HOT BLAST STOVES AND CHOICE OF REFRACTORIES

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Hot Blast Stove (HBS)

-regenerative heat exchanger to provide hot blast air to the blast furnace

-high temperature of air remains one the most important parameter

-development focused on longer lifetime,higher hot blast temperature, lower CAPEX/OPEX and CO emissions

-campaing life is 20+ years

-blast air temperature is 1250-1300^{0}C

On-Gas Cycle

Close Blowoff Valve

Open Chimney Valves

Open Air Valve

Open Gas Valve

Checkers heat up

Heat until max temp in Dome and Grid reached

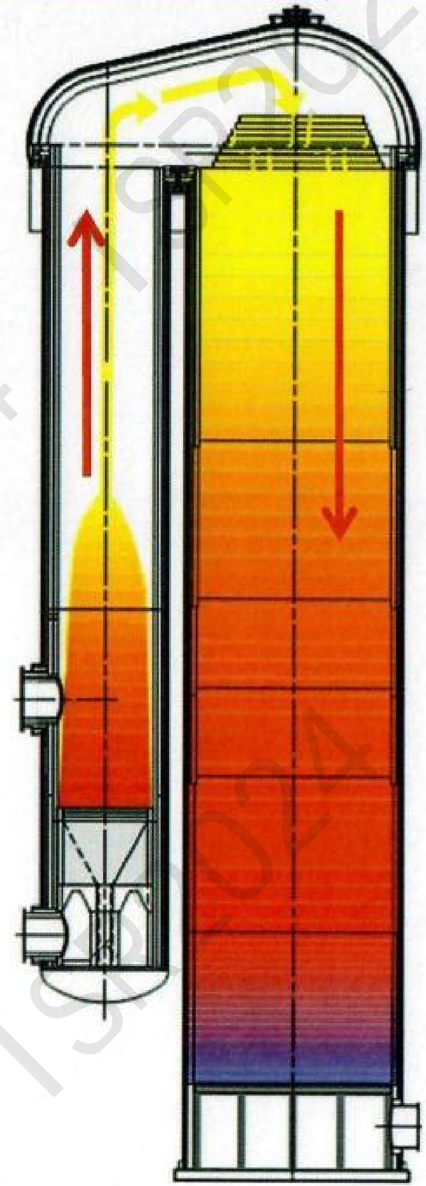
Close Gas Valve

Close Air Valve

Close Chimney Valves

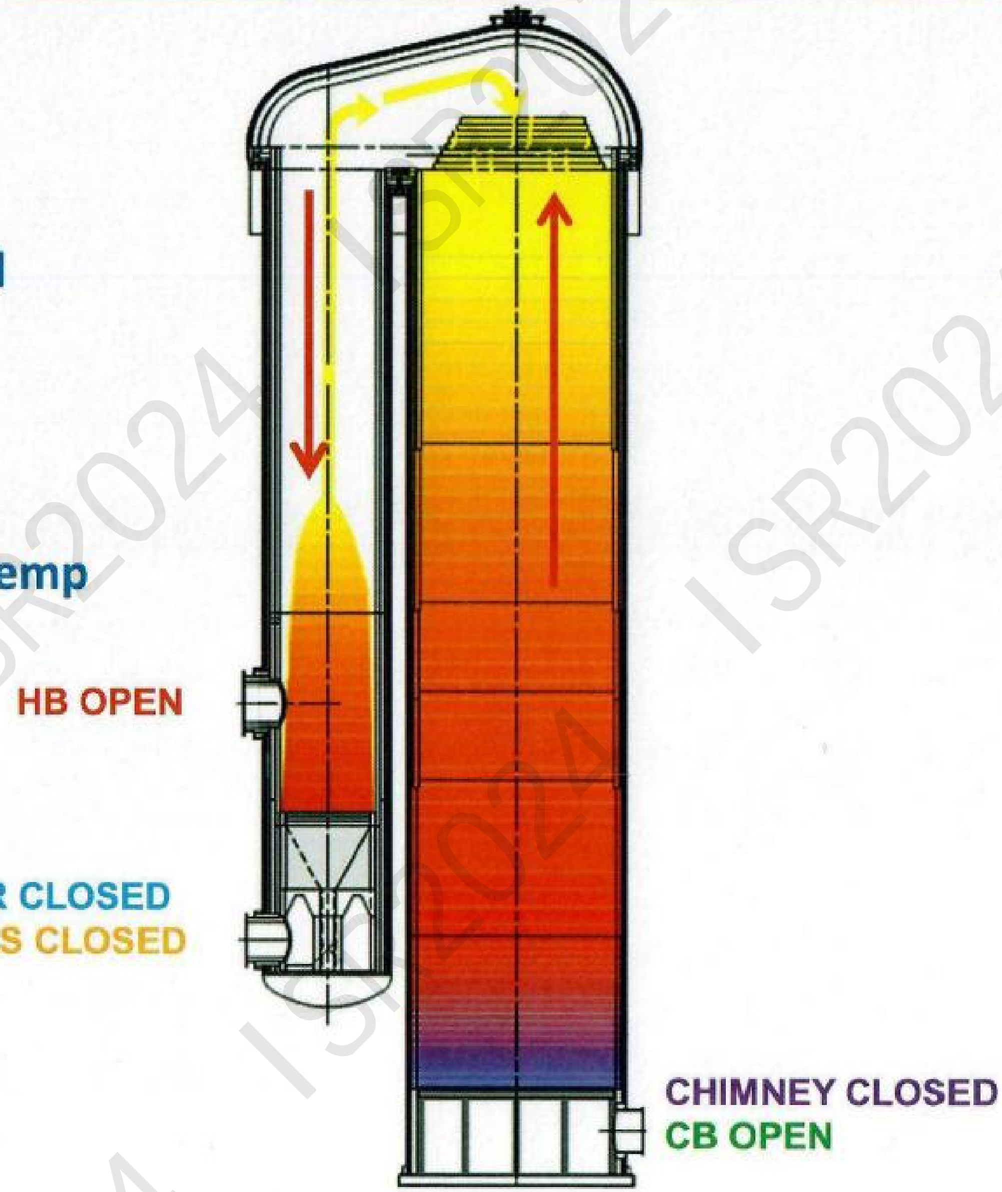
