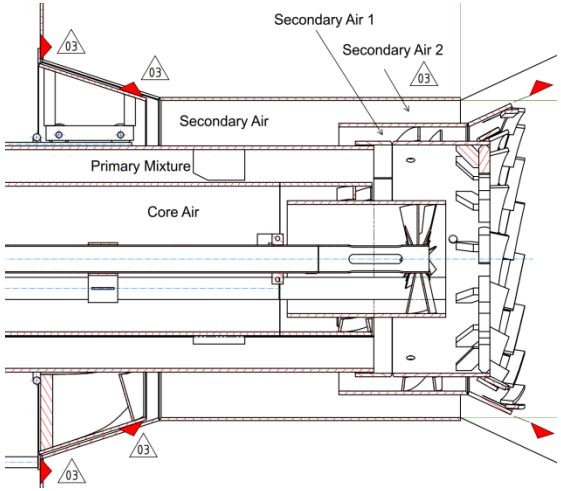
- for primary NOx ≤ 400 mg/Nm^3, dry gas at excess air ratio n = 1,4 (= 6 % O_2)
- for primary CO ≤ 400 mg/Nm^3, dry gas at excess air ratio n = 1,4 (= 6 % O_2)

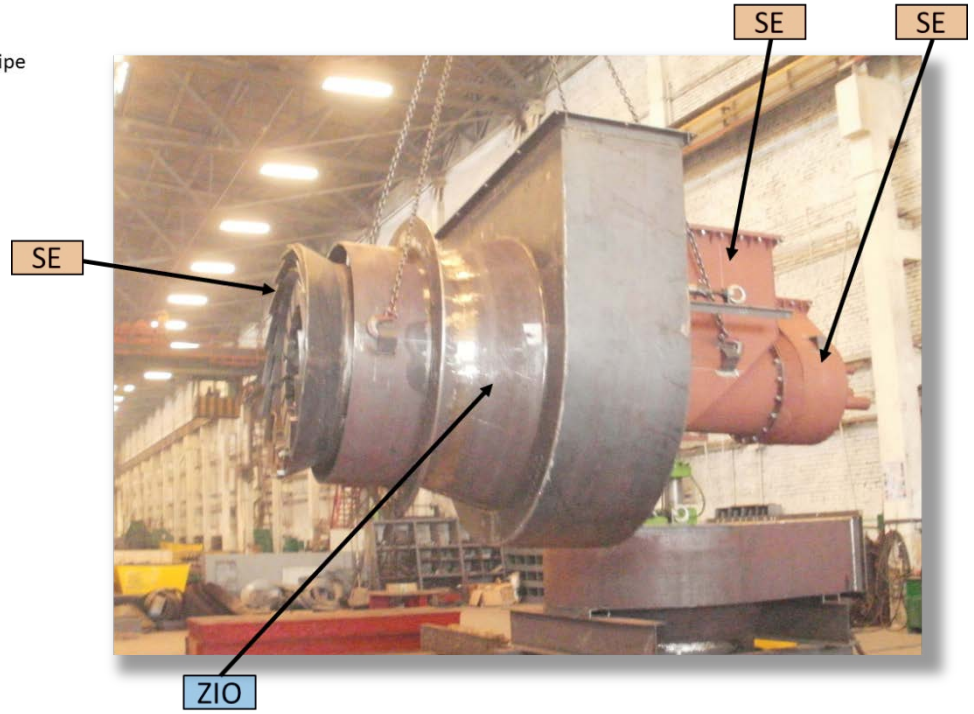


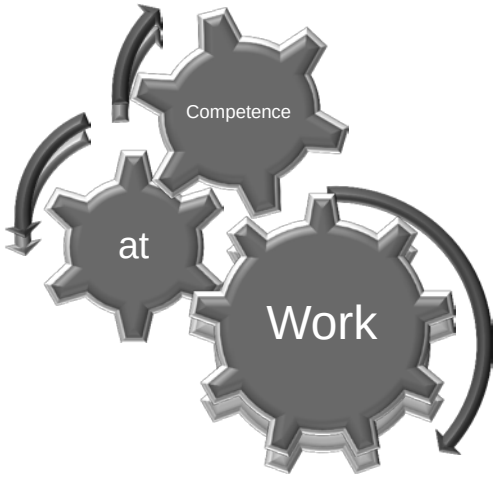
Scope of Steinmüller Engineering

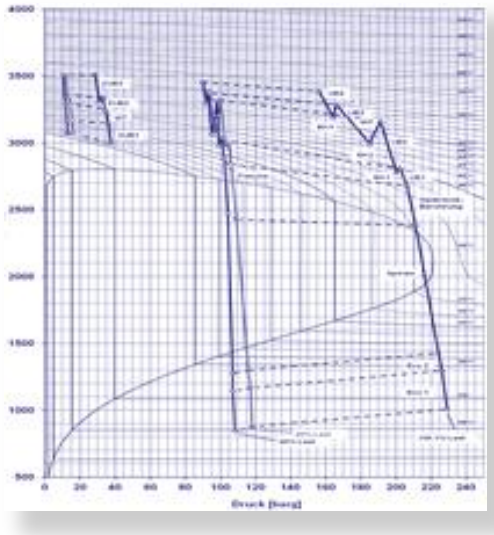
- Firing concept – arrangement and design of coal and oil burners
- Heating surface arrangement – heat distribution in radiative and convective heating surfaces
- Cleaning devices (soot blowers, water cannons etc.)
- Spray injection
- The design influencing parameters such as fuel/air ratio, coal fineness, minimum number of mills in operation, unburnt carbon in ash, slagging & fouling, minimum boiler load without support firing, etc. are to be agreed in a very short duration, i.e. Basic engineering stage, before proceeding with the tight manufacturing schedules
- Design Review of boiler


