Presenter Name: Surendra Prasad, GM & I/c (Refractory) SAIL CET-Ranchi

Paper name: **REFRACTORY DESIGN DEVELOPMENTS & APPLICATION FOR STOVES OF BLAST FURNACES IN SAIL PLANTS**

PRESENT AFFILIATION	**Steel Authority of India Limited (SAIL), Centre for Engineering & Technology (CET)**
AREAS OF INTEREST	**Refractory design & application, learning & teaching**
Education	B.Tech. in Ceramic Engineering in 1986 from "**Institute of Technology, Banaras Hindu University**"

Experience	• **Sri Prasad** joined Bokaro Steel Plant (BSL) in Aug. 1986 as Management Trainee (Technical). He worked there for three & half years in "**Refractory Material Plant**". • **In Jan. 1990**, Mr Prasad joined **CET**, the in-house consultancy wing of **SAIL** and is posted in its Head Office at Ranchi. Since then, he is involved in design, engineering & consultancy for "**Refractories**" in the area of Blast Furnace, Steel Melting, Coke-Oven etc. Besides this, he is also involved in the jobs related to "**Solid Waste Management**".
Projects:	**Sri Prasad** was fully involved in the in-house design, engineering and refractory erection of 530 m3 Blast Furnace Complex at VISL, Bhadrawati in the year 1993-95, which was a first of its kind in India. His contributions in up gradation of a number of Blast Furnaces & Hot Blast Stoves in SAIL and other than SAIL, is quite significant and appreciable.
Publication/ Patent	• **Sri Prasad** has a number of technical paper (more than **45**) to his credit and has won a number of awards. • Widely traveled in India and once in **Egypt**. • Member of "**Indian Ceramic Society**", "**Institute of Refractory Engineer**", "**Institution of Engineers India**", "**Computer Society of India**" and "**Indian Institute of Metals**"

REFRACTORY DESIGN DEVELOPMENTS & APPLICATION FOR STOVES OF BLAST FURNACES IN SAIL PLANTS

By:
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(from SAIL/ CET, Ranchi)

Occasion: REFIS 4.0 International Conference Refractories in Steel Industries
At: Bokaro Steel City, Jharkhand
Date : 23-24 Sept. 2022

Contents

Part – 1

(Background)

Background–What's Stove, it's Type & History?

Stove

- Regenerative heat exchanger
- An integral part of BF
- To supply fixed quantity of hot air at desired temperature

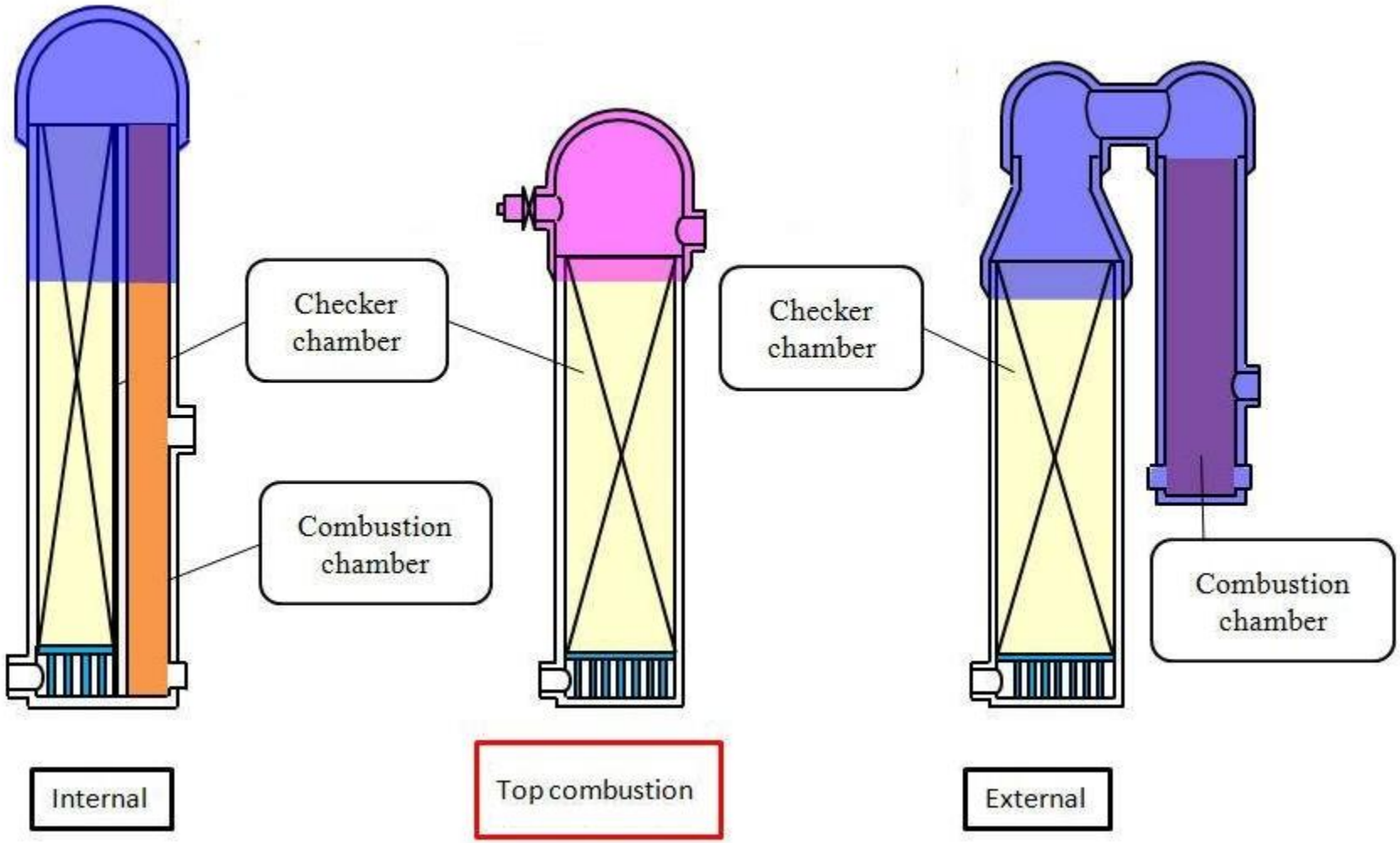
Types of Stove

- External combustion chamber
- Internal combustion chamber
  - Burner at Bottom
  - Burner at Top