Open Blowoff Valve

Valve Open with all others closed = "BOTTLED"



On-Blast Cycle

- Close Blowoff Valve
- Open Fill Valve
- Wait until stove is pressurized
- Open Hot Blast Valve
- Open Cold Blast Valve
- Checkers cool down
- Hold on blast until Hot Blast temp starts dropping
- Bring next stove on blast
- Close Cold Blast
- Close Hot Blast
- Open Blowoff Valve



Design of HBS

-HBS consists of tall,cylindrical steel structure

-3 main parts

combustion chamber with burner

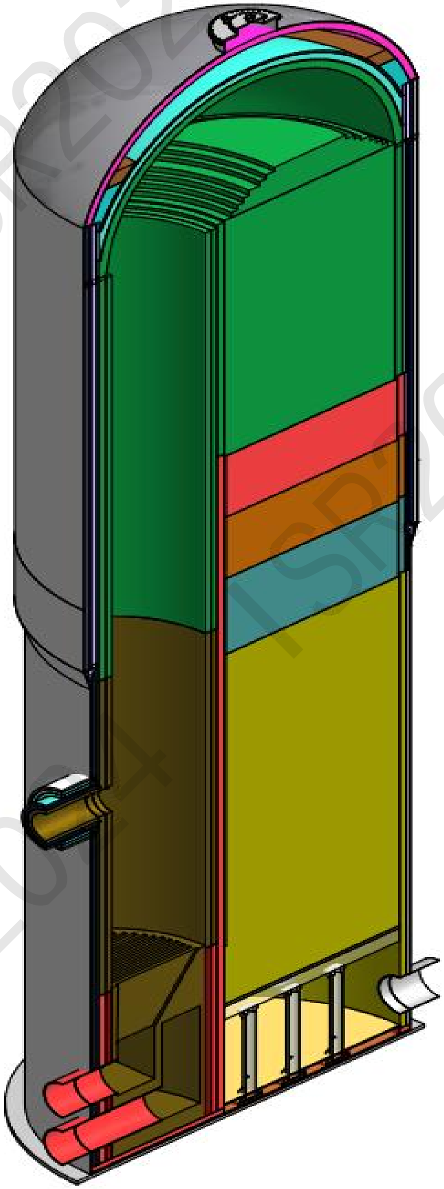
the dome

chamber with checker-work

-constructed from refractory materials

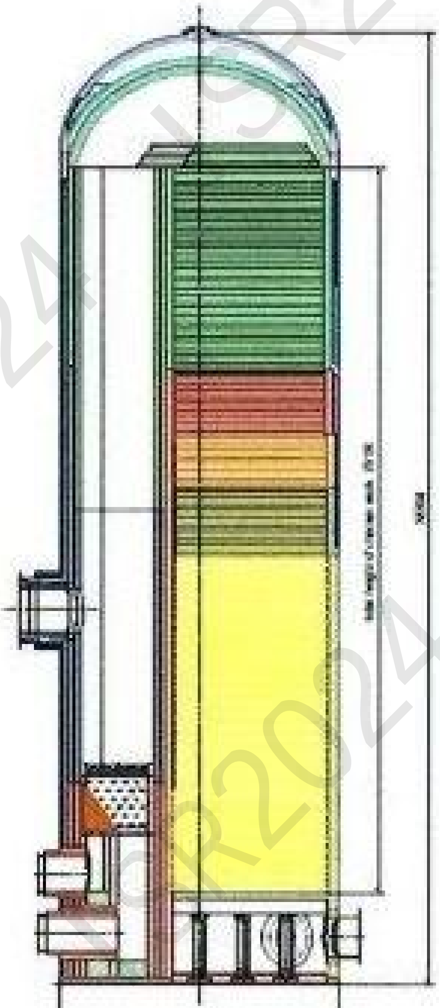
-variety of design developed by Hoogovens, VAI,Krupp Koppers, Didier and Kalugin