Primary air inlet
Secondary air inlet
Burner tip
Core air – built-in components
Core air inlet
secondary air 2 - pipe
Swirler secondary air
Adjusting device swirler

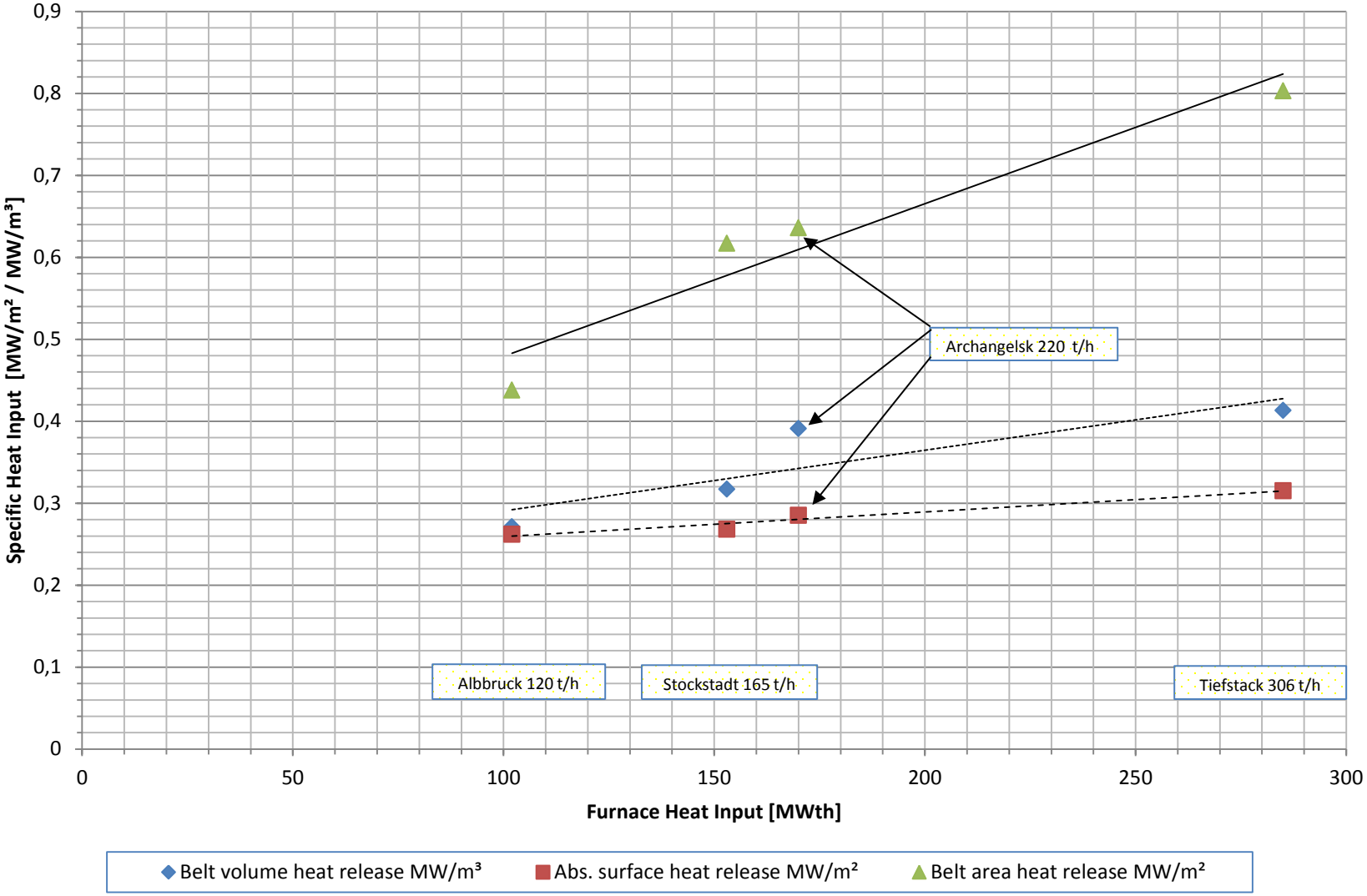

Secondary Air 1
Secondary Air 2
Secondary Air