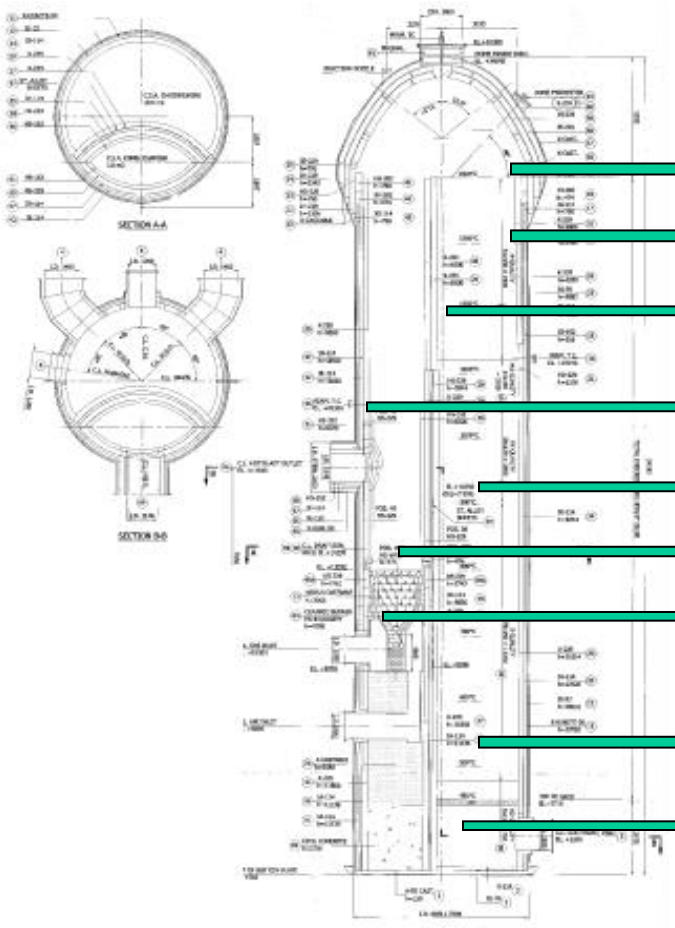
Stove Design History

- Till 1960, BF stoves were designed world over for a max. HBT of 800 ^{o}C
- Advanced countries installed stoves for higher temperature.
- Presently, HBT of 1250 ^{o}C is in use
- In 1988, SAIL/CET acquired know-how from HTS, The Neatherland for higher HBT
- Presently, new design stoves with metallic ceramic burner & mushroom doom are available

Background - Types of Stove



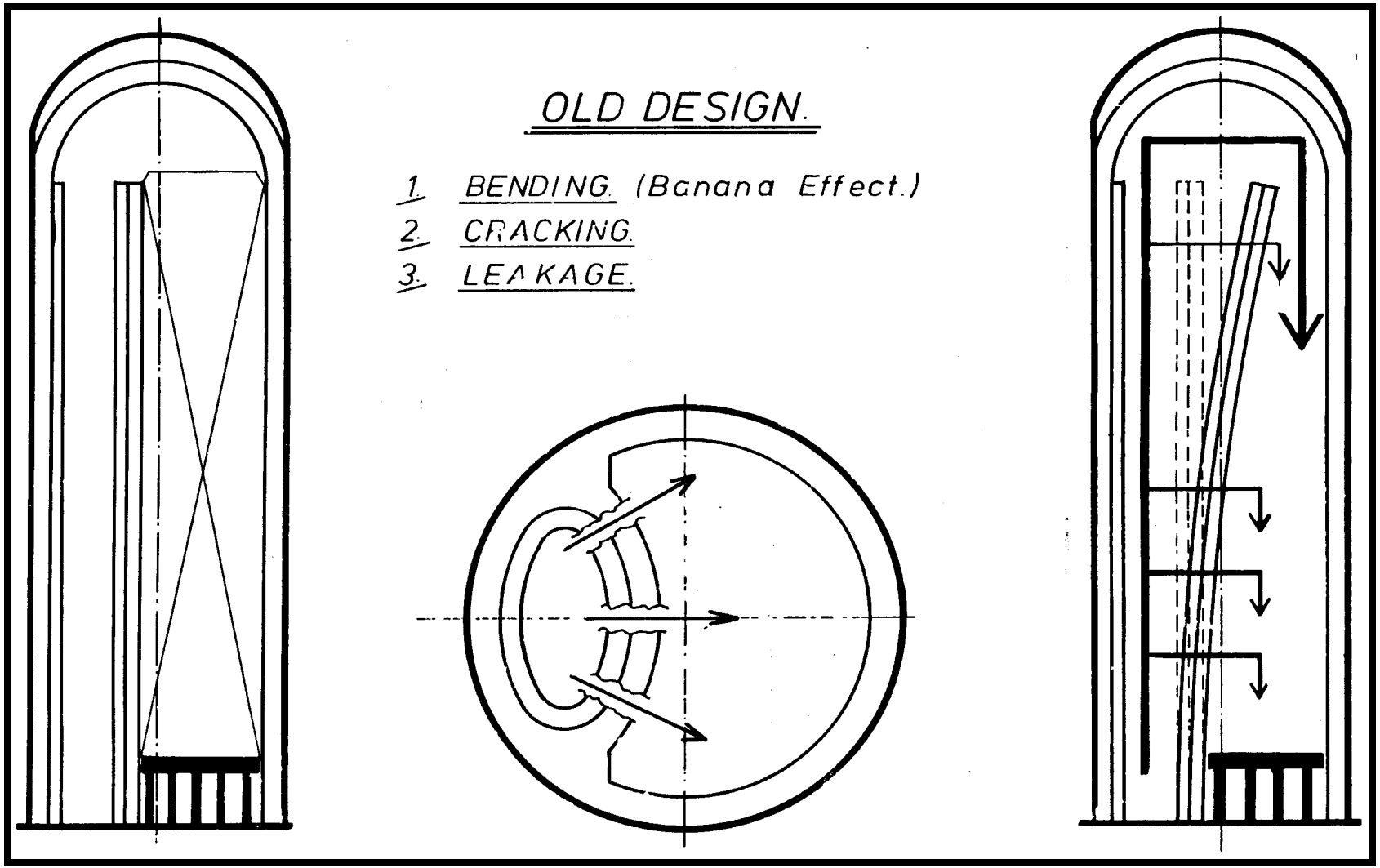
Background-Parts & Working Principle of Stove