-internal,external and dome combustion stoves

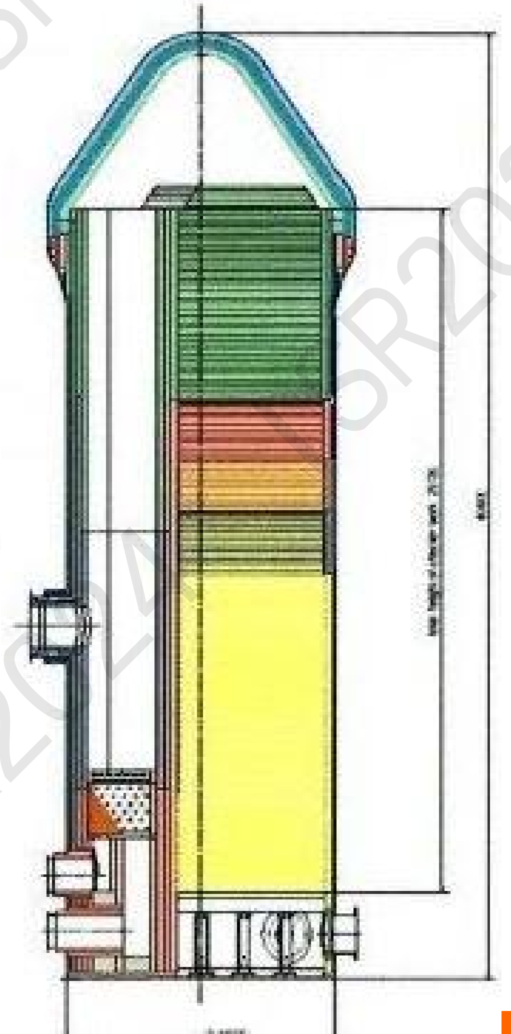


Internal Combustion Shaft

Stove with refractory supported dome



stove with shell supported „mushroom“ dome



Internal Combustion Chamber

-main feature of both design is division wall between combustion and checker chamber,which is exposed high heat impact from burner flame

-lower part of division wall facing checker chamber is located in the coldest part of the stove-banana effect

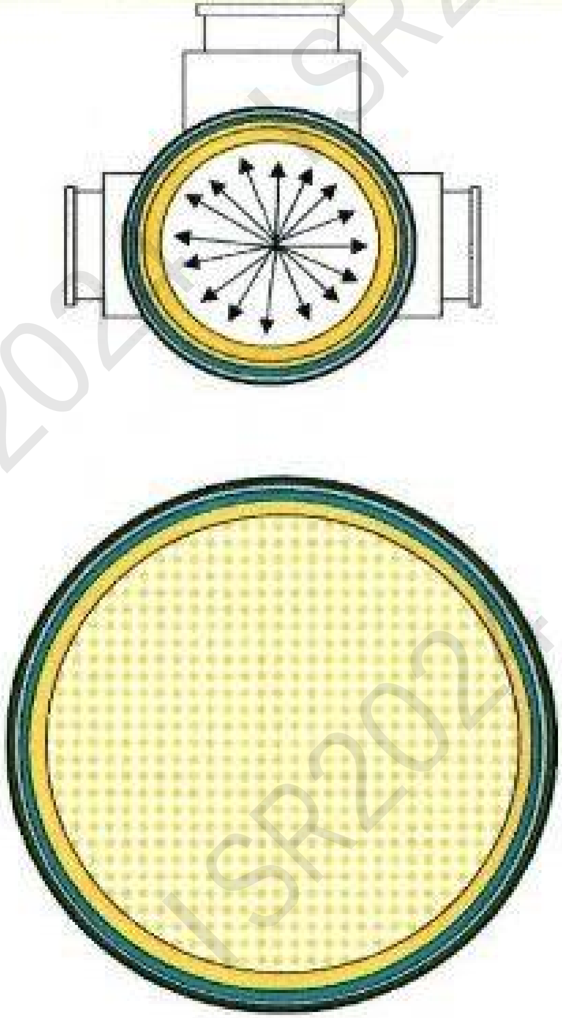
-division wall is constructed with 3 layers utilizing tongue and groove design on radial face