Primary Mixture
Core Air
03


SE
SE
SE
ZIO

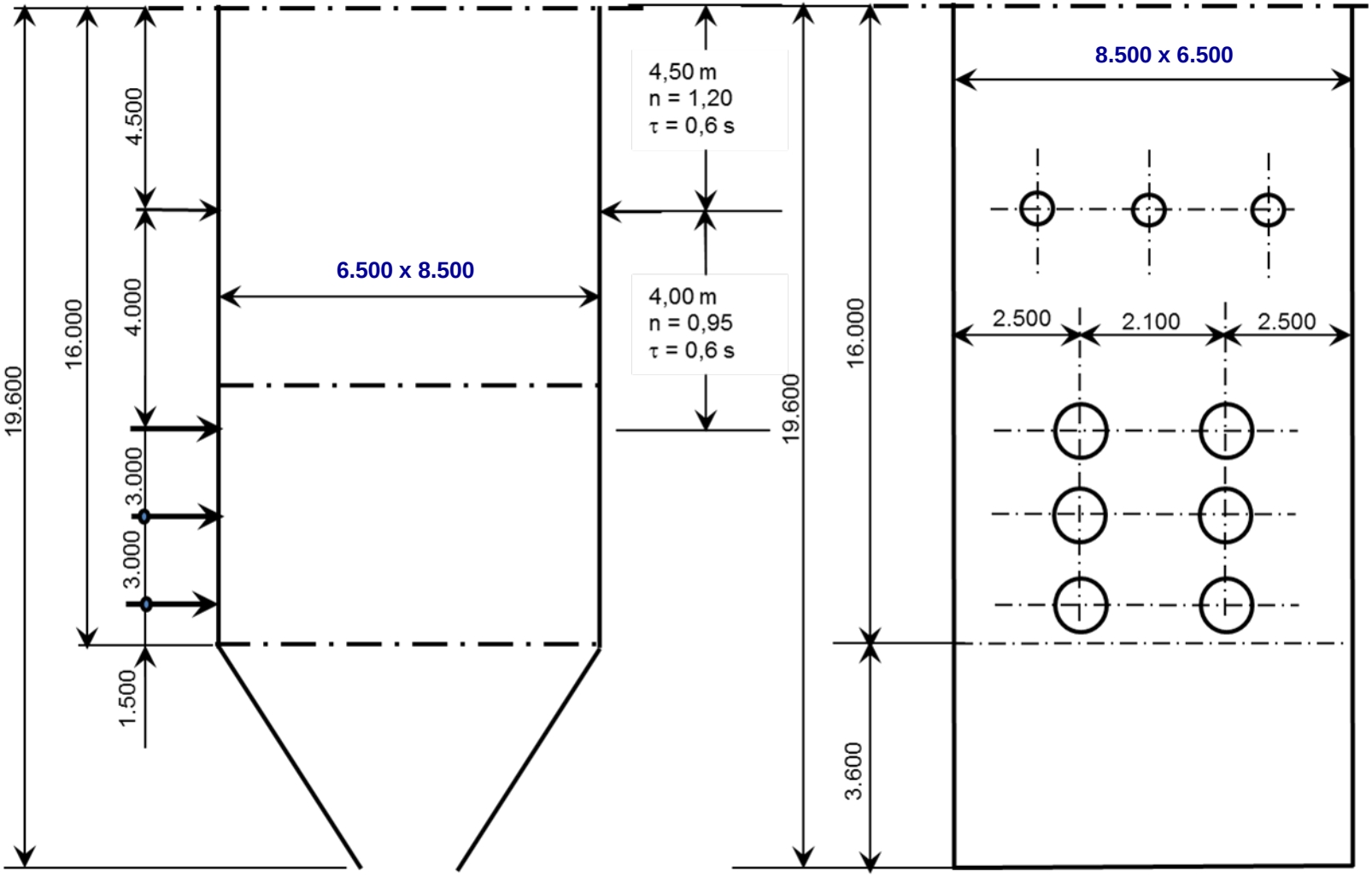


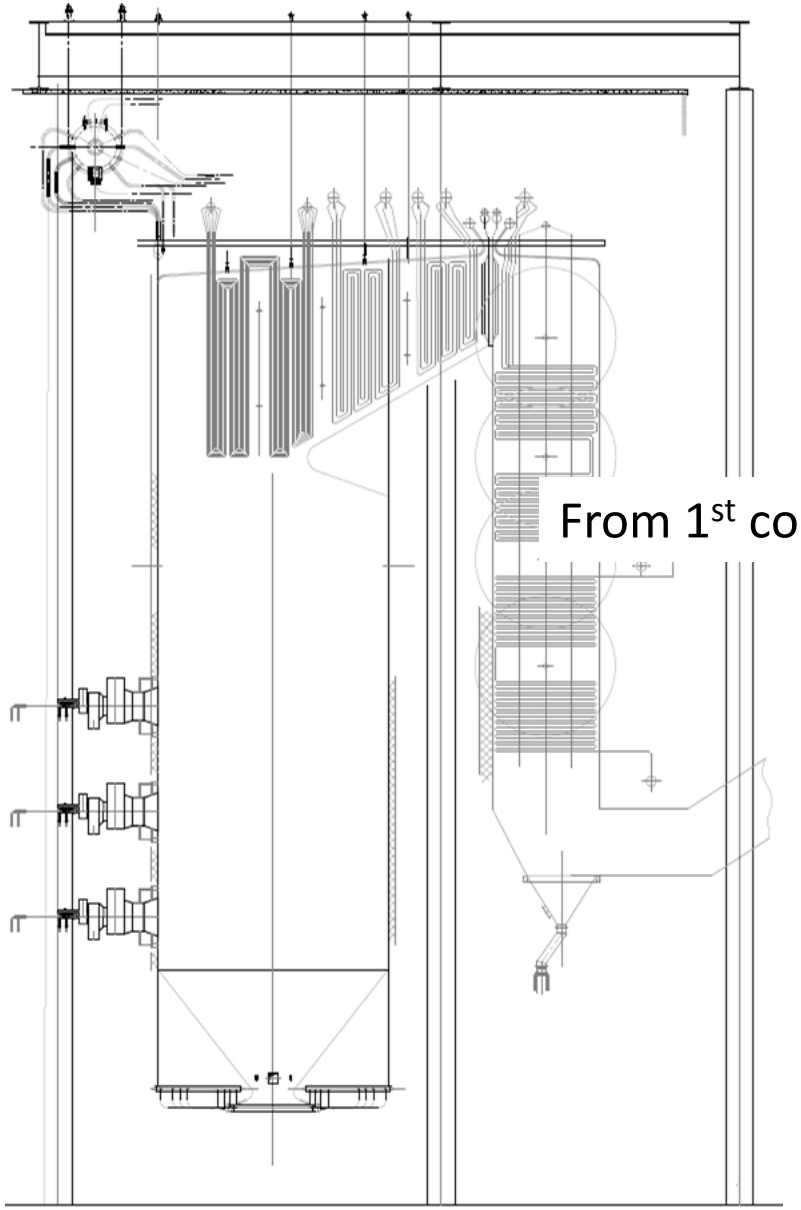


Outcome

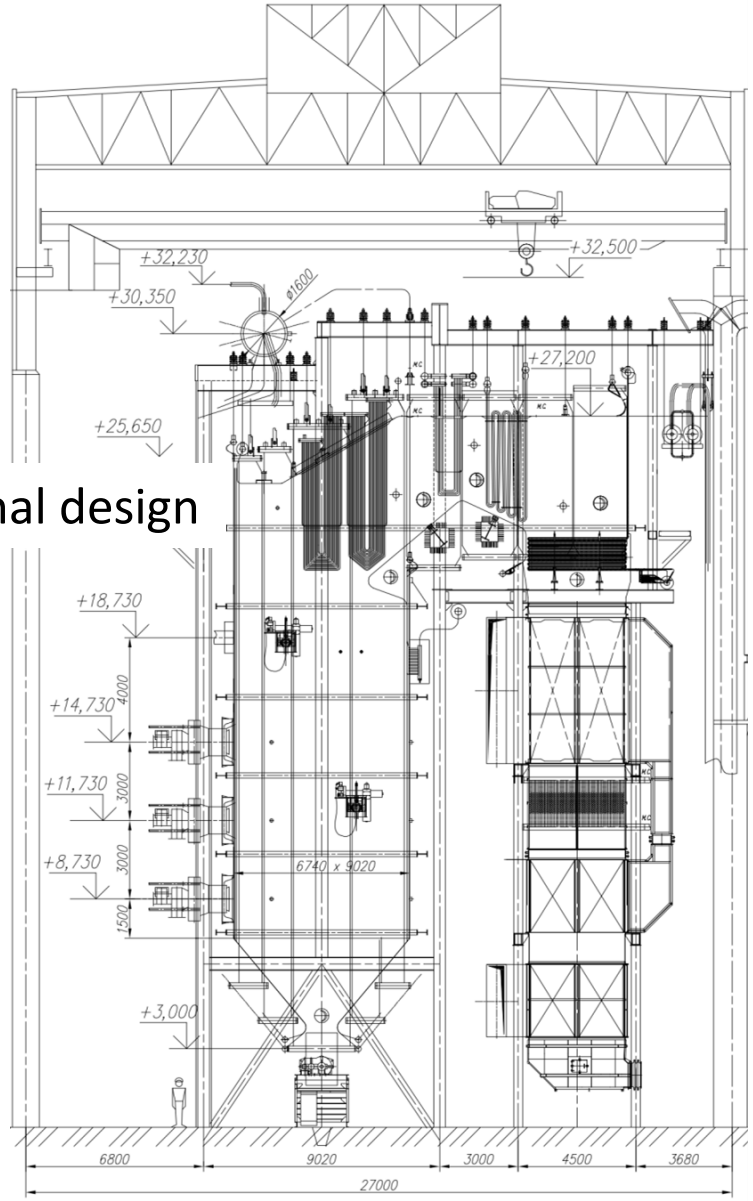

0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
Specific Heat Input [MW/m² / MW/m³]
0
50
100
150
200
250
300
Furnace Heat Input [MWth]
Archangelsk 220 t/h
Albbruck 120 t/h
Stockstadt 165 t/h
Tiefstack 306 t/h
Belt volume heat release MW/m³
Abs. surface heat release MW/m²
Belt area heat release MW/m²

