Thyssenkrupp Industrial Solutions

Coke Plant Technologies

The value of engineering for reduction of CAPEX and OPEX as well as for optimizing the performance of coking plants

25 Anniversary of Polish National Cokemaking Conference

Koksownictwo 2017

engineering.tomorrow.together.

thyssenkrupp

Development of coke plant technologies

~ 1980s

- Large number of coal mines and coke plants in Europe
- Rapid development of coke plant technologies
- Innovations constantly implemented on new plants
- Speed of innovation slowing down from 1980s

1990 ~ 2003

- Constant reduction of steel and coke production in Europe
- Supply of low cost coke from China
- Reduced number of projects for new plants
- Sharp reduction of specialists for design / R&D projects

2003 ~ 2012

- Enormous increase of coke price
- Boom in constr. of new and replacement of aged plants
- Copies of existing designs with little innovation
- Low number of R&D projects and design specialists

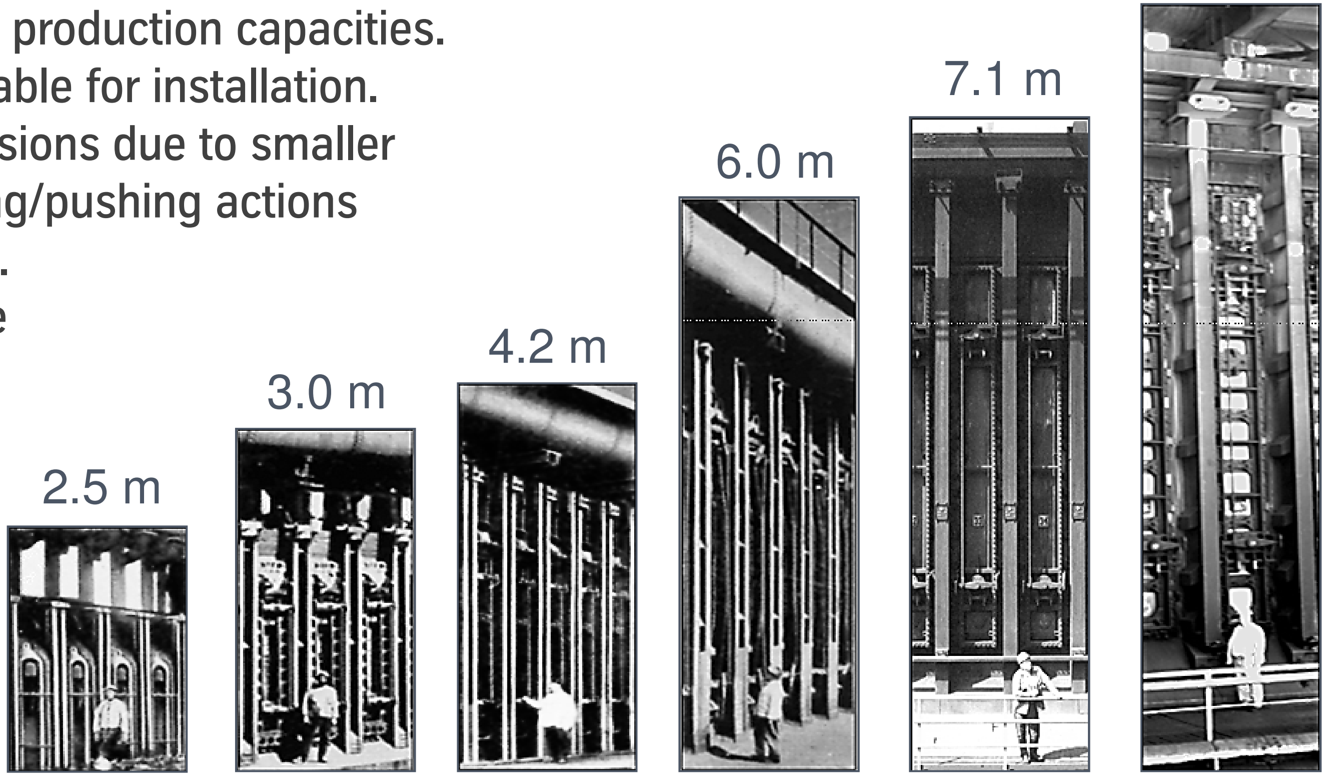
2012 ~ now

- Over-supply of steel on world market => low profits
- Very few projects for new plants
- Main buying criteria is lowest price (of engineering)
- Value of technology and design is not respected

Development of coke plant technologies

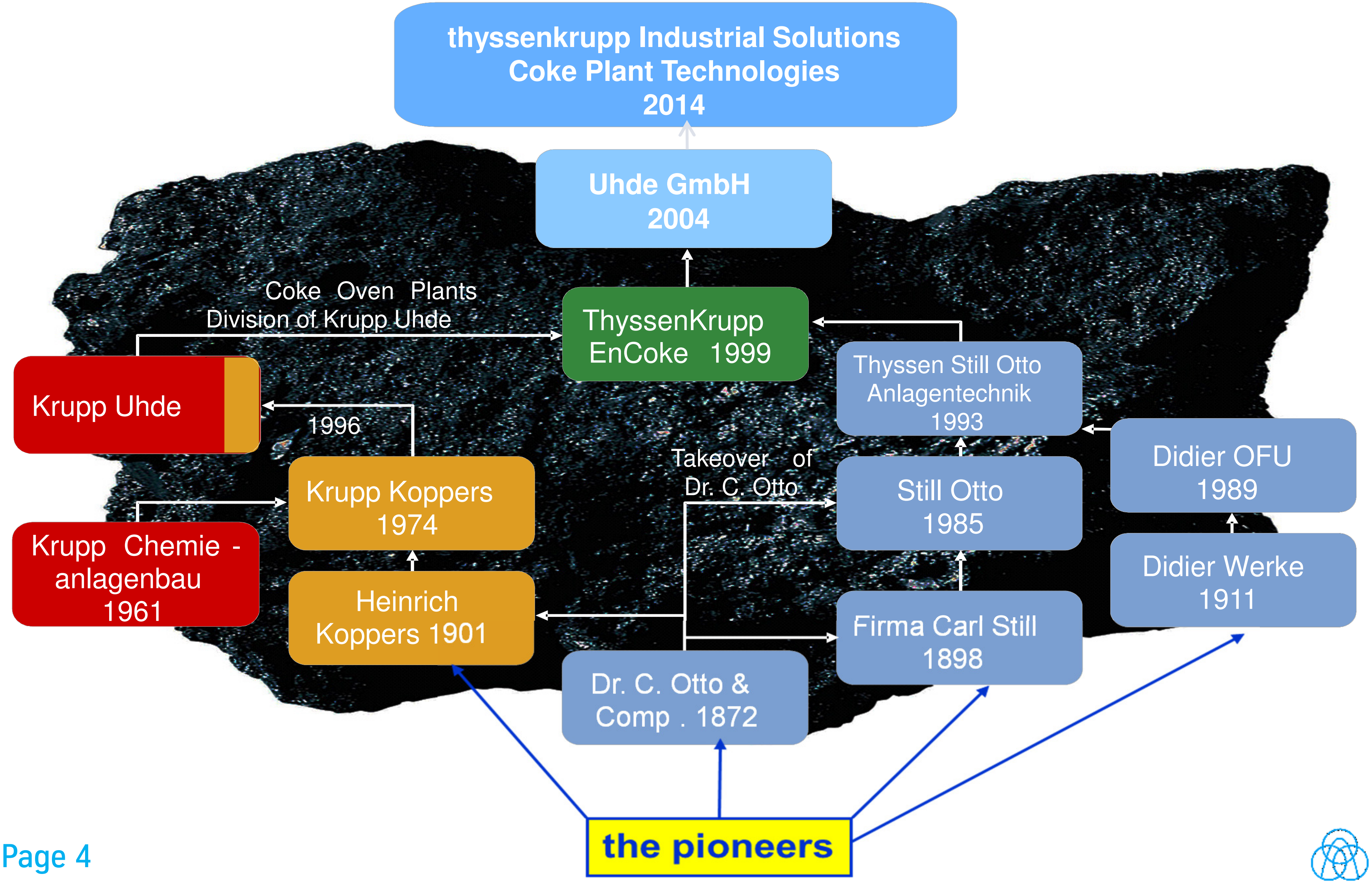
Example: increase in oven dimensions:

- Demand for larger production capacities.
- Limited area available for installation.
- Reduction of emissions due to smaller number of charging/pushing actions and oven closures.
- Desire to decrease manpower for operation and maintenance.



Development slowing down →

History of German companies for Coke Making Technology



Development of coke plant technologies

Requirements for future sustainability of coking industry

Optimization of

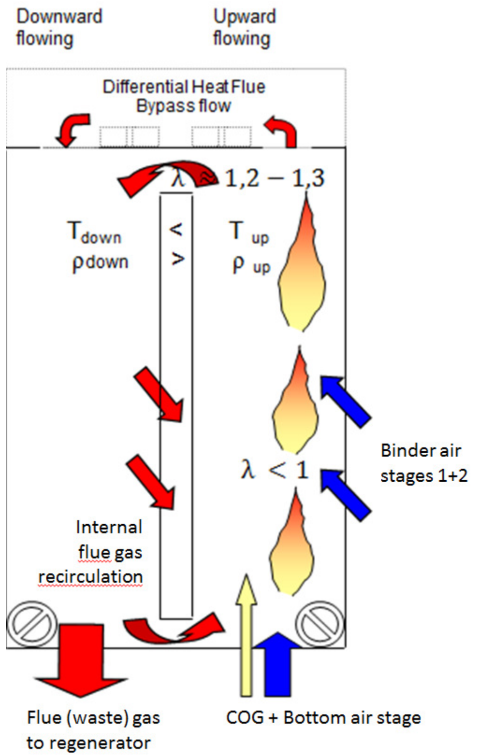
- operational safety and plant performance
- environmental plant performance
- working conditions in the plant
- cost for operation and maintenance (OPEX)
- plant service life