-vertical sliding joints allow free vertical expansion of each individual layer

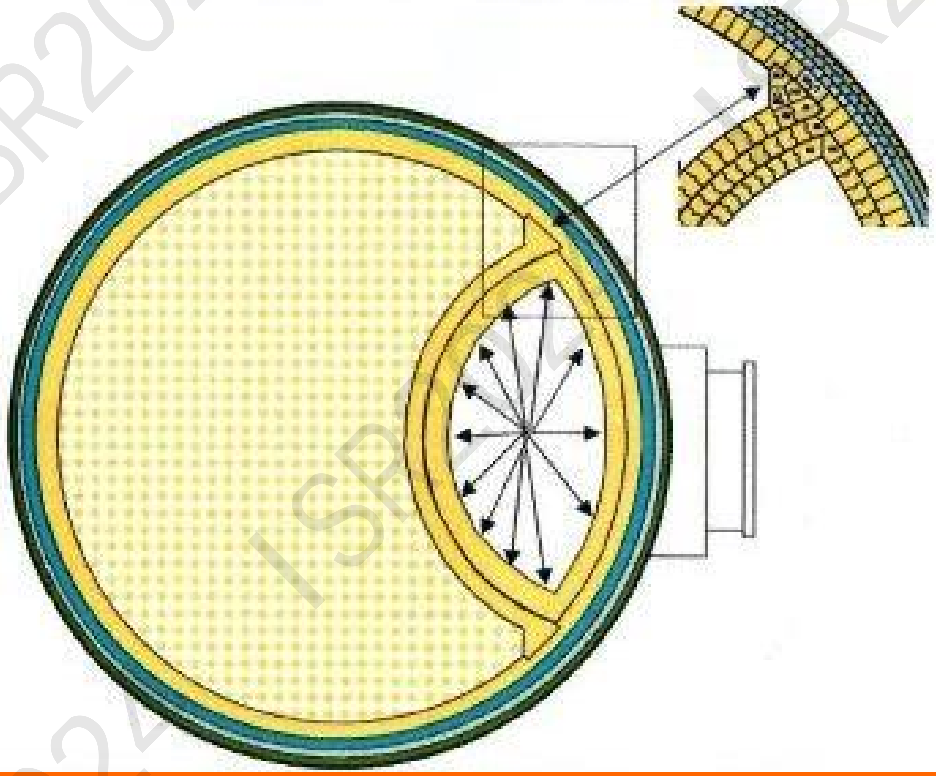
-in the lower part an additional wall of insulation is used

Internal Combustion Chamber

Forces in Combustion Chamber
of Stove with External Combustion Chamber



Forces in Combustion Chamber
of Stove with Internal Combustion Chamber



External Combustion Chamber

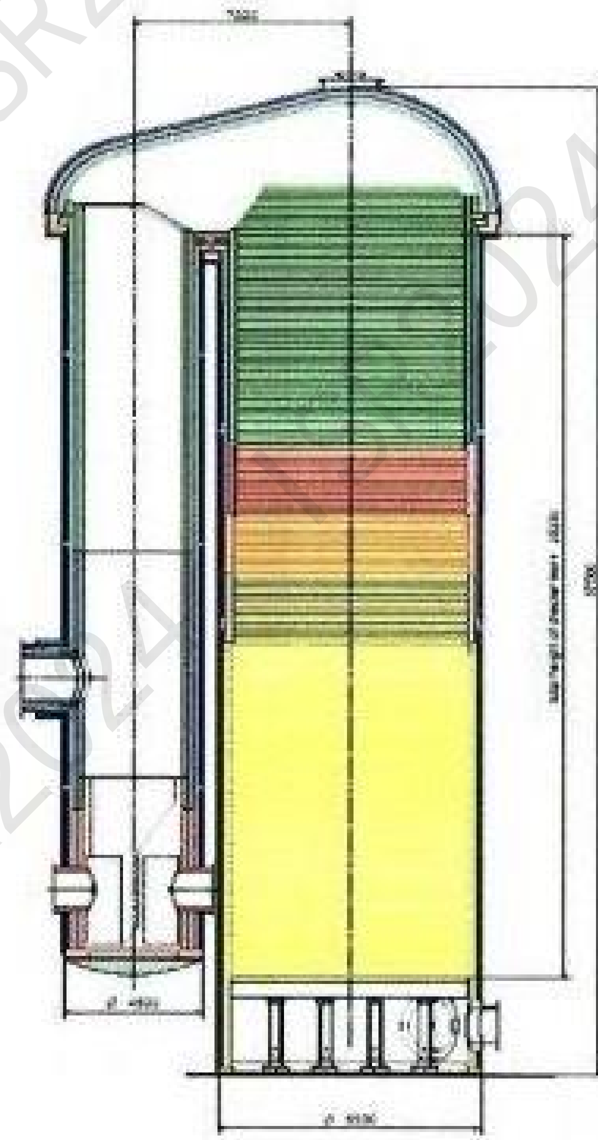
-separation of combustion chamber from checker chamber