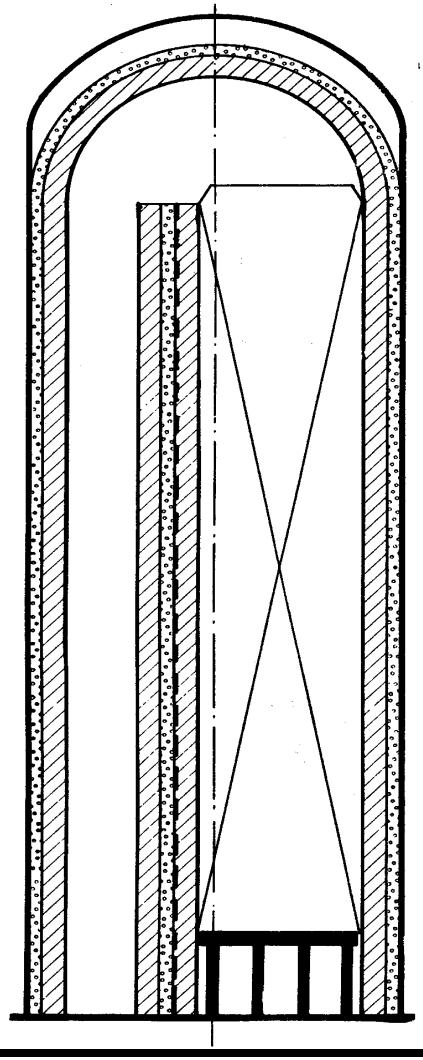
- Dome
- Checker Wall
- Partition Wall
- Combustion Wall
- Checker Chamber
- Comb. Chamber
- Ceramic Burner
- Checkers
- Ch. Support System

Working Principle: As regenerative heat exchange i.e. heat is absorbed during heating & supplied during blasting

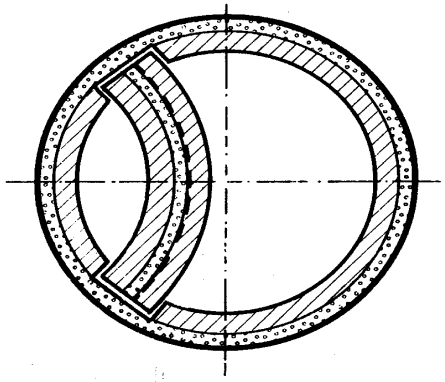
Old Design Stove - Demerits



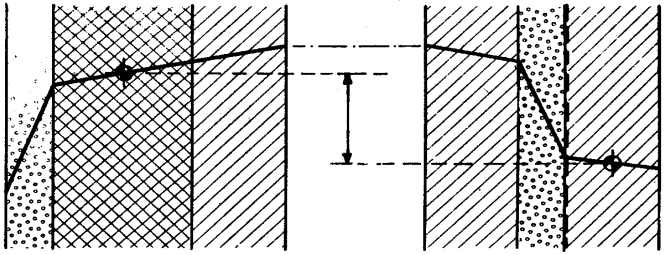
New Design Stove - Approach



NEW DESIGN.



1 NO BENDING.
2 NO CRACKING
3 NO LEAKAGE. (Steel Plate

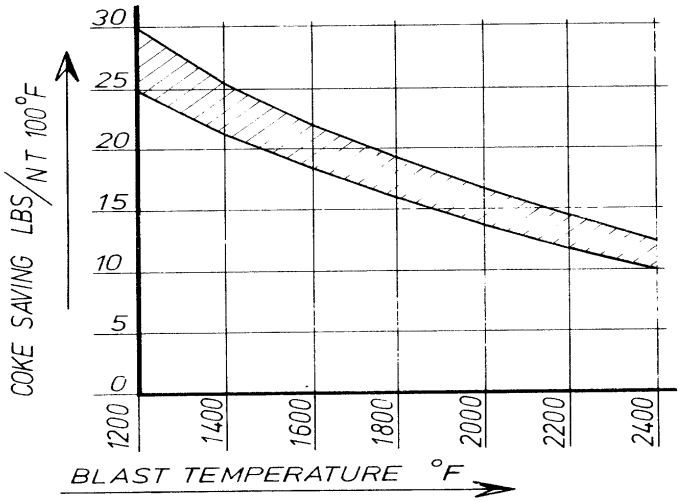


LOWER PART
BREAST WALL.

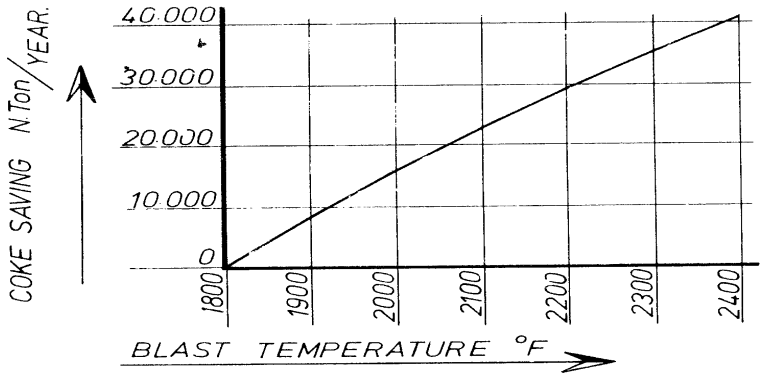
New Design Stove - Advantages

- Increase in productivity
- Increase in life of stove
- Increase in thermal efficiency
- Decrease in coke rate

COKE SAVING VERSUS BLAST TEMPERATURE.



COKE SAVING Ton/Year FOR A 1.000.000 N T H M/Year FURNACE.