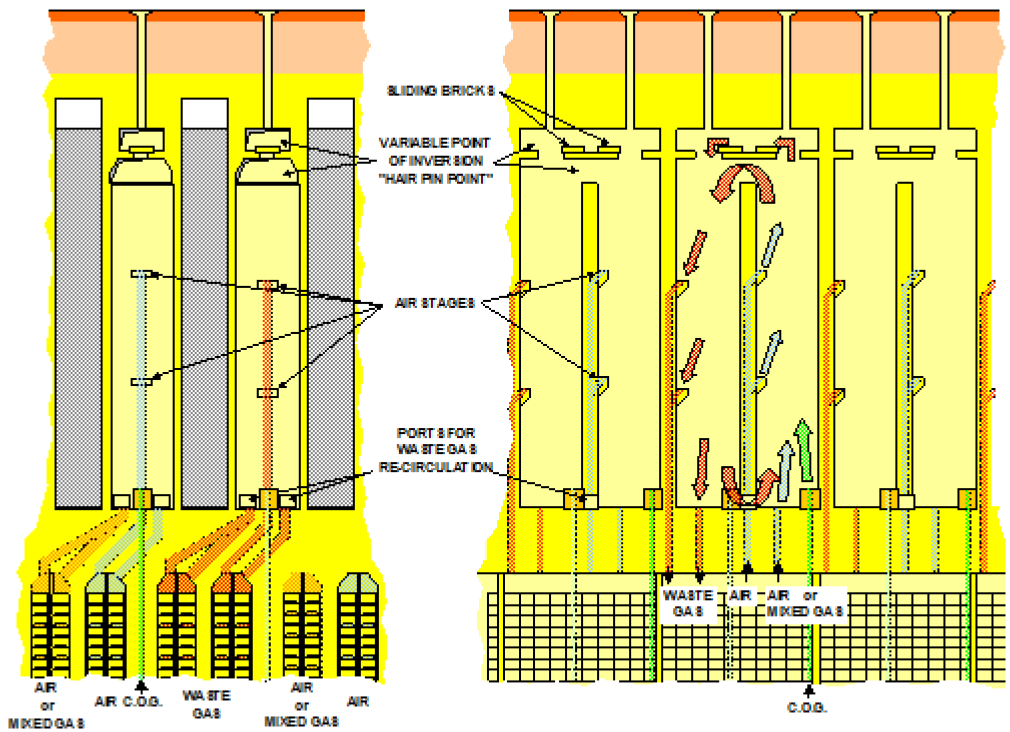
<u>Combined with reduced cost of investment (CAPEX) !</u>

How can that be achieved ??

Reduction of NOx-content in waste gas

Combiflame® heating system

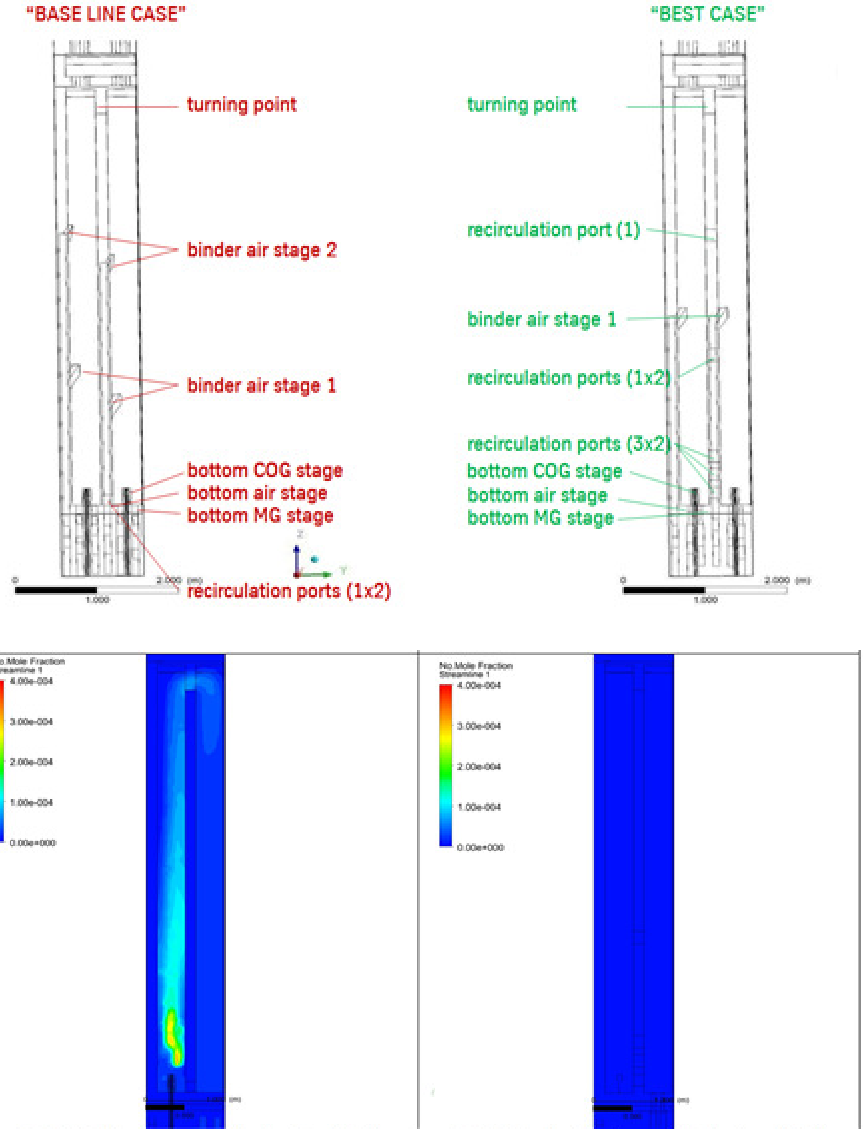




Combination of air staging and internal flue gas recirculation

Reduction of NOx-content in waste gas

Combiflame®
heating system



2. 2D NO_x distribution -mole fraction (COG)

2. 2D NO_x distribution - mole fraction (COG)

Combiflame® 2.0
heating system

Largely reduced
NOx-formation

Reduction of NOx-content in waste gas

Combiflame® 2.0 provides for:

- ➢ Reduction of NOx-formation at constant heating flue temperatures
- ➢ Improved heat distribution over the height of heating flues

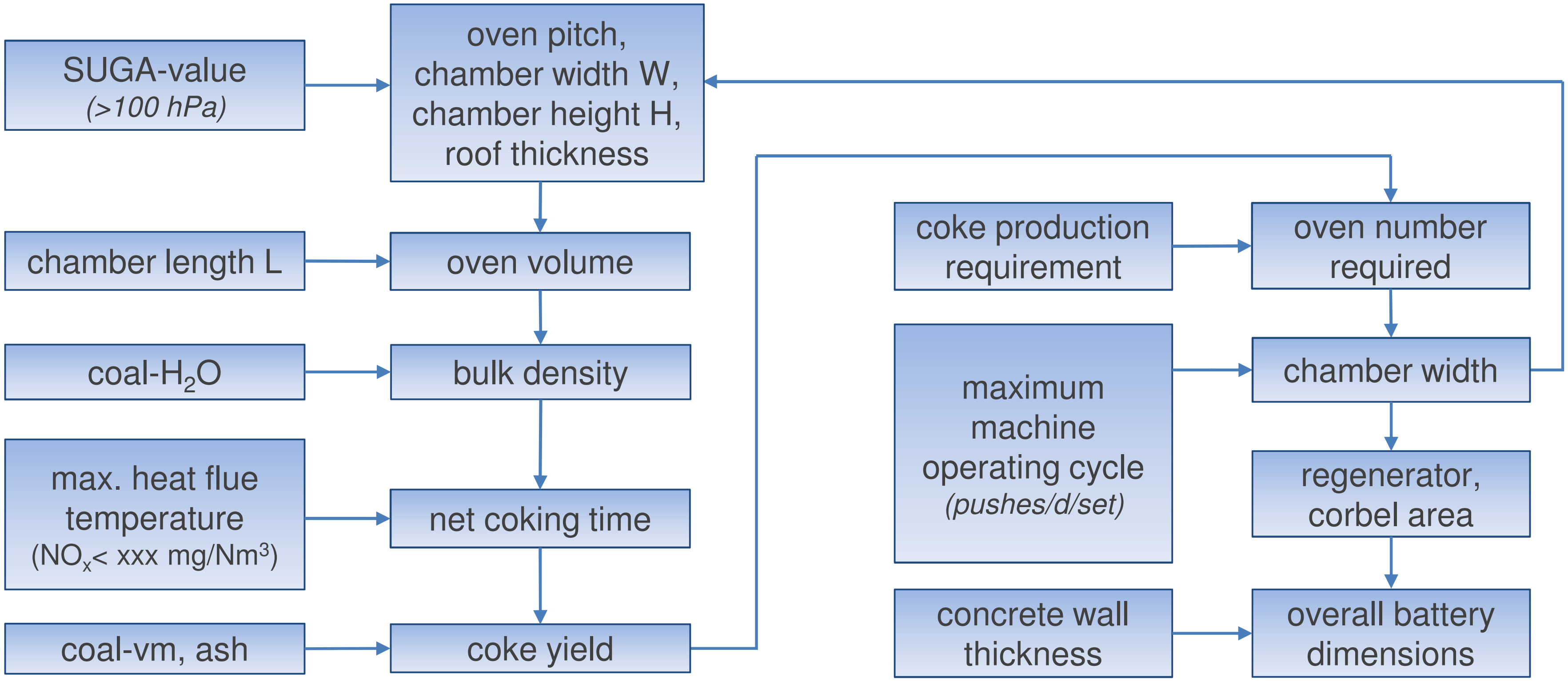
Example from a recent project:

Production capacity	1,600,000 tons/year
Limit of NOx-content in waste gas	< 150 ppm
Copy of an existing design requires	128 ovens
Average heating flue temperature	1,250°C
Optimized design concept requires	120 ovens
Average heating flue temperature	1,290°C
Reduced number of ovens	minus ~ 6.5%

<u>With much more potential after validation of present calculations</u>

Optimized oven dimensions

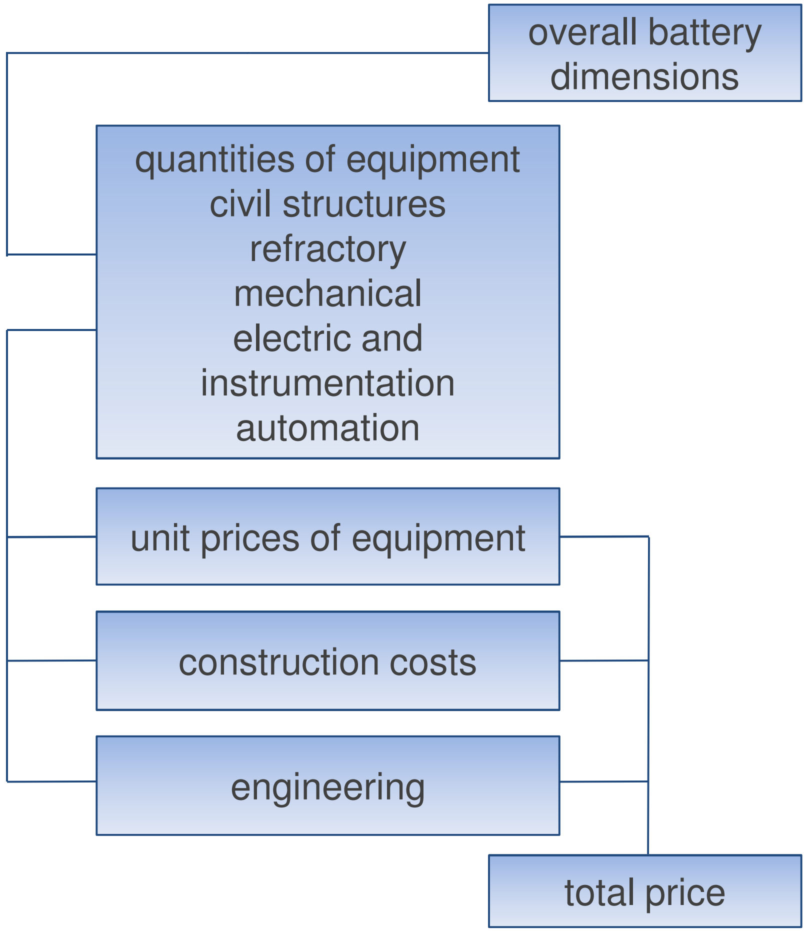
Methodology of main process engineering steps:



Optimized oven dimensions

Methodology of cost estimates:

- Total refractory quantities are calculated precisely based on the dimension of the battery.
- The quantities of all other equipment were compiled from completed plants and current project proposals, approximated by means of correlations with the battery dimensions.
- Unit prices for equipment and construction can be adjusted case by case depending on the country of manufacture / installation

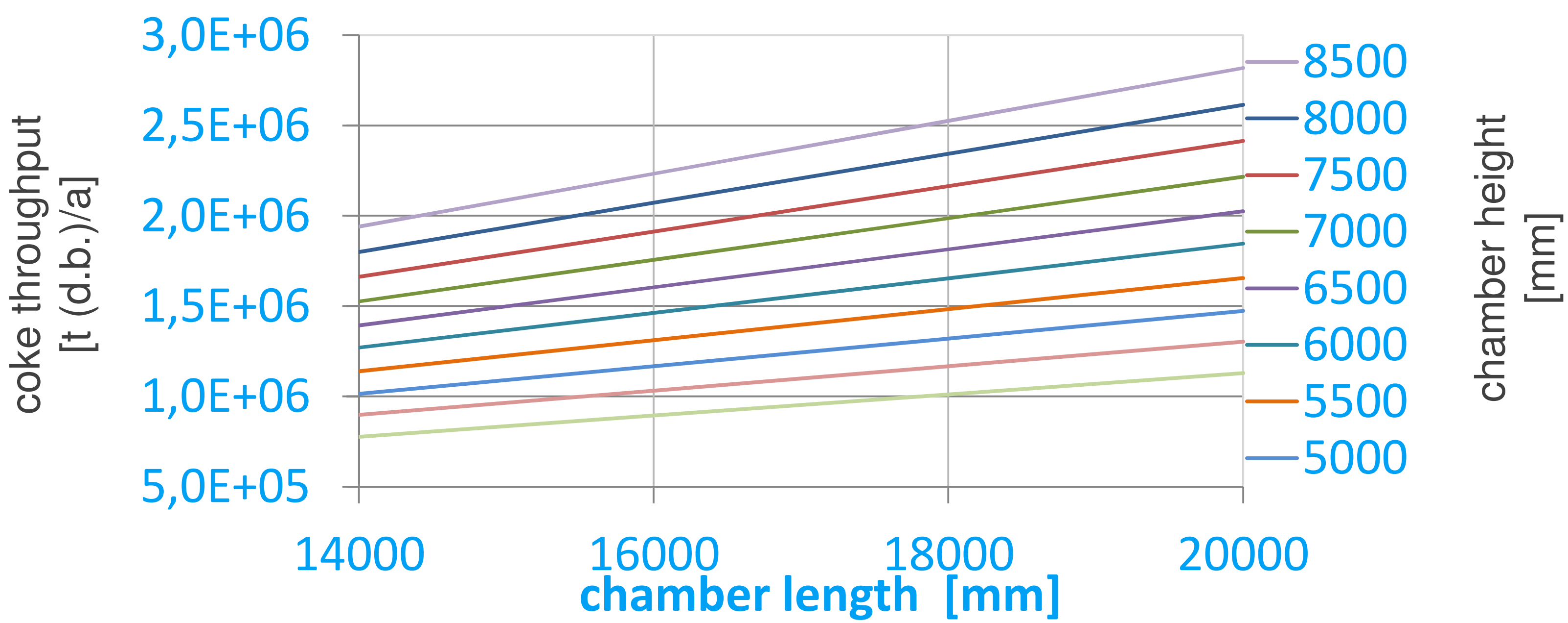


Optimized oven dimensions

Chamber length

Enlarging the chamber length causes:

- linear increase of production capacity (or reduced number of ovens)
- linear increase in quantities of refractory
- almost no increase in mech. equipment & electric/instrumentation/automation



Optimized oven dimensions
Chamber length

Enlarging the chamber length causes:

- linear increase of production capacity (or reduced number of ovens)
- linear increase in quantities of refractory
- almost no increase in mech. equipment & electric/instrumentation/automation

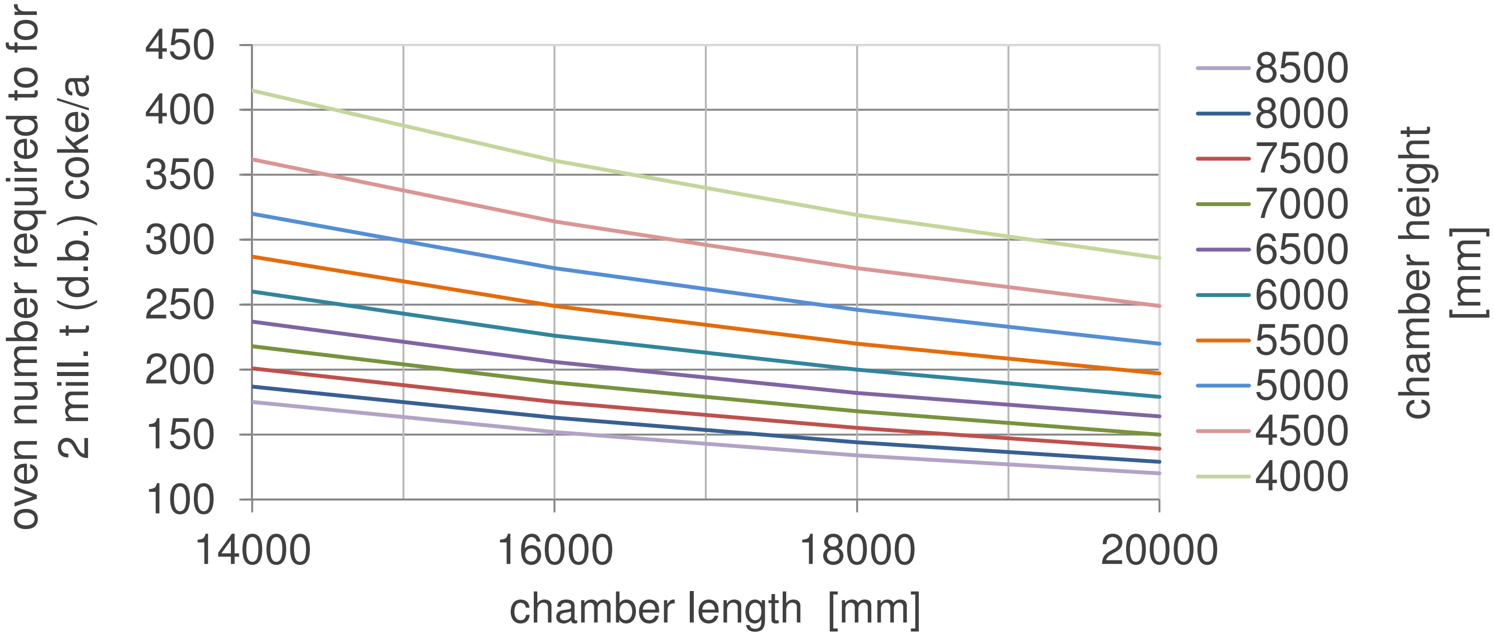
➢ The most economical way of capacity increase !

Optimized oven dimensions

Chamber height

Enlarging the chamber height causes:

- almost linear increase of production capacity (or reduced number of ovens)
- increased oven pitch in order to keep the wall stability
- disproportionate increase in quantity of almost all equipment



Optimized oven dimensions

Chamber height

Enlarging the chamber height causes:

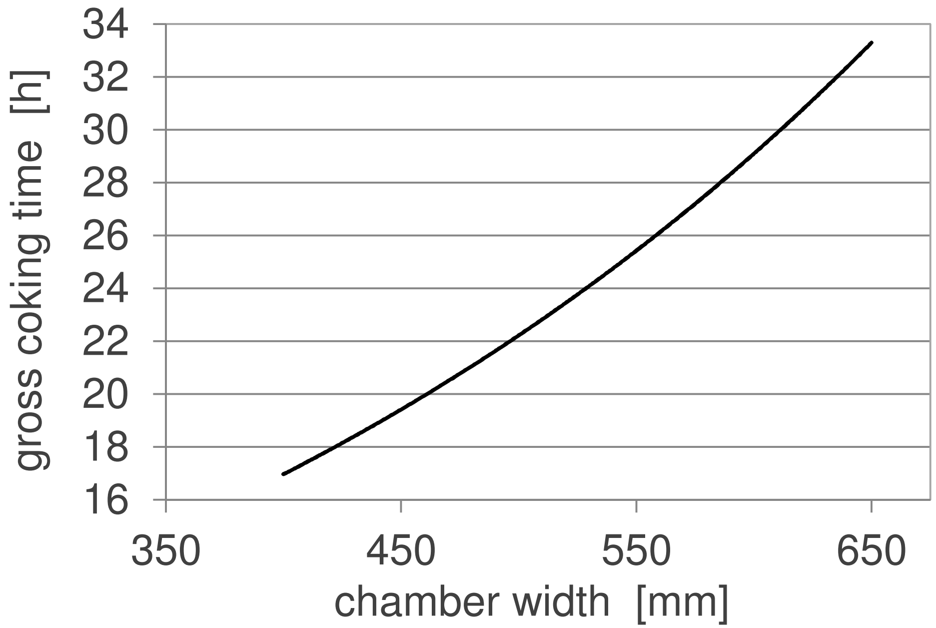
- almost linear increase of production capacity (or reduced number of ovens)
- increased oven pitch in order to keep the wall stability
- disproportionate increase in quantity of almost all equipment