-way of compensation of the different thermal and pressure related expansion

-one dome design to connect combustion and checker chamber

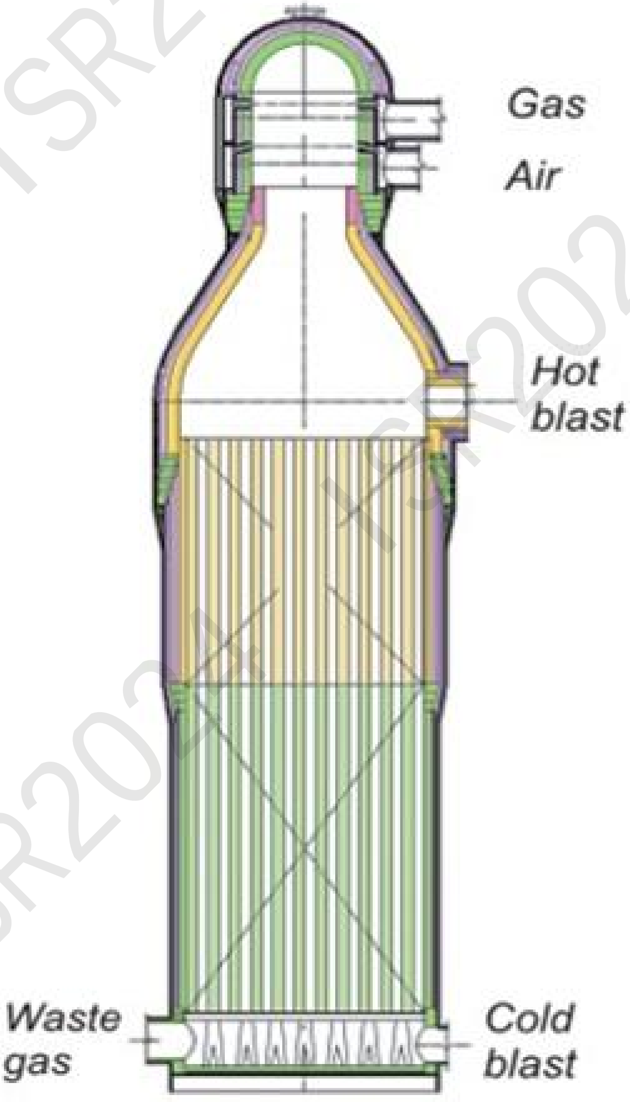
-more reliable structure,higher costs

-installed in large capacity blast furnace



Top Fired Stove

- -invented in Western Europe,promoted by russian company Kalugin
- -short circuiting and pulsation burning is eliminated
- -hot gas ditribution along the checkers is quite even
- -smaller dimensions for the same performance,30-40% less refractories
- -complicated burner design,bricks failure can block the checker work



