Review of Sulphuric Acid Plant Waste Heat Boiler System

Client: Technip Energies, Chennai

Project: IFFCO, Paradeep, Odisha

Scope: Performance check

- Thermal design verification of Sulphuric Acid Plant Waste Heat Boiler (121 TPH)
- Mechanical strength calculations
- Tubes and pipe sizing verification
- Weight estimation of Pressure parts and non-pressure parts
- Bill of material of Pressure parts and non-pressure parts
- Estimated cost and predicted price range

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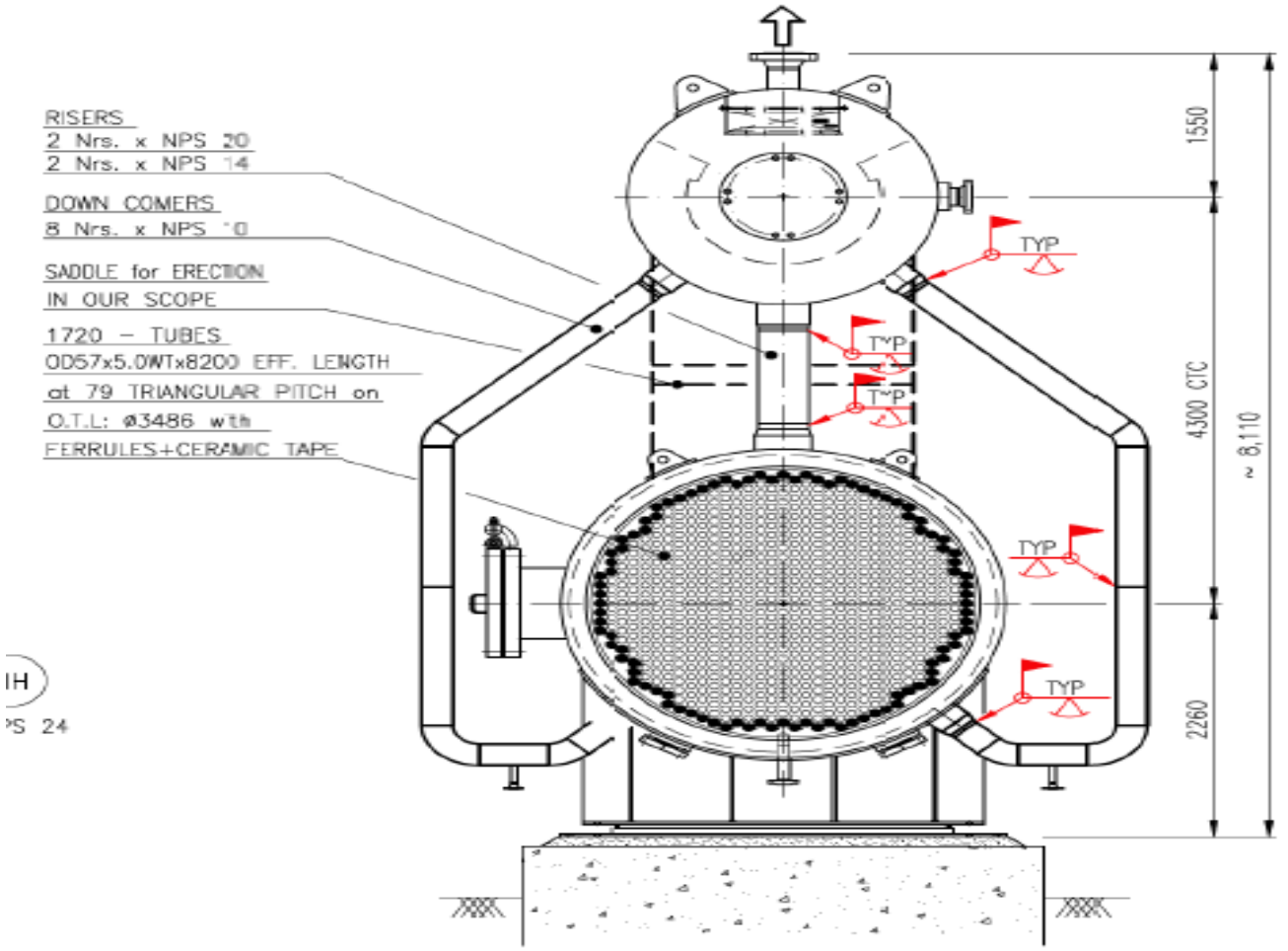