Stove Design - Considerations

FACTORS FOR HEAT TRANSFER

- Conductivity of brick work
- Shape & Roughness of surface
- Temperature Difference
- Heat capacity of Refractory Material
- Velocity of gas

FACTORS FOR STOVE DESIGN

- No. of Stoves
- Mode of Operation
- Duty Requirement
- Fuel & Fuel Enrichment
- Space Consideration
- Pressure Losses
- Efficiency

Stove Design - Steps

- Stove sizing using mathematical model
- Stove basic design
  - **Temperature Calculation**
  - **Quality-wise Refractory Ht. / Exp. Calculation**
  - **Refractory G.A. Drawing**
- Stove detailed design
  - **Brick Shape Generation (> 250 shapes)**
  - **B.O.M. Calculation (~ 1500T_Dense + 100T_Ins)**
  - **Tender Specifications**
  - **Detailed Drawings**
  - **Erection Instruction**

Part – 2

(Refractory Design Developments)

Refractory Design Development - Areas

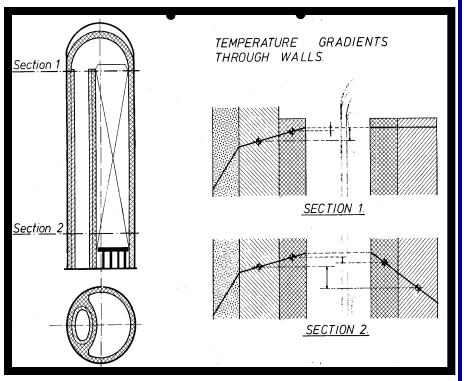
1. Shell Safety Lining
2. Partition Wall Lining
3. Dome
4. Expansion & Sliding Jt.
5. Burner
6. Checkers
7. Refractory Materials

1. Shell Safety Lining - Developments

1950
Mica Crumb
(Settling &
Hot Spot)

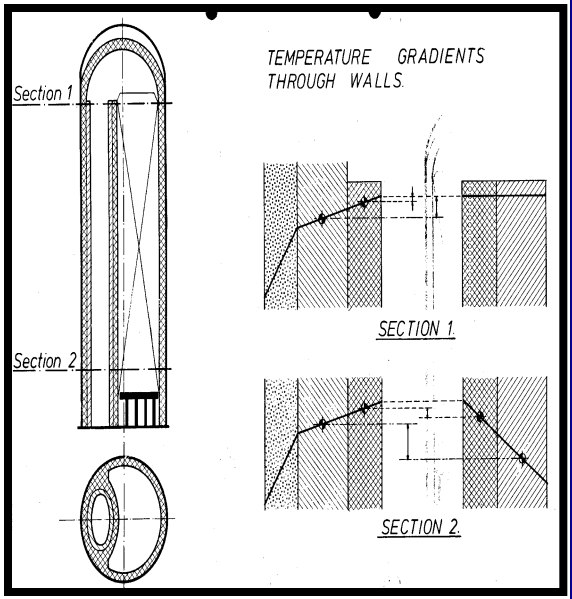
1990
Insulation
Slab
(Crushing &
Hot Spot)

2010
CFB/Gunning
Material
**(Excellent
Performance)**



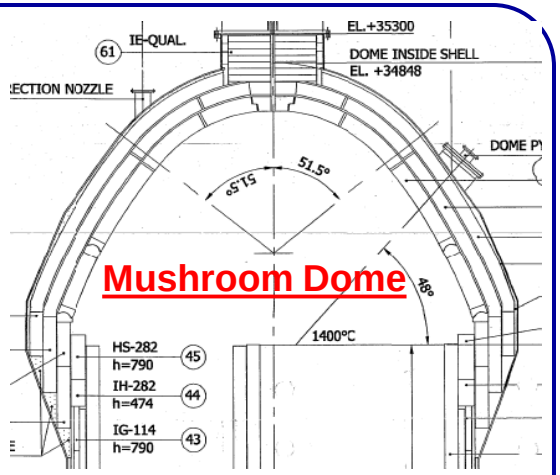
2. Partition Wall Lining - Developments

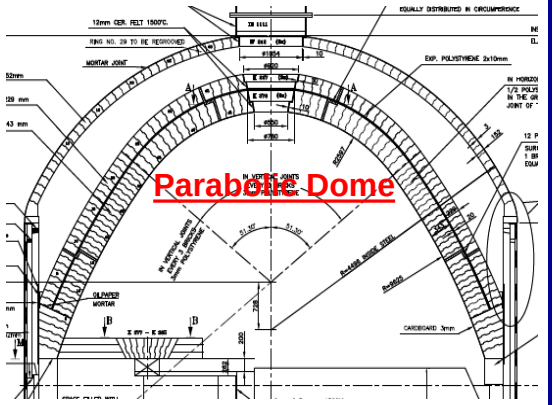
#	Description	1950	1990	2010
1	Partition Wall Construction	Air gap between 2-Dense	Ins. between 2-Dense	Better Ins. Between 2-Dense
2	Thermal Gradient/ Stress	High	Low	Lowest
3	Bending Tendency	Yes	No	No
4	Short Circuit	Yes	No	No
5	Use of SSS	No	Yes	Yes
6	Use of Silica for upper portion	No	Yes	Yes

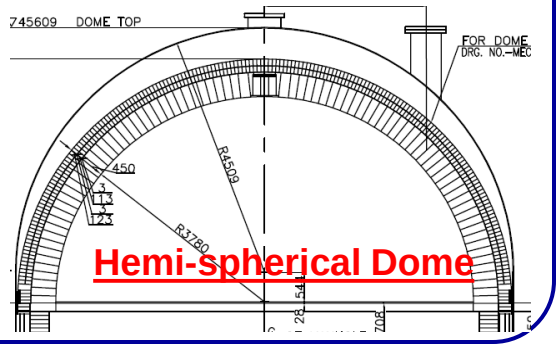


3. Dome - Developments

#	Description	1950	1990	2010
1	Type	Hemi-spherical	Parabolic	Mushroom
2	Supported On	Ref. Wall	Ref. Wall	Shell
3	Ref. Wall Thickness at Base	Thick	Thick	Thin
4	Movement w.r.t. Wall	Dependent	Dependent	Independent
5	Construction	Stable	Stable	More Stable
6	Stress/ Slipping of Bricks	Less	More	Least
7	Stability w.r.t. HBT	Good	Better	Best