➢ **The most costly way of capacity increase !**

Optimized oven dimensions
Chamber width

Enlarging the chamber width causes:

- slight reduction of production capacity (or more ovens)
- reduction of numbers of pushes per day
- reduction of regenerator height
- reduction of corbel thickness
- reduction of sole flue height
- increase of oven pitch
- slight increase of material quantities



Optimized oven dimensions

Chamber width

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- slight reduction of production capacity (or more ovens)
- reduction of numbers of pushes per day
- reduction of regenerator height
- reduction of corbel thickness
- reduction of sole flue height
- increase of oven pitch
- slight increase of material quantities

➢ **Important factor for achieving the optimum number of coke pushes per day !**

Optimum oven dimensions

Example from a recent project:

Production capacity	1,600,000 tons/year
Copy of an existing design requires	120 ovens 105 pushes / day

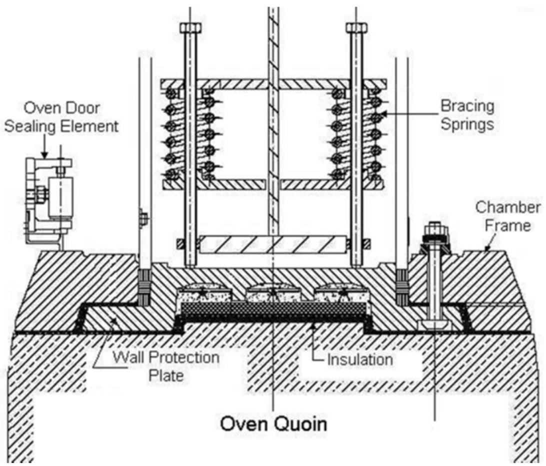
Optimizations of chamber dimensions proposed by tkIS:

- Increase of chamber length
- Reduction of chamber width
- Reduction of oven pitch

Optimized design concept requires	100 ovens 104 pushes / day
Reduced weight of mechanical equipment	minus 20%
Reduced weight of refractory material	minus 10%

Design improvements

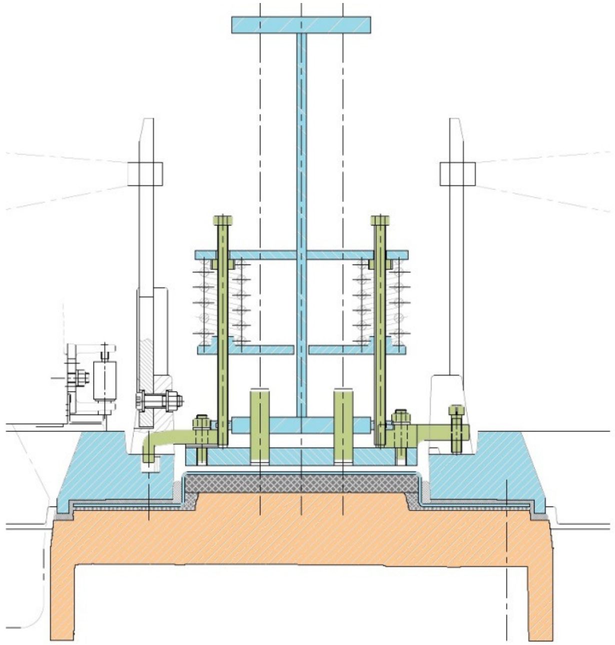
Design of wall protection plates



Design with wall protection plate of cast iron

Very heavy => high cost

High thermal deflection



Design with wall protection plate plus sealing membrane of mild steel plate

Light weight => low cost

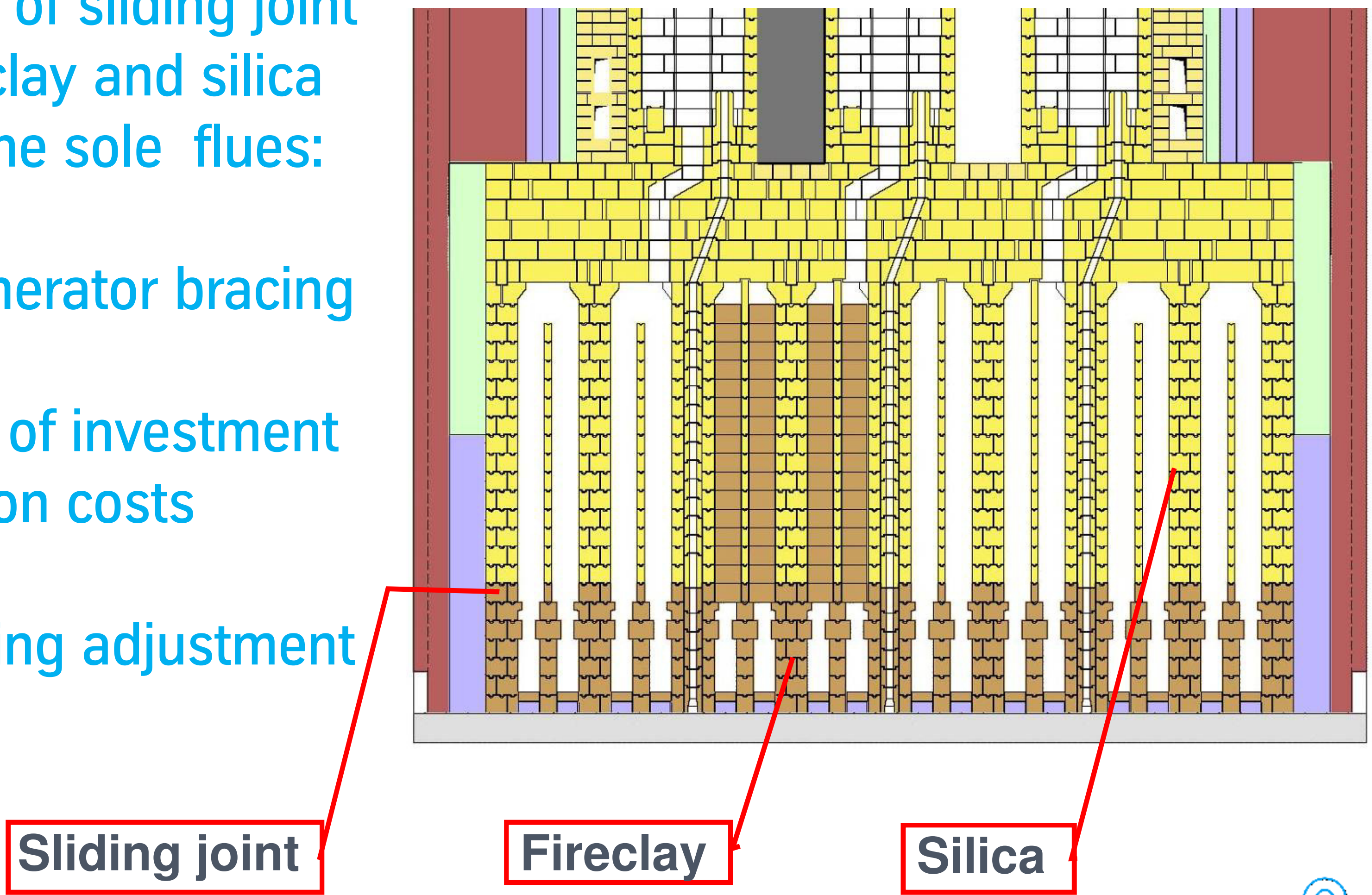
Easy adjustment

Increased tightness

Design improvements
Location of regenerator sliding joint

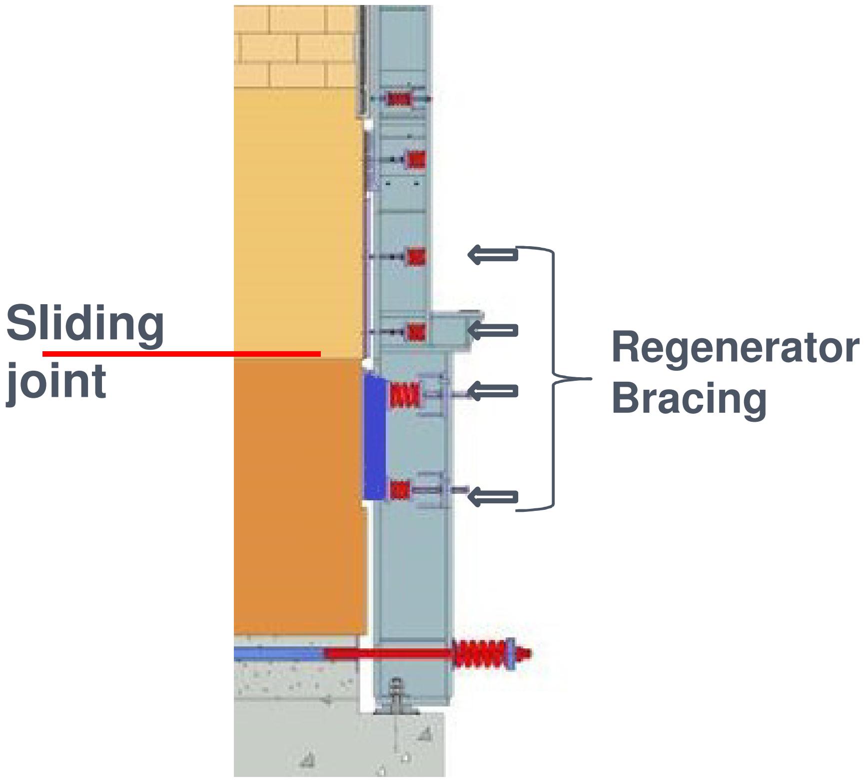
Arrangement of sliding joint between fireclay and silica right above the sole flues:

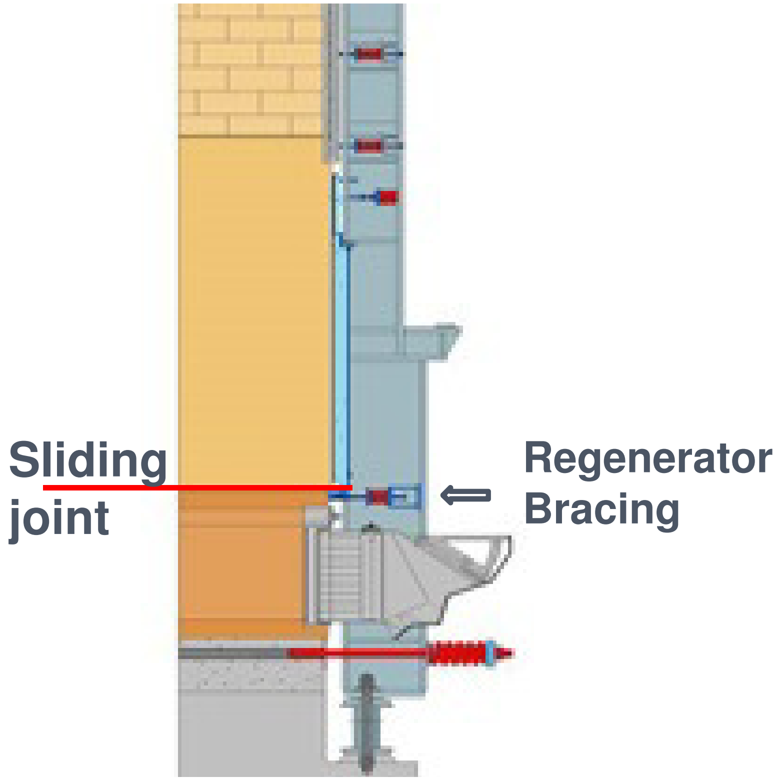
- Less regenerator bracing
- Reduction of investment and erection costs
- Easier spring adjustment



Design improvement

Location of regenerator sliding joint





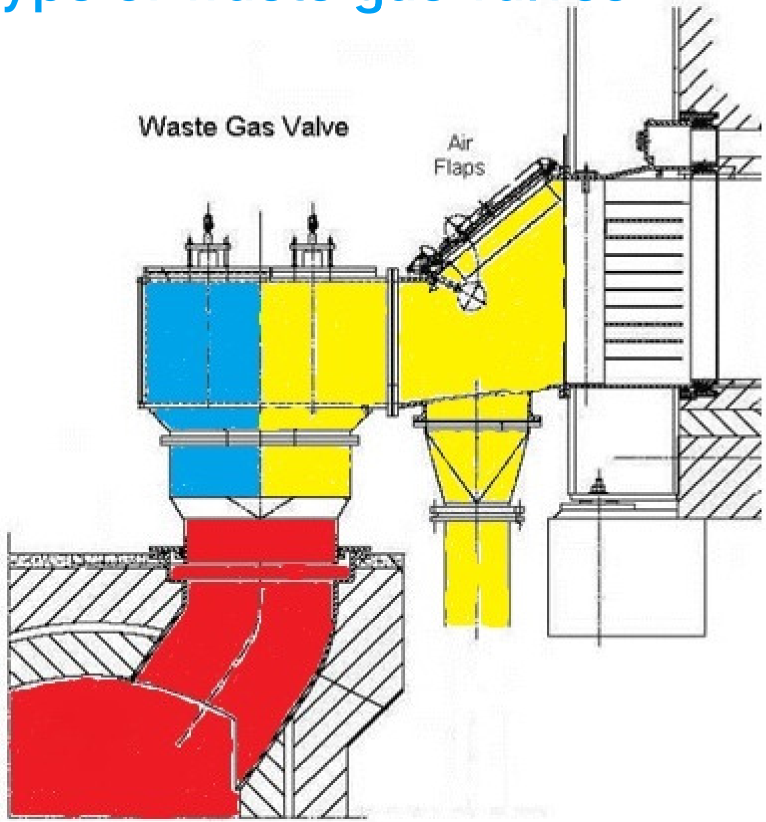
High level of sliding joint

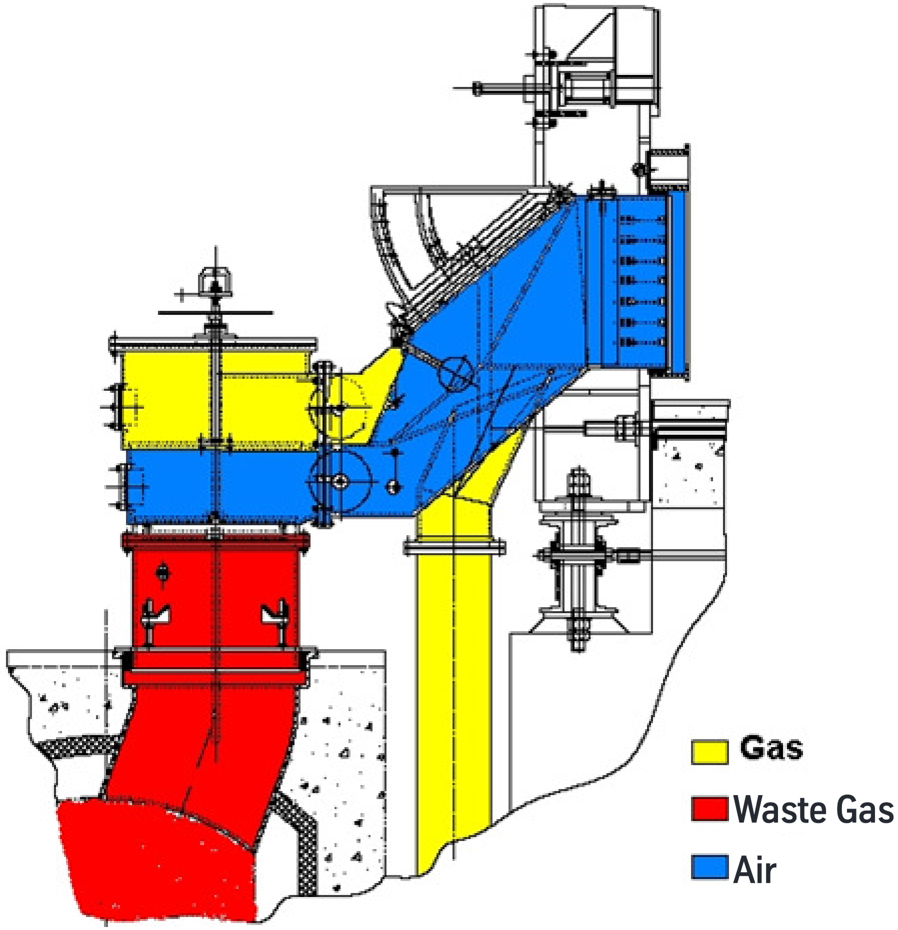
Many springs, high cost, difficult adjustment

Low level of sliding joint

Less springs, reduced cost, easier adjustment, reduced strains on buckstay

Design improvements
Type of waste gas valves

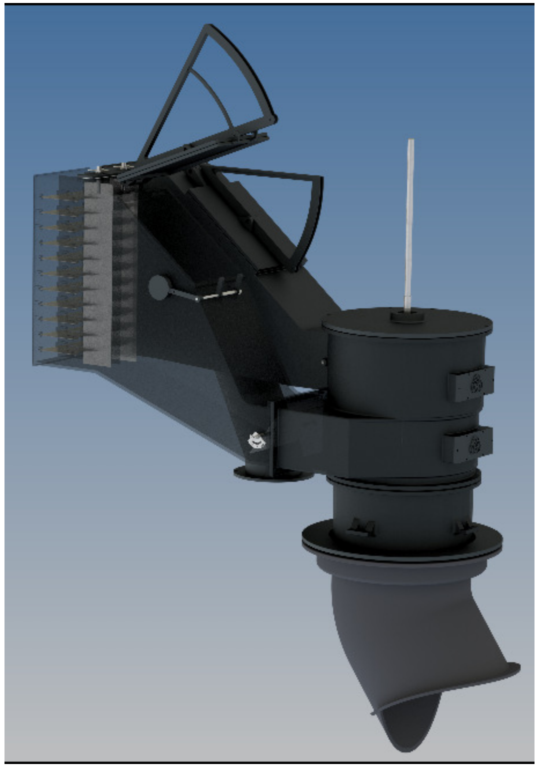


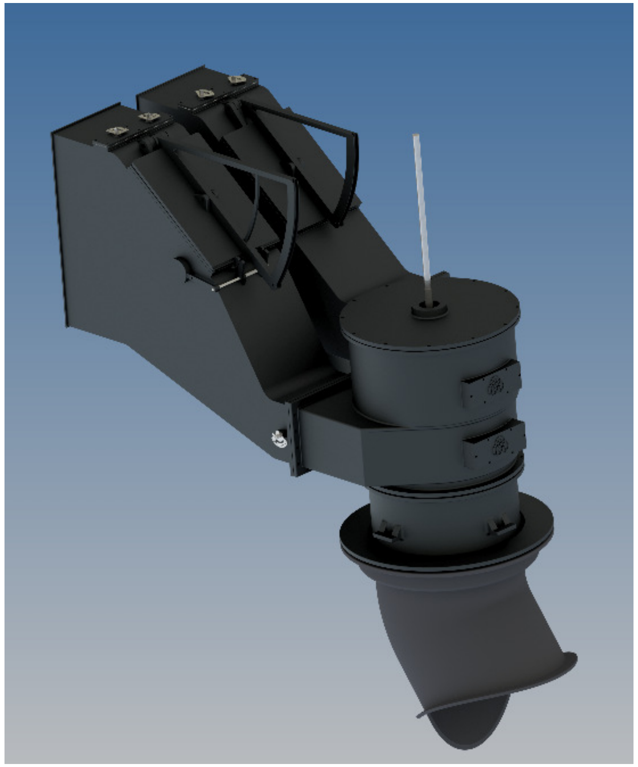


Valve with 2 spindles
Leakages possible between air and waste gas

Valve with 1 Spindle
With bettersealing between gas and waste gas (air between gas and waste gas)