Checker Bricks

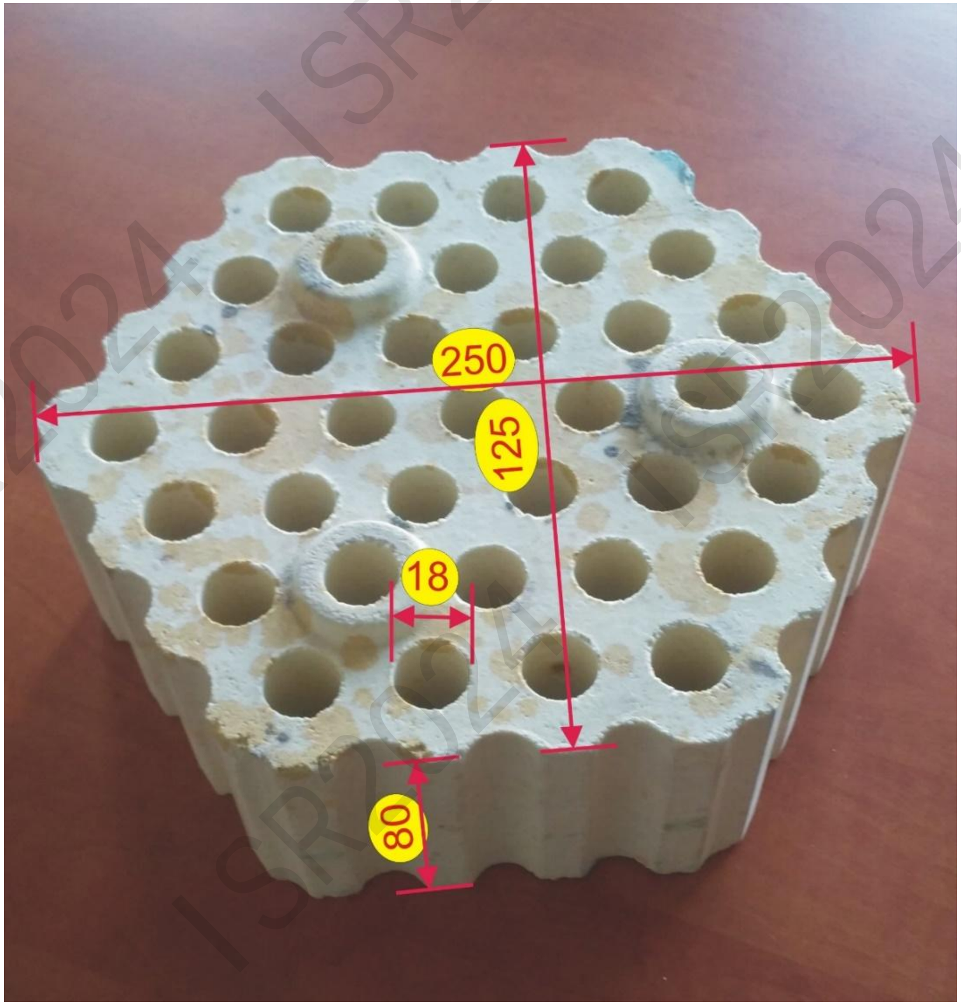
-made of fireclay,silica,HA

-basic characteristic is heat-exchanging surface per volume

-smaller openings and decrease the wall thickness between the openings

-wall thickness closely to 10 mm

-modification of the openings shape-contributing the turbulences of gases

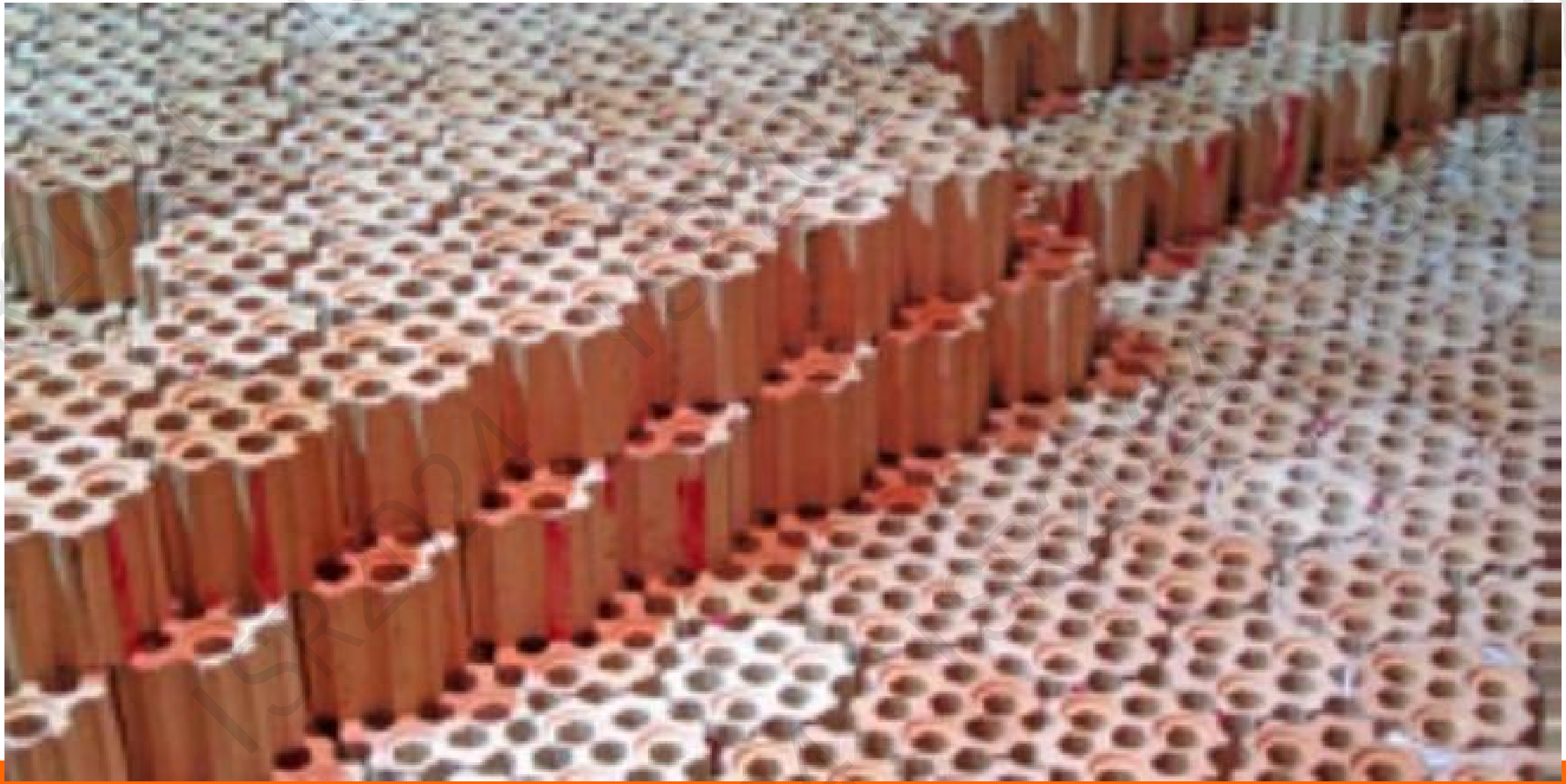


Checker Bricks

- Hexagonal Flues give 15% more surface area than a circle.
- Flues are tapered to prevent laminar boundary layer from developing.
- Grooves are on top to provide flat surface to measure level of course.

Checker Brickworks

-interlacing placement-relaying of the previous layer brick to brick
-spread of pressure to the individual bricks is by far well-proportioned



High-temperature Creep

-the most serious failures of stoves are connected to the deformation and even total collapse of checker bricks

Primary causes are all the time:
-wrong assesment of temperature along the checkers height
-wrong definition of temperature area for safety operation
-wrong choice of refractory materials for checkers

-it is important to know the essential material properties, especially resistance against creep deformation.

-creep test-performed usually with time period 25-50 hours at the test temperature and under load (e.g.0,2 MPa)

-method for guess of safety temperature with respect to usage of refractory materials have been worked out

Refractory Materials Selection

-choice between silica and high alumina-HA

-number of qualities for HA,but only limited number can be considered for stove linings