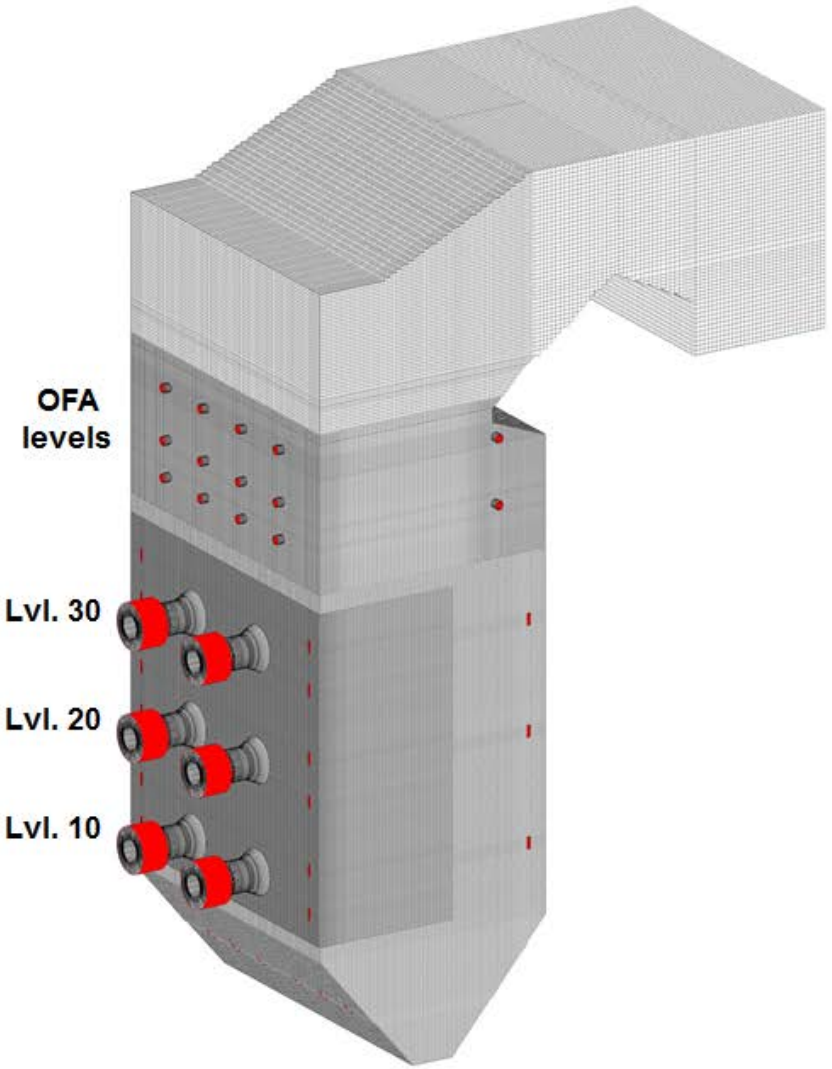
1st furnace concept

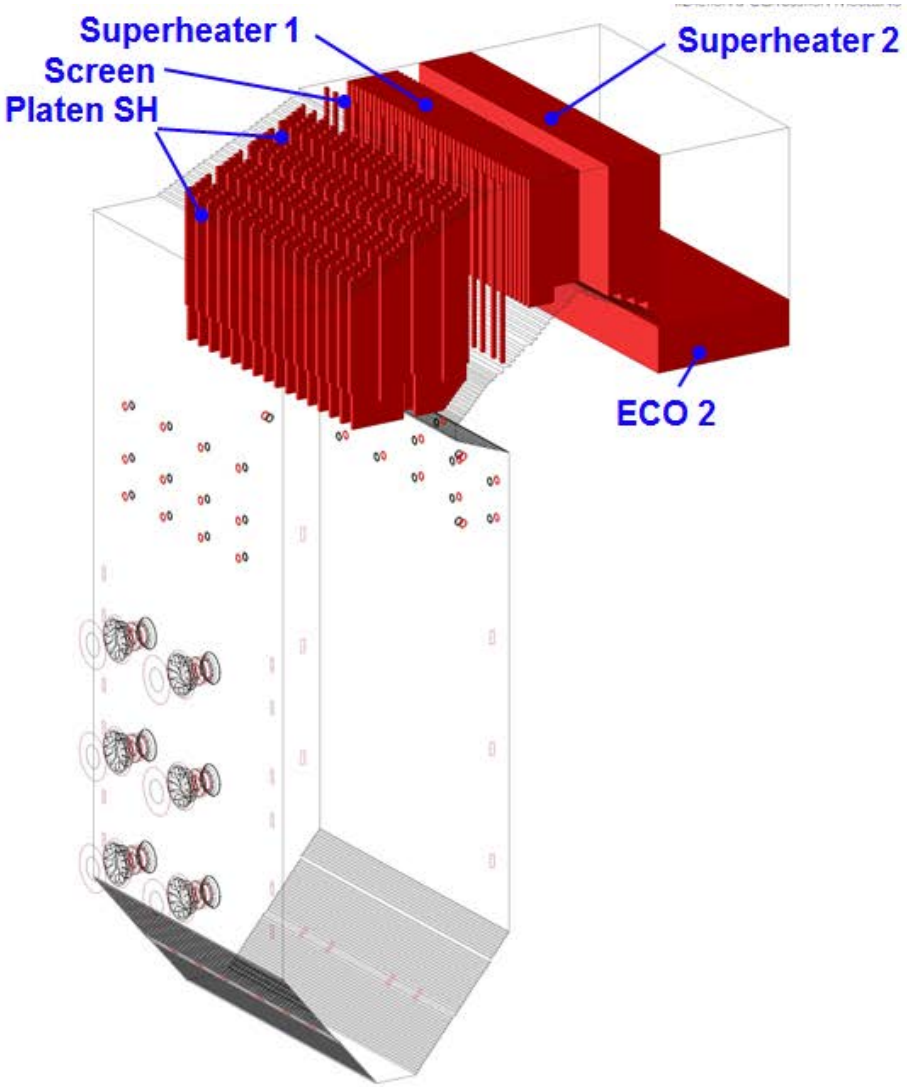


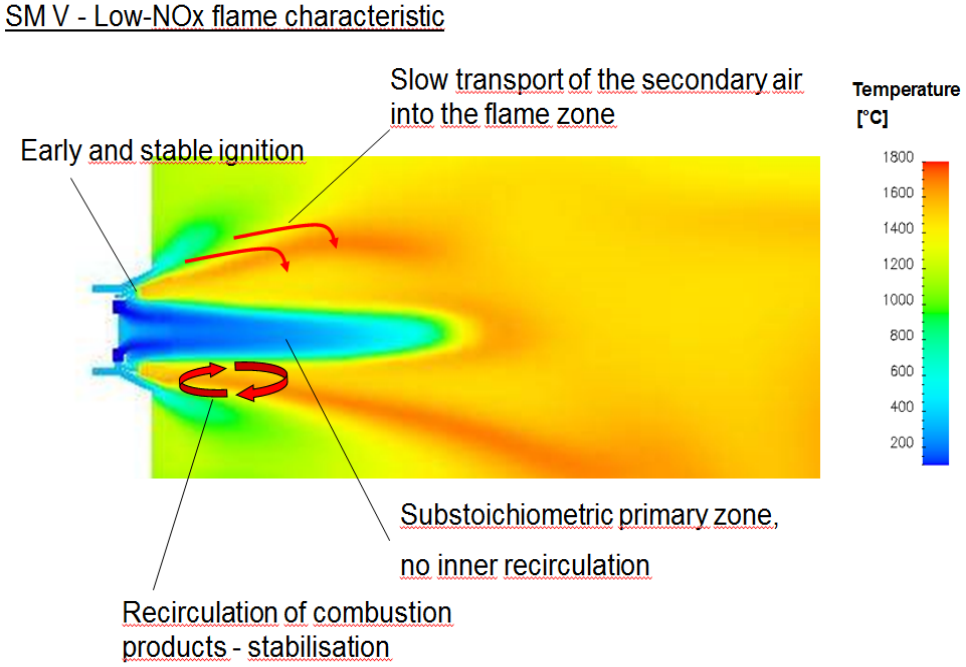


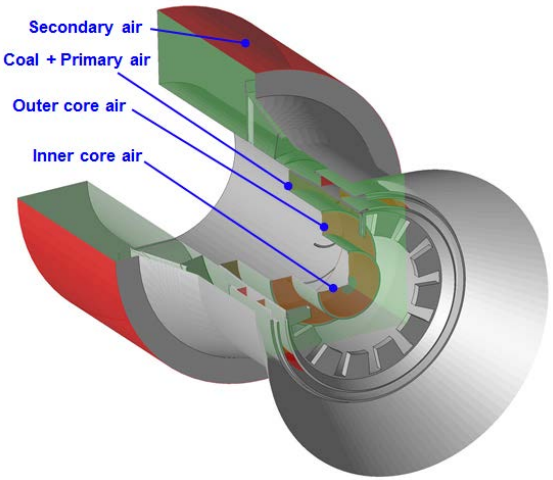
From 1st concept to final design




OFA
levels