Design improvements
Type of waste gas valves



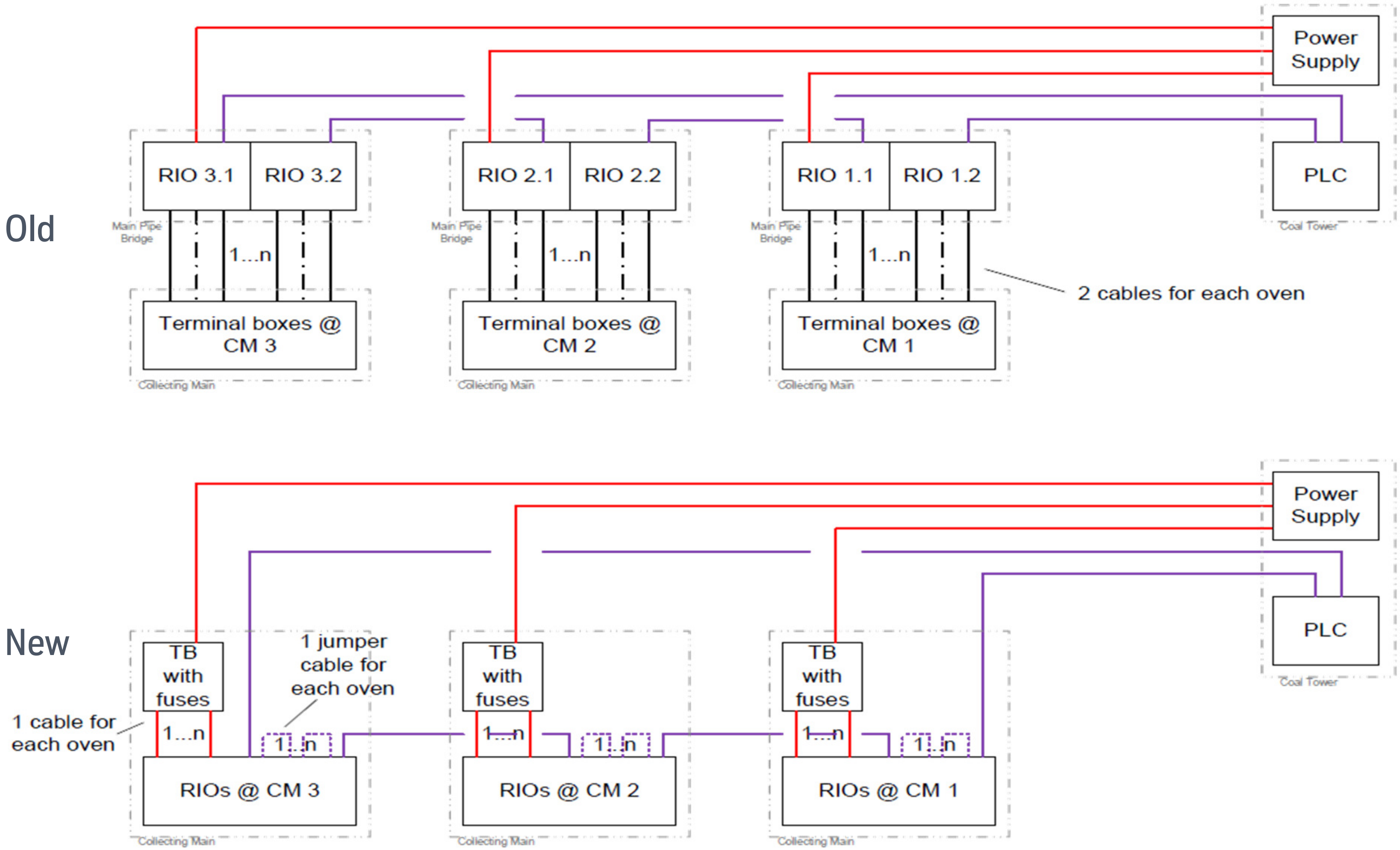


Improved design
with 2 separate connection pieces between valve and sole flues
=> reduced cost for manufacturing

Design improvements

Oven pressure control system

EnviBAT 2.0



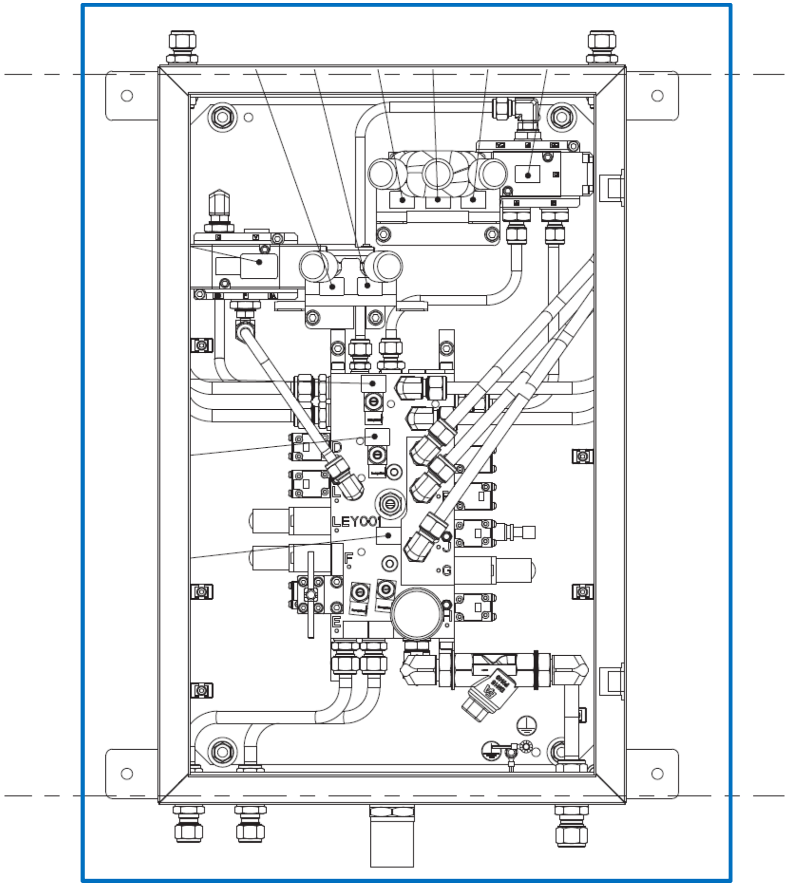
Simplified connection to DCS

Design improvements

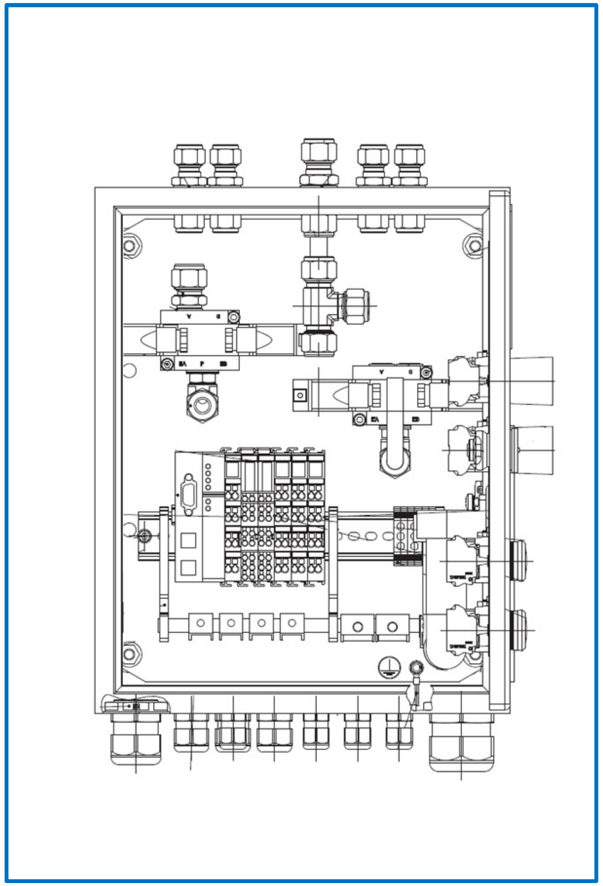
Oven pressure control system

EnviBAT 2.0

Current pneumatic cabinet



New pneumatic cabinet with intelligent databus connection



Design improvements

Oven pressure control system

Merits of EnviBAT 2.0

- Simplified connection to DCS
- No RIO cabinets required
- Reduction of cables
- Simplified control cabinets

Resulting in reduction of:

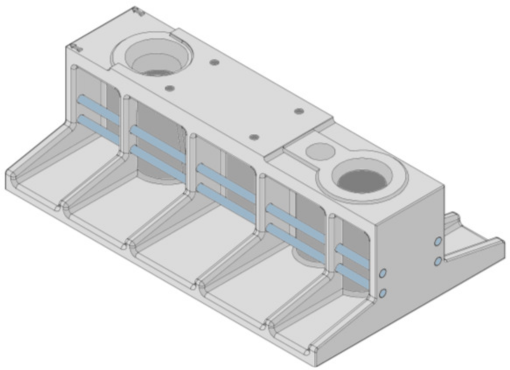
- Equipment cost
- Erection cost
- Erection time
- Maintenance cost

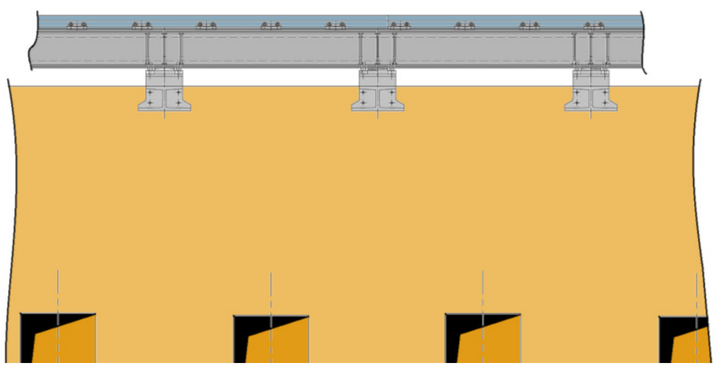
Design improvements
Compensator between standpipe elbow and gas collecting main

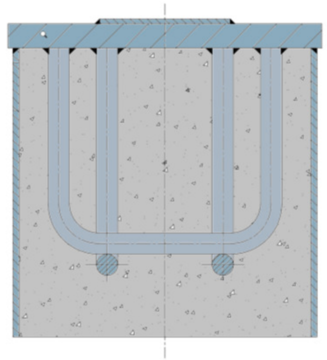
Easy installation, exchange and maintenance, more flexibility

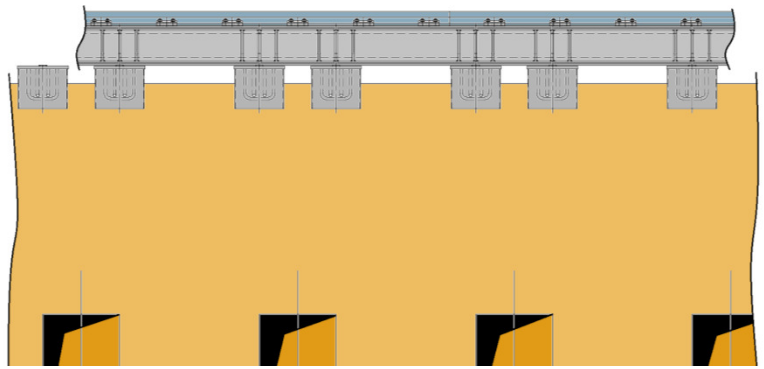
Less material cost than fixed connection

Design improvements
Charging car rail chairs









Heavy cast-iron rail chairs:
difficult alignment, expensive manufacturing

Simple, light steel rail chairs:
easier alignment, cheaper manufacturing

Design improvements

Example from a recent project:

Production capacity	1,600,000 tons/year
Copy of an existing design requires	120 ovens
➢ Weight of mechanical equipment	14,620 tons
➢ Weight of refractory material	60,070 tons
Optimized design concept requires	120 ovens
➢ Weight of mechanical equipment	13,470 tons
➢ Weight of refractory material	59,490 tons
Reduced weight of mechanical equipment	minus ~ 8%
Reduced weight of refractory material	minus ~ 1%