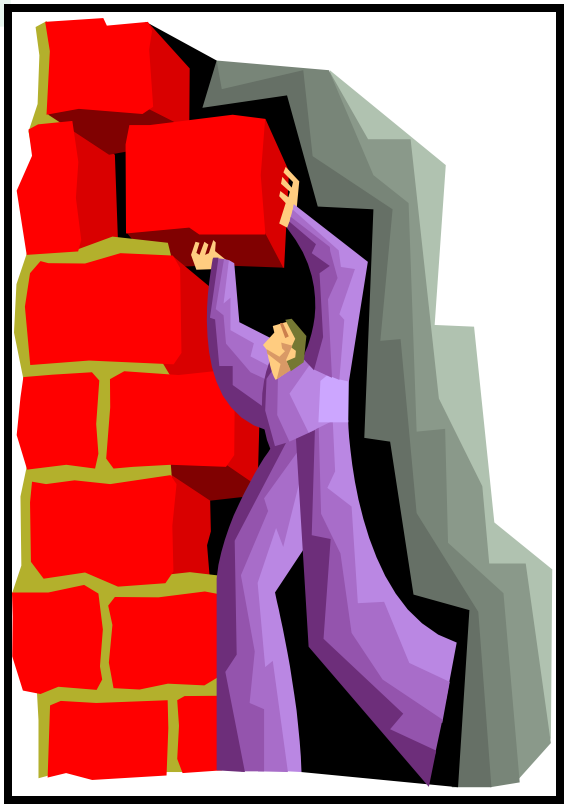
4. Exp. & Sliding Jts. - Developments

#	Description	1950	1990	2010
1	Exp. Jts.	No	Yes	Yes
2	Sliding Jt.	No	Yes	Yes

- *Expansion Joint.:*

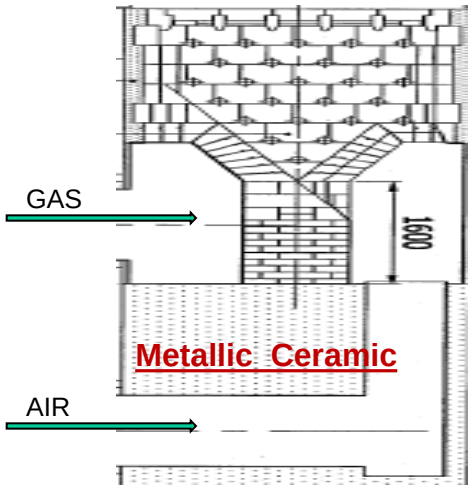
  Absorption of expansion of bricks
- *Sliding Joint.:*

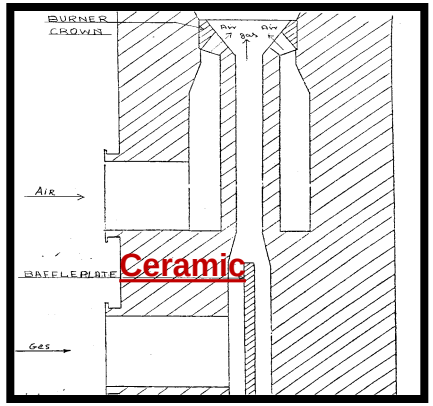
  To ensure independent movement (of different grades of refractories)
- Advantages :
  - Elimination of cracks
  - Elimination of hot spot
  - Elimination of pre-mature failure