Lvl. 30
Lvl. 20
Lvl. 10

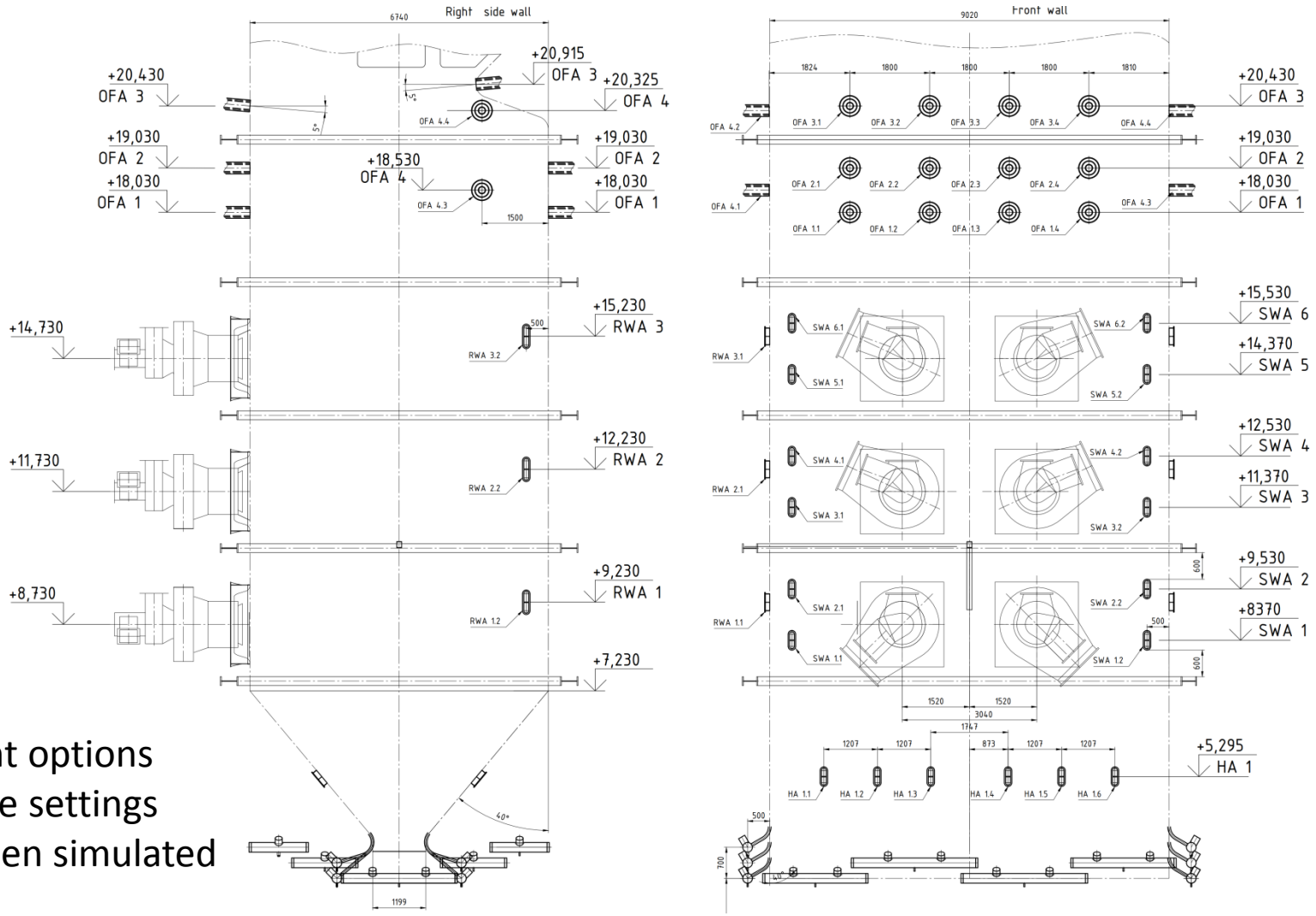

Superheater 1
Screen
Platen SH
Superheater 2
ECO 2





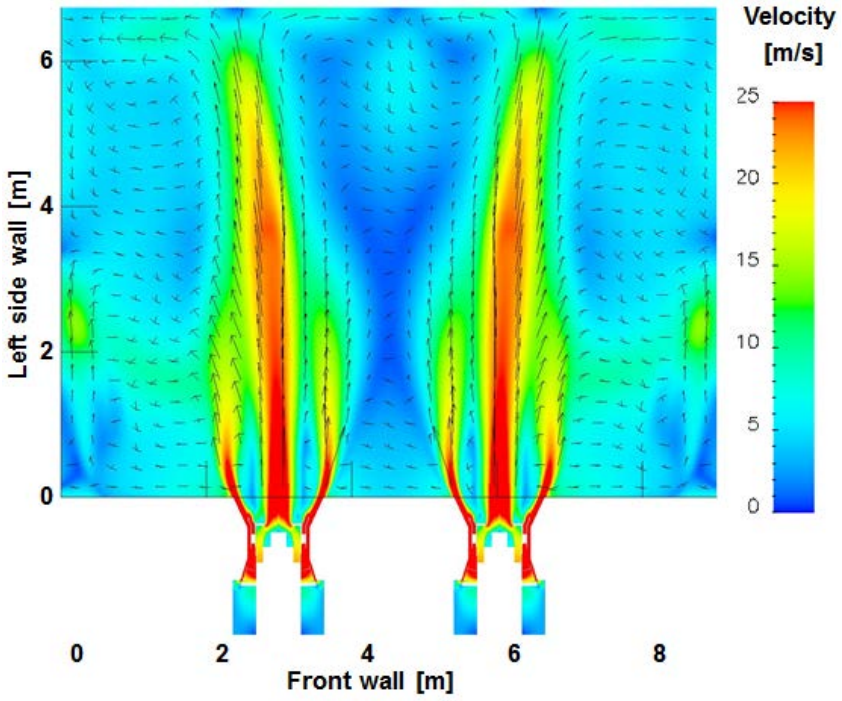
- Ratio of primary air to coal of 1,8 kg/kg (better even 1,6 kg/kg)
- Substoichiometric primary air zone needed for avoiding NOx-formation (formation of N_2 instead of NOx)
- High secondary air velocity is needed for internal air staging
- Optimal ratio of low NOx and CO emissions at the same time has to be adjusted