Effect of reduced NOx-formation, design improvements and optimized oven dimensions

Example from a recent project:

Design concept	Number of ovens	Weight of mechanical equipment	Weight of refractory material
Copy of existing plant	128	100%	100%
+ NOx-reduction	120	93.8%	93.8%
+ design improvements	120	86.4%	92.9%
+ optimized oven dimensions	100	74.8%	84.6%

<u>Large savings on equipment and construction !</u>

Effects on total investment costs (CAPEX)

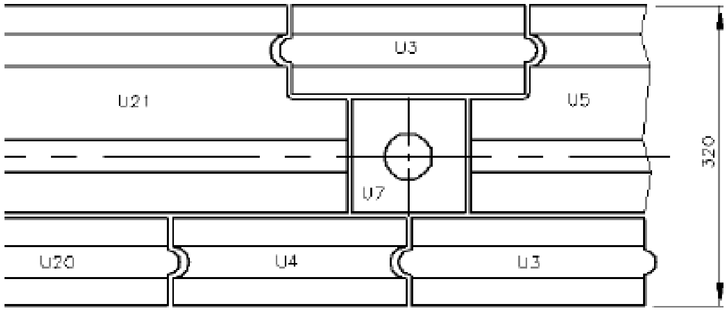
Evaluation of cost factors:

- Engineering: 10% ~ 15%
- Equipment: 40% ~ 50%
- Construction: 35% ~ 50% (related to quantity of equipment)

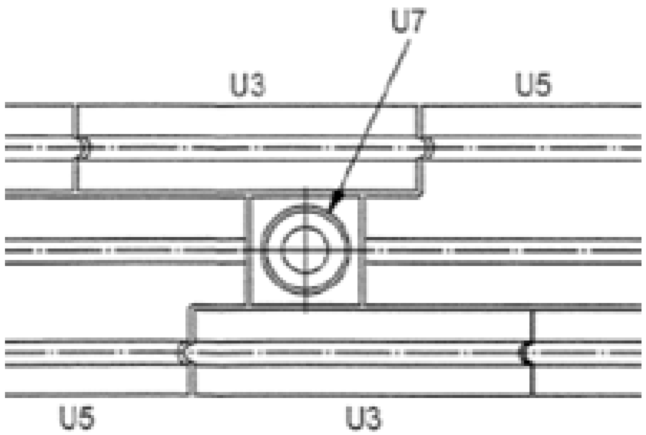
❖ 85% ~ 90% of investment costs are related to the quantity of equipment

➢ Reduction of equipment quantities is most important for optimization of investment cost !