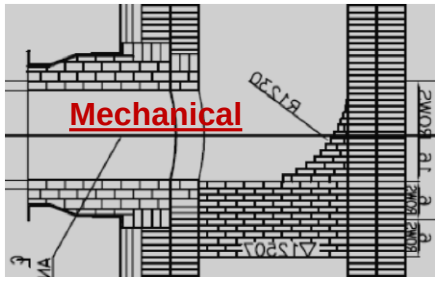


5. Burner - Developments

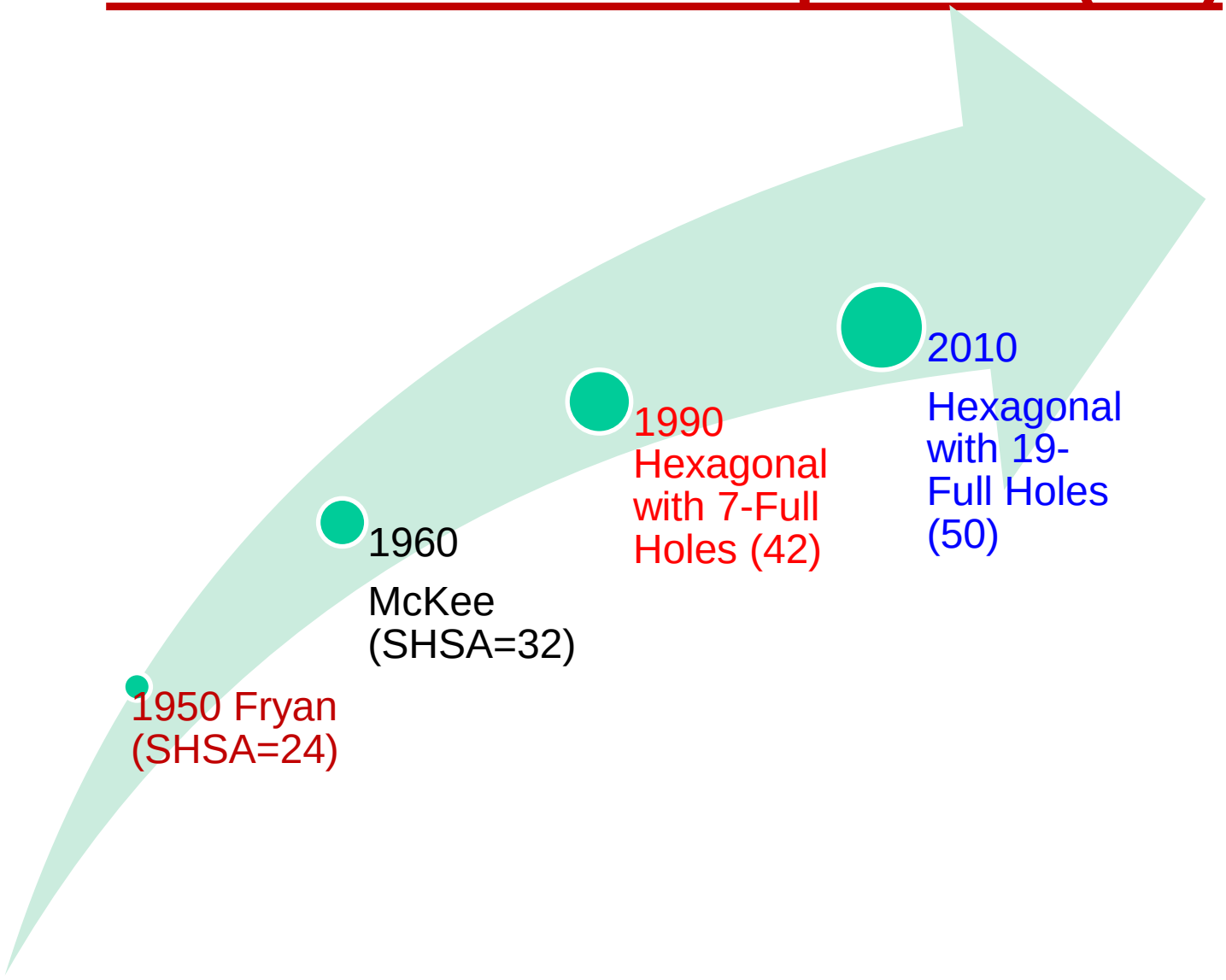
#	Description	1950	1990	2010
1	Type	Mechanical	Ceramic	Metallic Ceramic
2	Combustion	Fair & Un-stable	Good & Stable	Very Good & Stable
3	Thermal Distribution	Poor	Good	Very Good
4	Short Circuit	Yes	No	No
5	Hot Spot	Yes	No	No
6	Pressure Drop	High	Low	Low
7	Pulsation	Yes	No	No