CFD Simulation

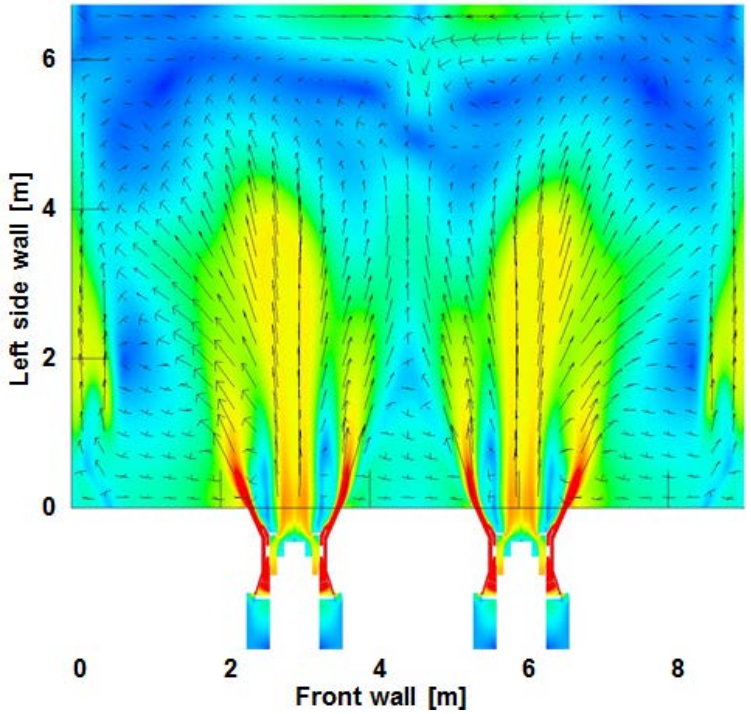


Different options of nozzle settings have been simulated

Simulation results Burner comparison

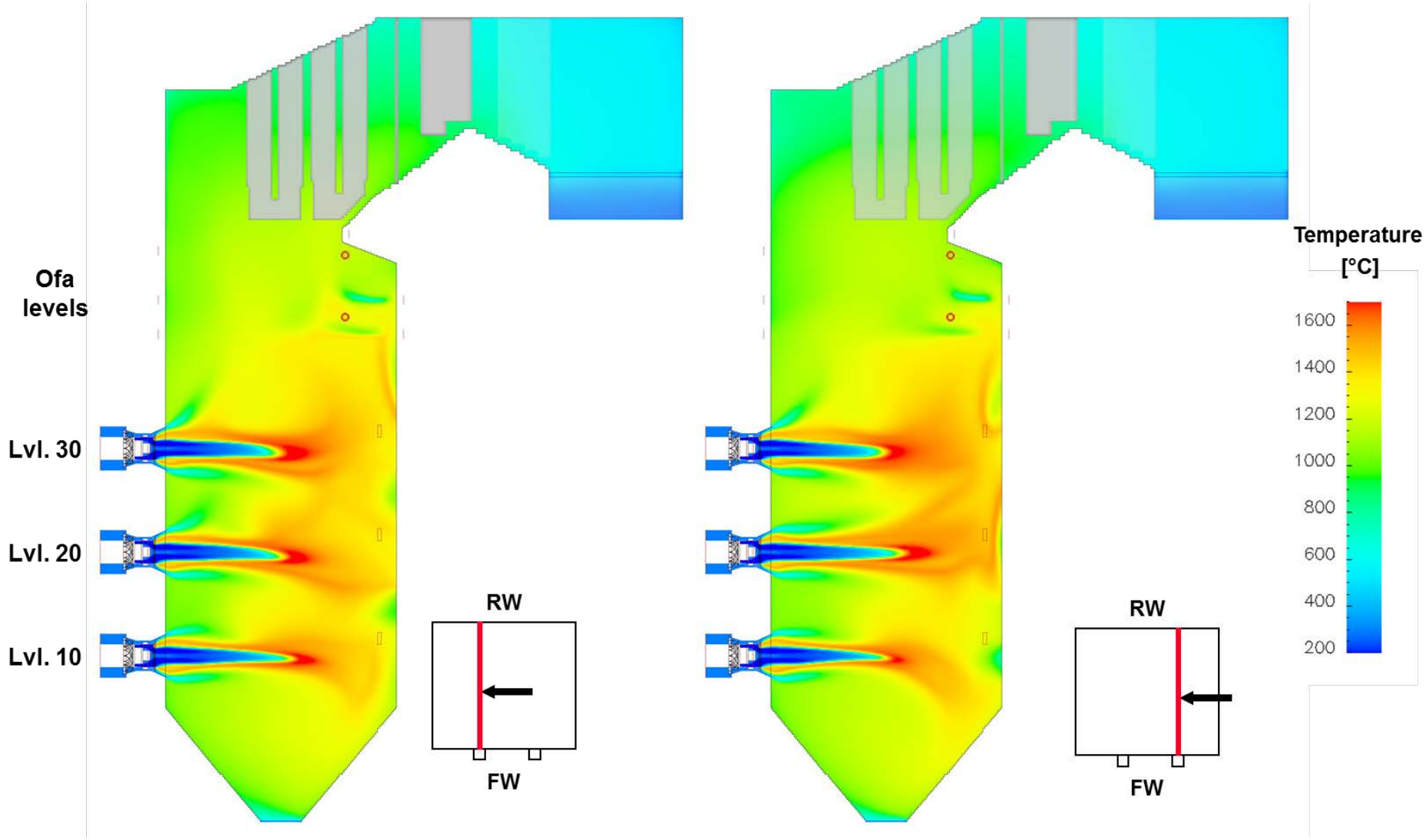


Velocities and flame shapes of early design



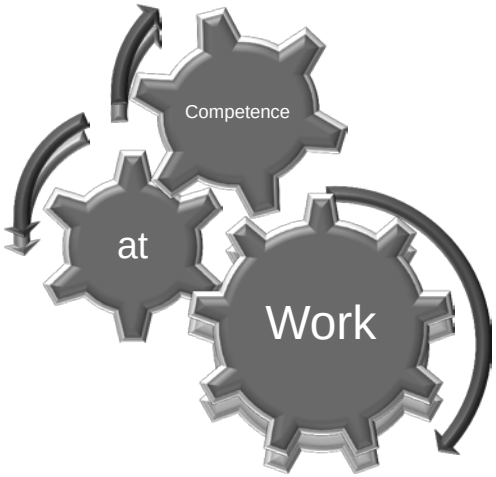
Velocities and flame shapes of final design

Simulation results Temperature profile



- 5 different case simulations
- 3 burner design variants
- Different OFA and SWA nozzle configurations / arrangements
- Complying NOx emissions
- Wall atmosphere and unburned carbon to be improved

	Baseline Simulation LNB Baseline Case	Simulation 2 Modified LNB	Simulation 3 Coal dust concentrated at flame holder teeth	Simulation 4 Smaller flame holder teeth + mod. OFA arrangement
Average gas temperature at nose level (21.1 m) [°C]	1150	1146	1132	1138
CO [mg/Nm^3@6%O_2]	90-100	95-105	95-105	85-95
NO_x [mg/Nm^3@6%O_2]	395-430	380-410	370-400	365-395



Conclusion

Conclusion

-Predicted Goals -

- NOx reduction less than 400 mg/Nm³ without secondary measures
- Corrosion protection of combustion chamber by sidewall air
- Avoiding of slagging and fouling of furnace and convective heating surfaces by staggered excess air and optimized flame shape
- Protection of furnace tubes against corrosion
- Boiler fits into existing boiler house
- Increase of operating flexibility and availability compared to existing boilers
- A safe and stable combustion of pulverized and specified coal is ensured for the load range of 40% - 100% of boiler load
- Long life of burners

Customer benefit

- Steinmüller Engineering is used to apply tailor-made solutions for customers benefit
- Decades of experience with high-skilled lead engineers
- Flexible contract structure (Engineering only, Engineering & Supply, Expediting services, EPC, …)
- Network of reliable sub-suppliers
- In-house design tools with continuous development and validation with feedback from operating plants
- Engineering & evaluation independent from supply & technology
- Continuous R & D and technology development
- After sales service
- Skills development and localisation

The described project shows that an integral approach and combined effort of all parties results in the best customized solution with lowered emissions and upgraded efficiency, without generating additional risks in the later operation.