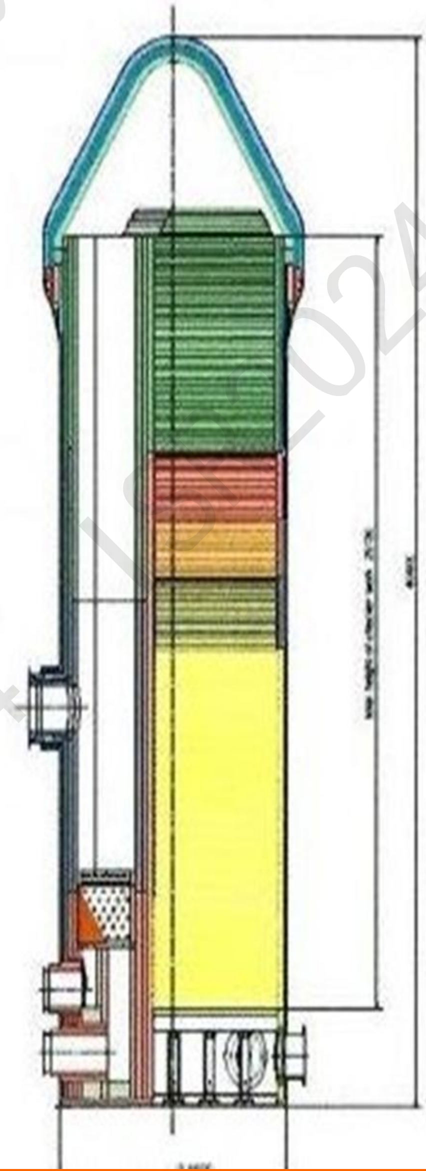
-quartz-free type silica should be applied

-used in combustion shaft,dome and upper part of checker brickwork

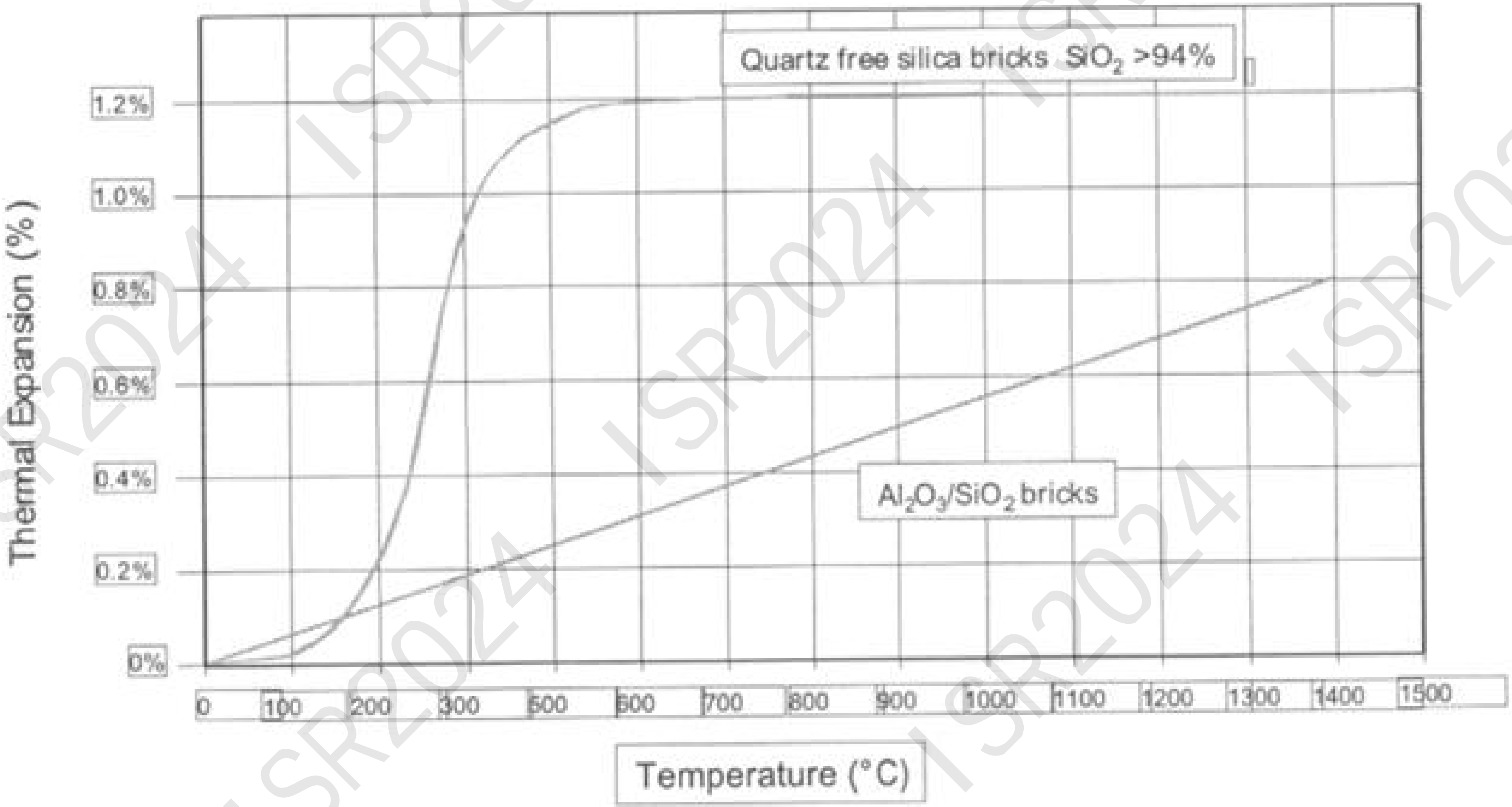
-high resistance to creep in heat and under load