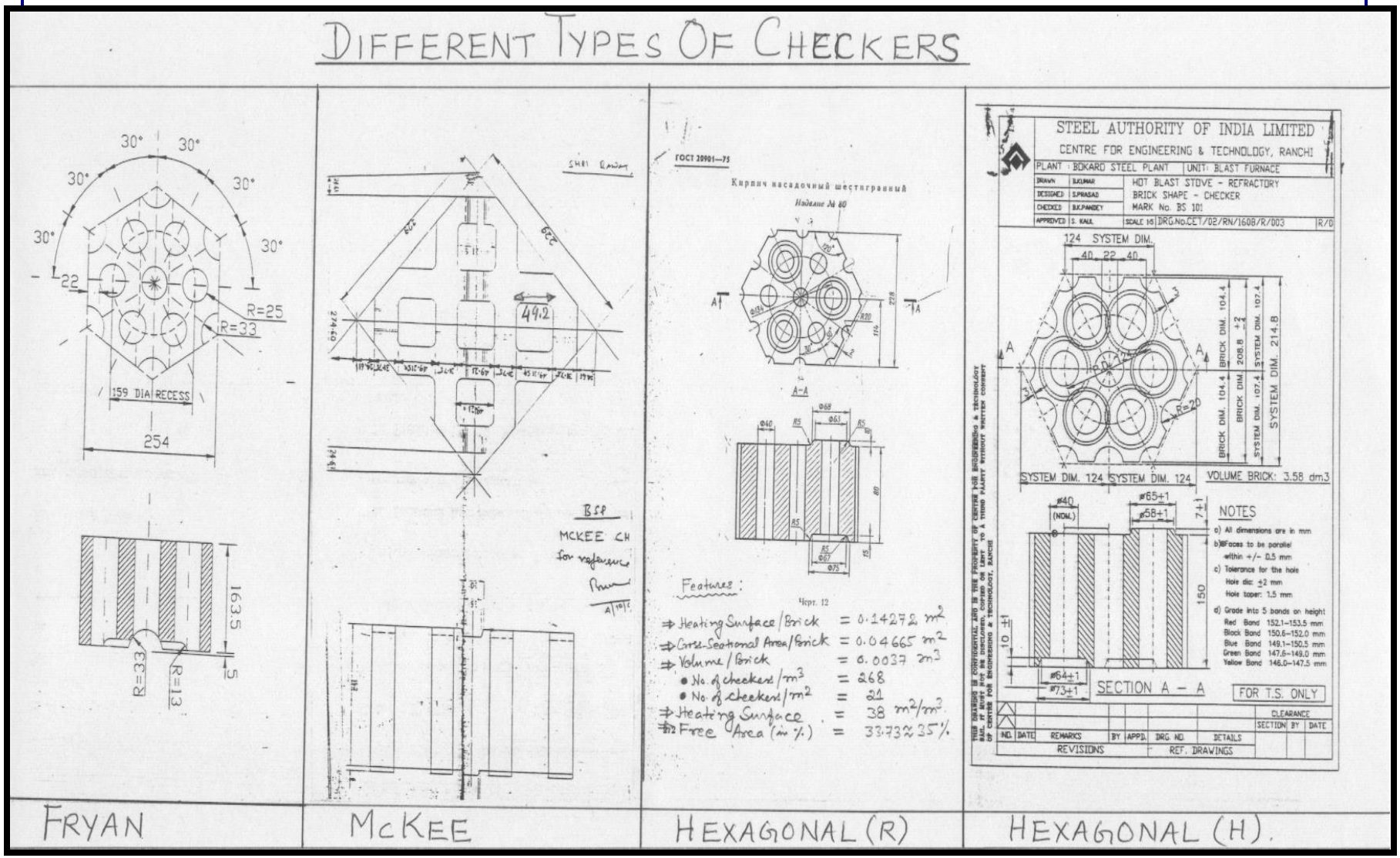




6. Checker – Developments (1/4)

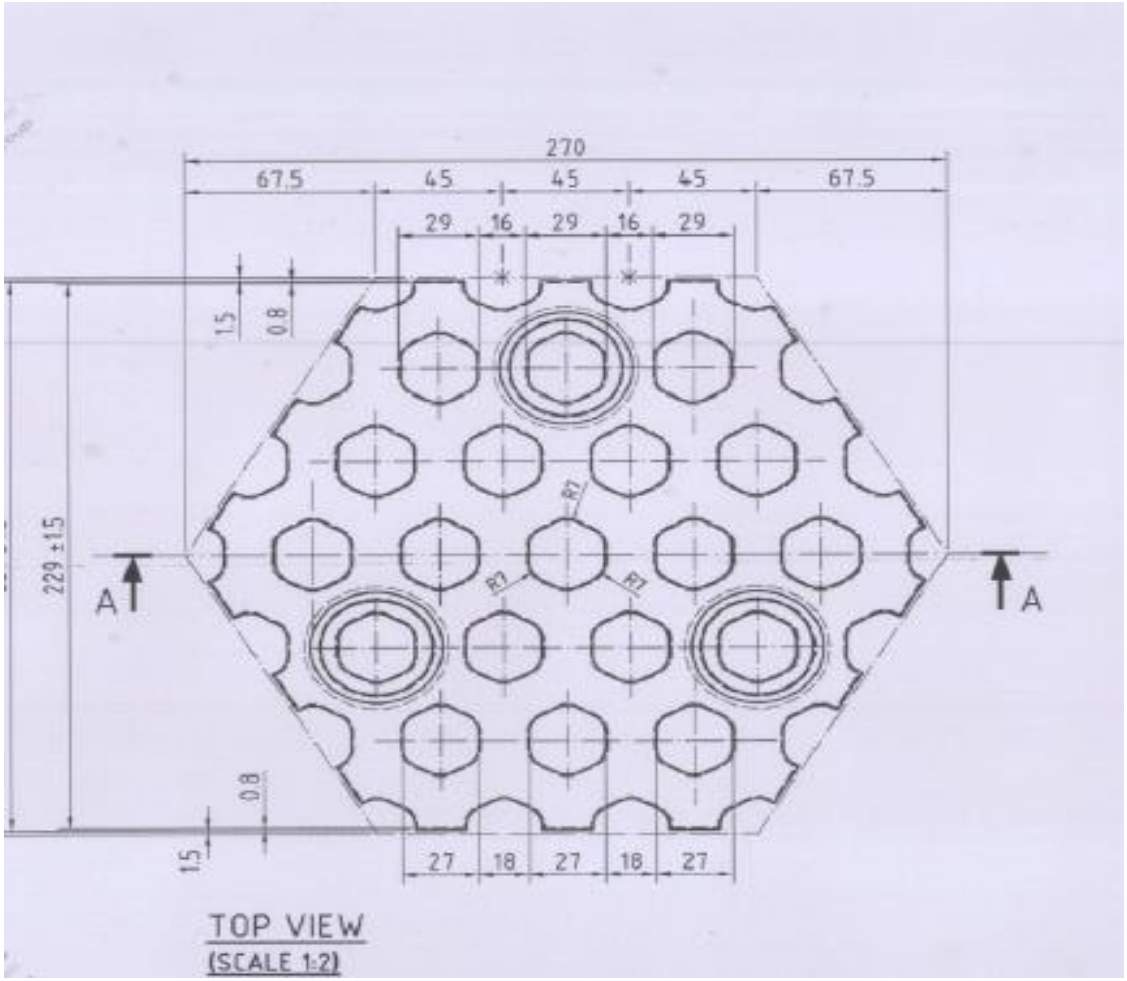


6. Checker – Developments (2/4)



6. Checker – Developments (3/4)

Latest Design Checkers



6. Checker – Developments (4/4)

#	Description	Unit	Type of Checker			
			Fryan	McKee	Hex. (7)	Hex.(19)
1	Specific heating surface	m^2/m^3	24.01	31.75	42.10	50
2	Heating surface area / stove	m^2	27,114	38,855	47,430	65,450
3	Gas volume	Nm^3/h	40,628	39,371	39,182	38,872
4	Air volume	Nm^3/h	35,980	34,874	34,718	34,556
5	Waste gas temperature	^oC	302	258	255	249
6	Efficiency	%	78.98	81.5	81.89	82.78
7	Fuel cost/yr.	Rs Cr	262.1	254.0	252.8	251.2
8	Saving w.r.t. Fryan	%	0	3.1	3.55	4.2

7. Refractory Material - Developments

#	Description	Unit	Refractory Material		
			Silica	Magnesite	High Alumina
1	Thermal expansion	%			
	At 0 – 300 °C		1.1-1.2	0.35	0.1-0.2
	At 300 – 600 °C		0.1-0.2	0.4	0.1-0.2
	At 600 – 1500 °C		**0.0-0.2**	**1.8**	0.4-0.6
2	Thermal expansion	-			
	At 0 – 300 °C		Very Poor	Poor	Good
	At 300 – 600 °C		Good	Poor	Good
	At 600 – 1500 °C		**Excellent**	Poor	Good
3	Bulk Density	g/cc	1.8	2.5-2.6	**3.0**
4	Heat Capacity	-	Low	Very High	**High**
5	Chemical Resistance	-	**V/Good**	Good	Good
6	Dust built on top Checkers	-	**None**	Small	Cauliflower formation