Further design improvements
Optimized design of regenerator walls

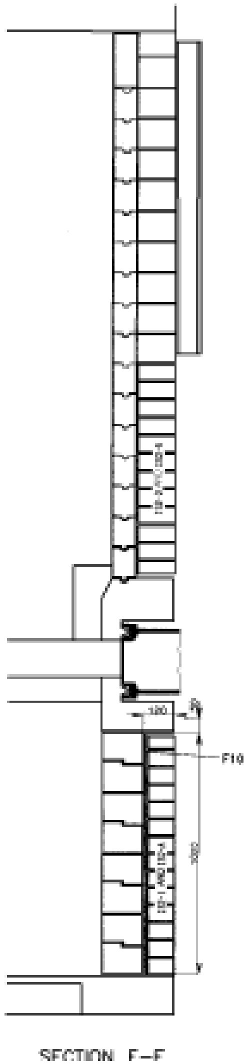


Previous design

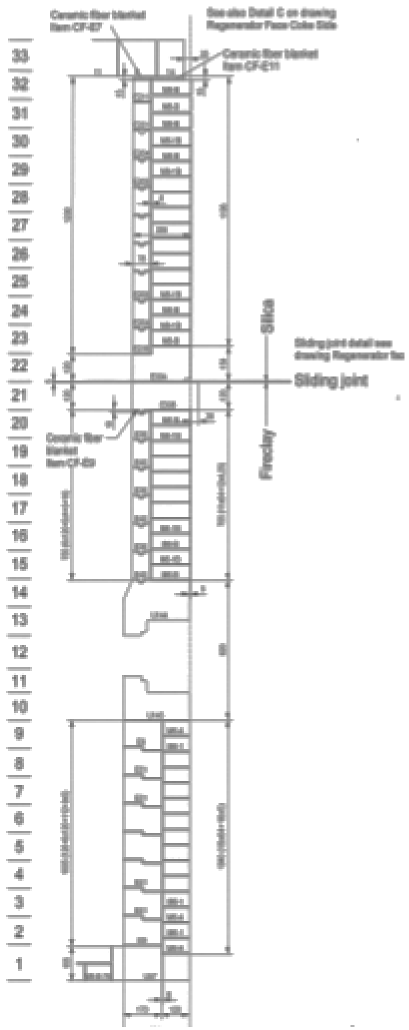


New design with improved tightness due to larger staggering of joints

Further design improvements
Optimized design of regenerator faces



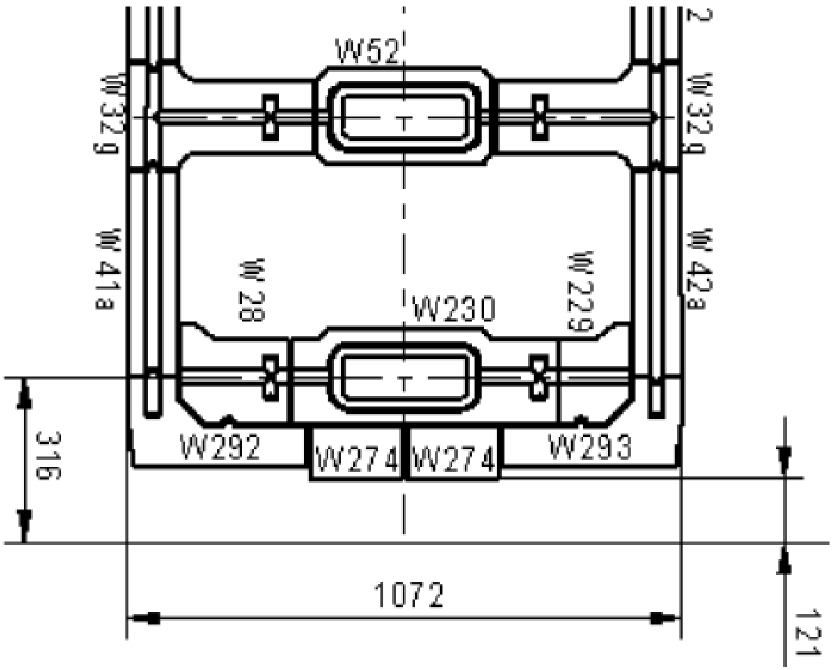
Previous design



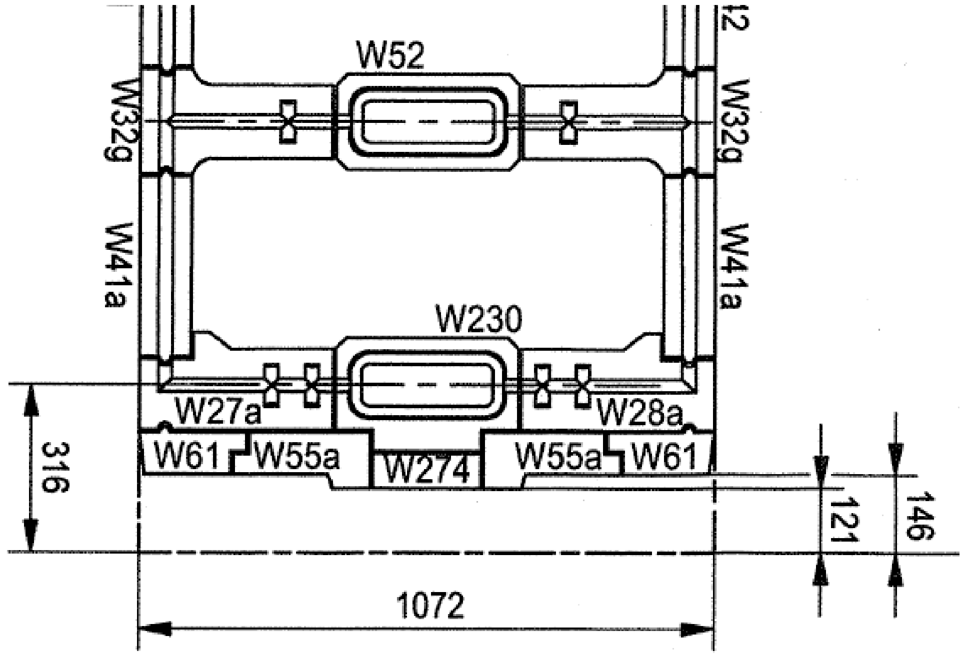
New design with improved tightness

- Reduced energy demand and
- Reduced emissions

Further design improvements
Optimized heating wall quoin



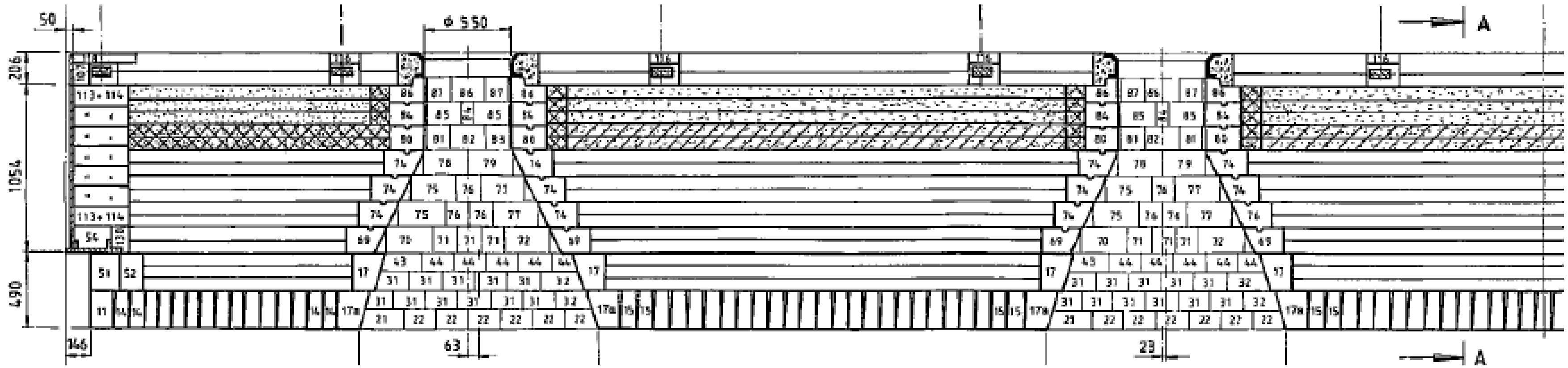
Previous design



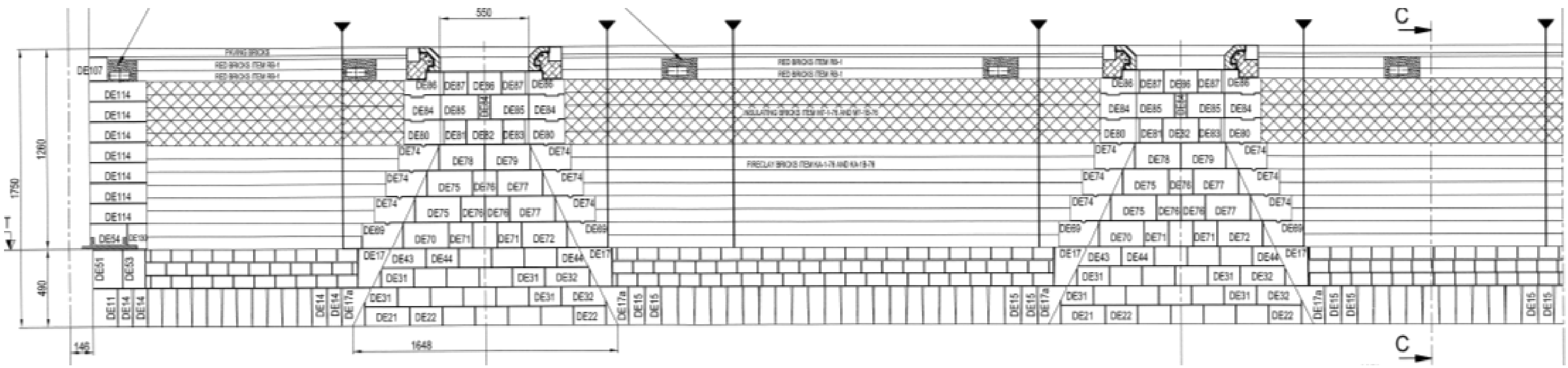
New design with improved tightness

Further design improvements

Optimized oven roof design



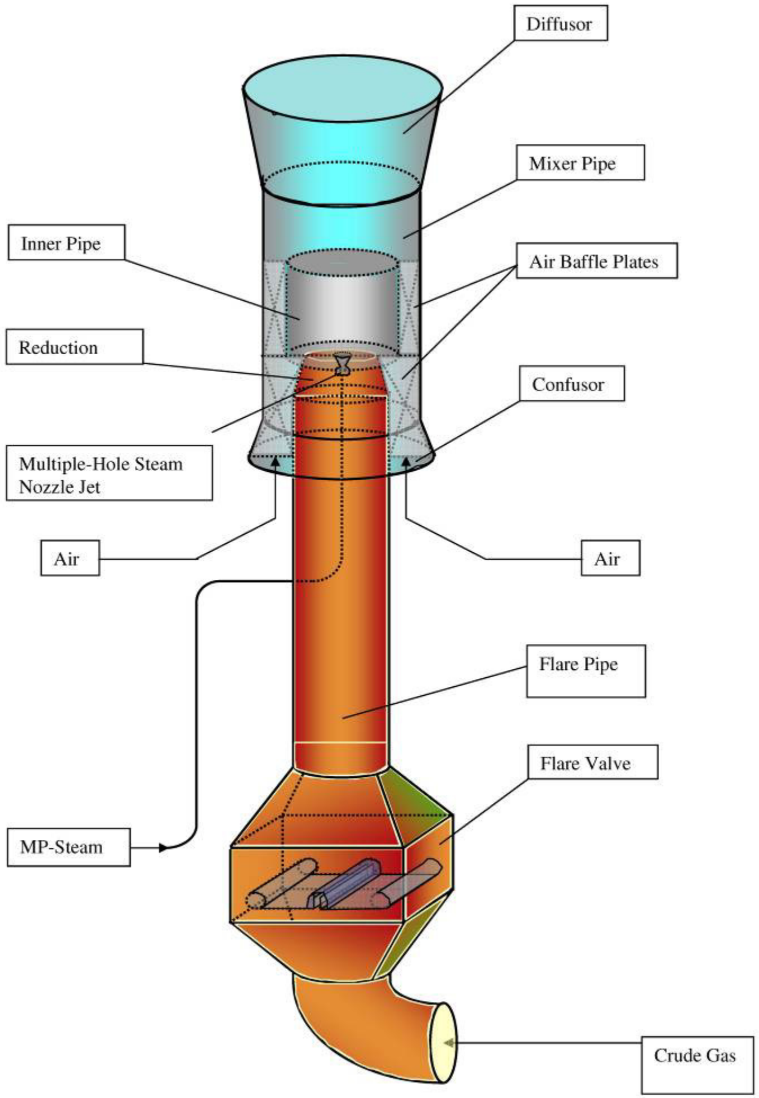
Previous design



New design with grouting joints for improved tightness

Further design improvements
Low emission bleeder system

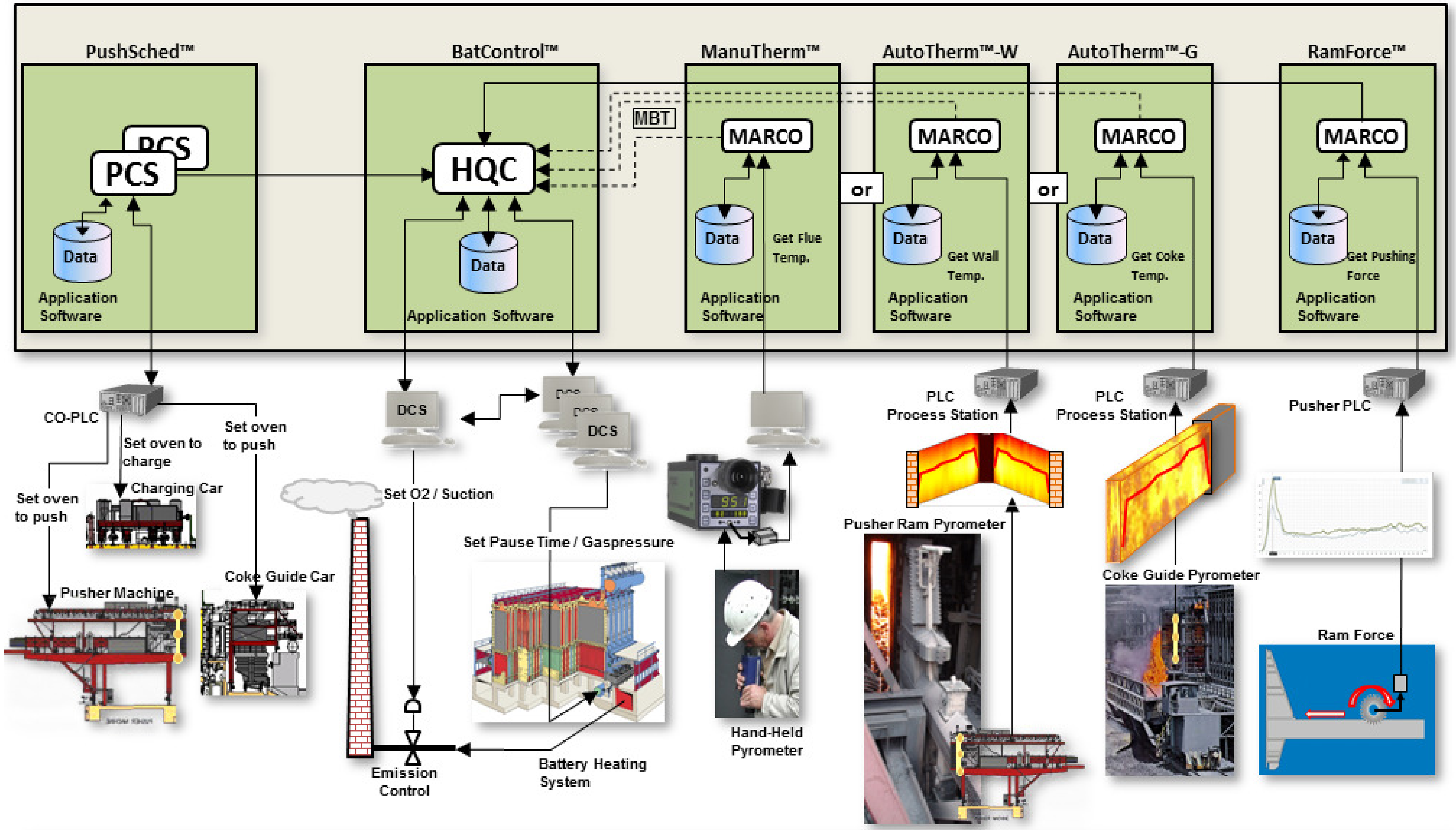
- ➢ Safe ignition of the crude gas
- ➢ Complete, soot-free, combustion
- ➢ Low NOx-emissions
- ➢ Low thermal radiation
- ➢ Stable flame direction, i.e. no straying flames due to wind impacts



Further design improvements
Low emission bleeder system

Smokeless bleeder system in operation

Coke Plant Automation – The COKEMASTER® Suite



Operation Control	Battery Heating Control	Heating Flue Temp. Measurement	Oven Wall Temp. Measurement	Coke Temp. Measurement	Pushing Resistance Measurement

PCS	= Pushing and Charging Supervision and Control	MARCO	= Evaluation Software for ManuTherm AutoTherm, RamForce for Coke Ovens	DCS	= Distributed Control System
HQC	= Heat Quantity Calculation and Control	MBT	= Mean Battery Temperature for Heat Control	PLC	= Programmable Logic Controller

Commissioning, plant adjustment and operator training

All system and design optimizations will only be effective if

- the construction is executed in accordance with the specifications
- the plant is well commissioned and adjusted
- the plant is operated and maintained properly

Supervision of construction and precise plant adjustment are of high value

Training courses provide a high motivation to operation and maintenance personnel to use and maintain the plant well

Resumee

An optimized technical concept considering the available design improvements will cause an increase in engineering cost,

but has a large potential for improvement of the:

- operational safety and plant performance
- environmental plant performance
- working conditions on the plant
- cost of operation and maintenance (OPEX)
- plant service life

<u>and for considerable reductions of cost</u>

<u>for equipment and construction</u>

Oil & Gas

Mineral Processing

Fertilizer Plants

Coke Plants

Naval

Thank you for your interest in our technologies!

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