-lower thermal capacity-lower bulk density

-400^{o} C is bottom temperature line for safe use of silica with usual characteristics



Thermal Expansion of Silica



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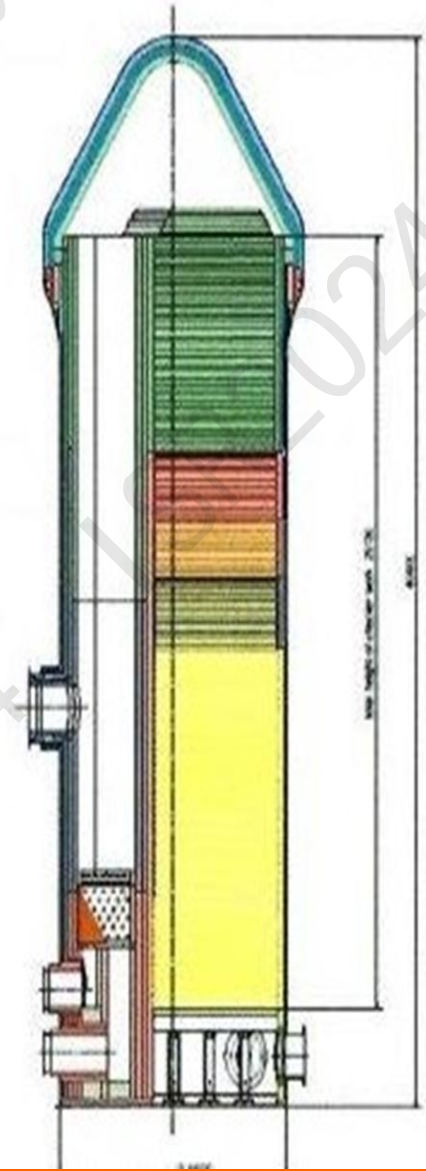


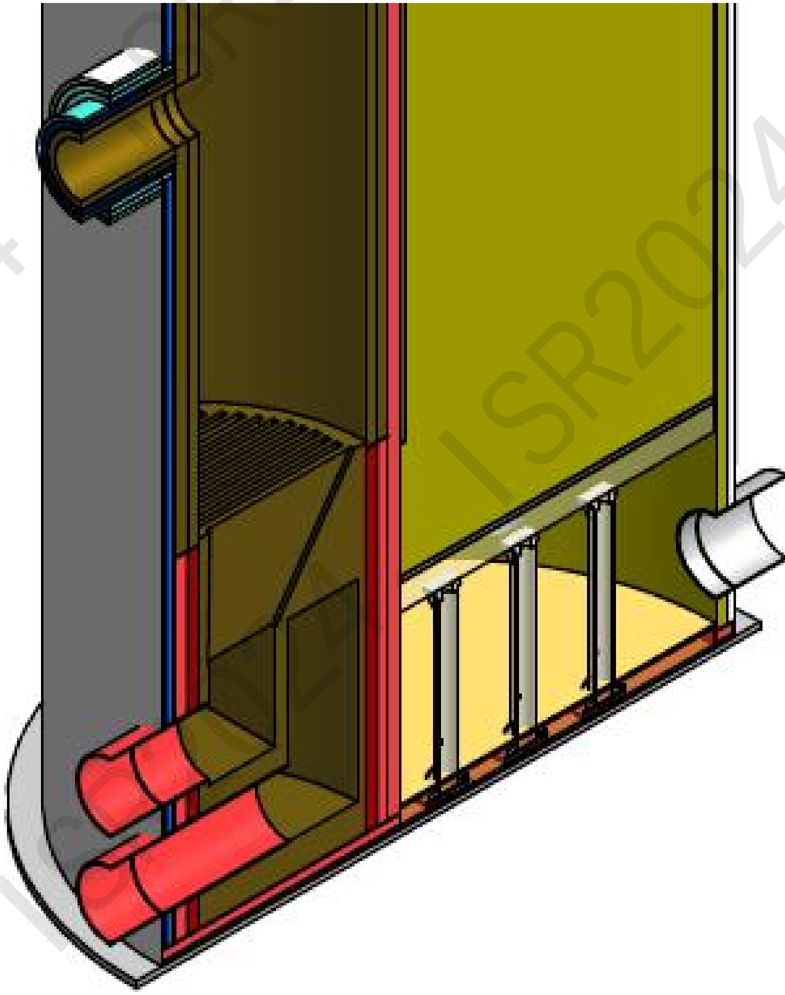
The Ceramic Burner

-stoves and burners are becoming larger and larger

-crown of burner is exposed to repeated temperature changes-extreme thermal shock resistence

-bricks on andalusite basis with high thermal shock and CO resistence

-lower part of the combustion shaft-temperature changes and huge load of the complete shaft brickwork height



Conclusion

-analysis of property changes of refractory materials became usual aspect

-together with its results the experiences with the previous stoves operation served to the futher improvements

-failure-free operation for 20 or more years justifies the previous measures in sufficient way

-precise determination of temperature spread and fluctuation along the HBS height and refractory materials with high creep and thermal shock resistance enable to achieve a lifetime of two blast furnace generations

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Thank you for your attention

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