Part – 3

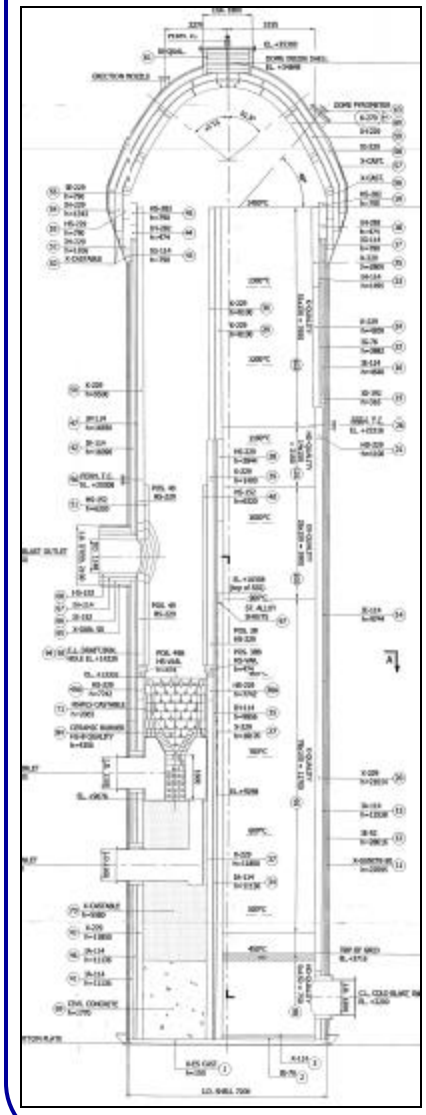
(Status of Stove Design in SAIL)

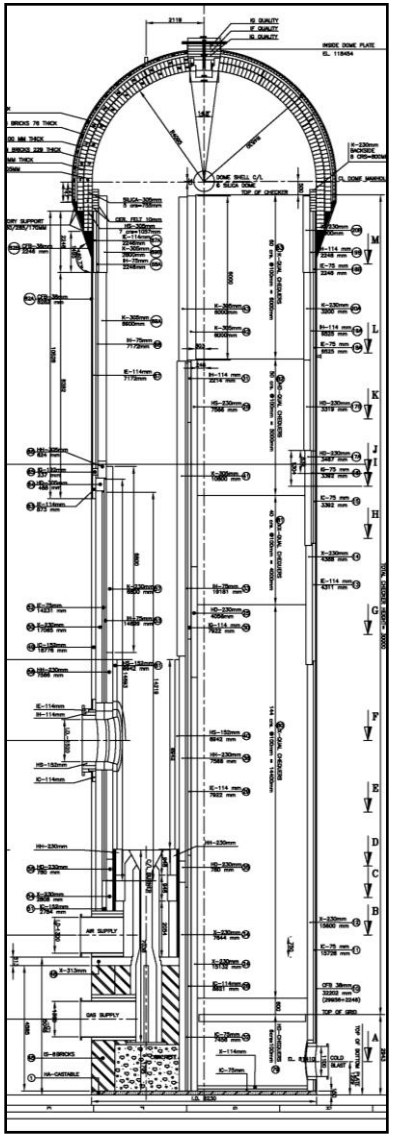
Status of Stove Design in SAIL

Desc.	Unit	BSP				DSP		RSP			BSL			ISP
BF#	-	1	4-6	7	8	2-3	4	1	4	5	1	2	3-5	5
BFs (18)	Nos.	1	3	1	1	2	1	1	1	1	1	1	3	1
U/V	m^3	1033	1719	2355	4060	1400	1800	1710	1658	4060	2000	2586	2000	4060
Design	-	USSR	USSR	USSR	PW	UK	UK	DC	Germ	DC	USSR	USSR	USSR	Posco
Yr. of Inst.	-	59-60	64-71	71	2018	59-62	67	59	60-62	2013	72	76	78-82	2014
Stoves/BF	Nos.	3	4/3	4	3	3	3	3	3	3	3	3	3/4	3
Stoves (57)	Nos.	3	10	4	3	6	3	3	3	3	3	3	10	3
Stove Dia.	mm	8500	8980	9000	10700	7920	8230	7200	8500	10200	7925	8980	8980	10200
Stove Ht.	mm)	40000	35974	45200	45343	33500	39487	34282	38000	48500	35830	45174	45174	48500
HBV	Nm^3/min	1200	3400	3570	5298	-	3000	2300	2750	1000	3333	3064	3000	1000
HBT	^oC	1100	1200	1100	1250	1100	1200	1200	1100	1200	1200	1100	1100	1250
Dome	-	H	H/ P	H	Mu	H/ P	P	Mu	P	Mu	Mu	P	H/ P	Mu
Burner	-	M	M/ C	C	C	C	C	MC	M/ C	C	MC	C	M/ C	C
Checker	-	B/H-7	H-7	Mc/H-7	H-7	H-7	H-7	H-7	H-7	H-7	H-19	H-7	H-7	H-7
Silica	-	N	N/ Y	N	Y	N	Y	Y	Y	Y	Y	Y	N/ Y	Y
Design	-	USSR	HTS	USSR	PW	CET	HTS	DC	CET	DC	PW	CET	CET	DC
Yr. of Inst.					2.2.2018			Co		6.8.2013	Co	2009	2012	30.9.2014

Note: H=Hemispherical, P=Parabolic, Mu=Mushroom, M=Mechanical, C=Ceramic, MC=Metallic Ceramic, B=Basket & Beave, H-7=Hexagonal with 7-holes, Mc=McKee, H-19=Hexagon with 19-holes, Co=Commissioned HTS=Hoogovens Technical Servises, PW=Paul Wurth, CET=Centre for Engineering & Technology, DC=Danieli Corus

Stove Refractory GA - Latest





Features:

1. CFB / Gunning Castable for Shell Safety Lining
2. Improved Partition Wall Lining
3. Mushroom Dome
4. Improved Exp. & Sliding Jt.
5. Metallic Ceramic Burner
6. Hex. Checkers with 7-holes
7. Silica for Upper Part & Dome

Conclusion

- SAIL has 57stoves
  - ✓15-Stoves are of latest design (Mushroom dome, etc.)
  - ✓35-stoves have been modified by CET (Parabolic dome etc.)
  - ✓07-Stoves are of old design (Hemi-spherical dome etc.)
    - ✓06-Stoves have Metallic Ceramic Burner
    - ✓33-Stoves have Ceramic Burner
    - ✓18-Soves have Mechanical Burner
      - ✓36-stoves have silica refractory
      - ✓21-Stoves have high alumina refractory
- Thrust in coming years:
  - ✓ To get maximum out of the stoves thro' :
    - ➢ Design modification
    - ➢ Material selection
    - ➢ Standardisation of material specification
    - ➢ Better stove operation

  With minimal investment


" THANK YOU "
There's a little bit of SAIL in everybody's life