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Project: IFFCO, Paradeep, Odisha

ADVANCED ENGINEERING SERVICES

THERMAL DESIGN CHECK COMPARISON

Sl.No.	Description	Unit(s)	OEM Provided Data	AES Ouput
1	**WASTE HEAT BOILER SHELL**			
	GAS VOLUME (Includes gas bypass)	Nm3/hr	198984	198984
	GAS VOLUME (95% FLOW)	Nm3/hr	-	189034
	GAS DENSITY	kg/Nm3	-	1.4454
	GAS FLOW (95% FLOW)	kg/hr	-	273236
	GAS INLET TEMPERATURE	°C	1094	1094
	GAS EXIT TEMPERATURE at WHB	°C	-	382
	GAS DUTY	Mkcal/hr	51.4	54.9
	BYPASS GAS FLOW (5% FLOW)	kg/hr	-	14382
	MIXED GAS TEMPERATURE	°C	405	407
	STEAM FLOW	kg/hr	121238	121238
	SATURATED STEAM INLET TEMP	°C	284	284
	SURFACE AREA	m2	2526	2526
2	**SUPER HEATER 1C**			
	GAS FLOW	kg/hr	287990	287990
	GAS INLET TEMPERATURE	°C	611	611
	GAS EXIT TEMPERATURE	°C	435	435
	GAS DUTY	Mkcal/hr	12.9	12.7
	STEAM FLOW	kg/hr	121238	121238
	STEAM INLET TEMP	°C	320	320
	STEAM EXIT TEMPERATURE	°C	480	480
	STEAM DUTY	Mkcal/hr	12.9	12.7
	SURFACE AREA	m2	2645	2637
3	**SUPER HEATER 4B**			
	GAS FLOW	kg/hr	212152	212152
	GAS INLET TEMPERATURE	°C	443	443
	GAS EXIT TEMPERATURE	°C	395	399
	GAS DUTY	Mkcal/hr	2.6	2.5
	STEAM FLOW	kg/hr	121238	121238
	STEAM INLET TEMP	°C	297	297
	STEAM EXIT TEMPERATURE	°C	320	318
	STEAM DUTY	Mkcal/hr	2.6	2.5
	SURFACE AREA	m2	798	796
4	**SUPER HEATER 5A**			
	GAS FLOW	kg/hr	212147	212147
	GAS INLET TEMPERATURE	°C	395	395
	GAS EXIT TEMPERATURE	°C	356	359

ADVANCED ENGINEERING SERVICES

THERMAL DESIGN CHECK COMPARISON

Sl.No.	Description	Unit(s)	OEM Provided Data	AES Ouput
	GAS DUTY	Mkcal/hr	2.1	2.0
	STEAM FLOW	kg/hr	121238	121238
	STEAM INLET TEMP	°C	284	284
	STEAM EXIT TEMPERATURE	°C	297	296
	STEAM DUTY	Mkcal/hr	2.1	2.1
	SURFACE AREA	m2	927	931
5	**ECONOMIZER 5C**			
	GAS FLOW	kg/hr	212148	212148
	GAS INLET TEMPERATURE	°C	356	356
	GAS EXIT TEMPERATURE	°C	225	257
	GAS DUTY	Mkcal/hr	7	5.7
	WATER FLOW	kg/hr	123712	123712
	WATER INLET TEMP	°C	190	190
	WATER EXIT TEMPERATURE	°C	241	235
	WATER DUTY	Mkcal/hr	7	5.7
	SURFACE AREA	m2	2795	2807
6	**ECONOMIZER 5A**			
	GAS FLOW	kg/hr	212148	212148
	GAS INLET TEMPERATURE	°C	225	225
	GAS EXIT TEMPERATURE	°C	135	142
	GAS DUTY	Mkcal/hr	4.8	4.4
	WATER FLOW	kg/hr	123712	123712
	WATER INLET TEMP	°C	109	109
	WATER EXIT TEMPERATURE	°C	135	146
	WATER DUTY	Mkcal/hr	4.8	4.5
	SURFACE AREA	m2	2813	2653
7	**ECONOMIZER 3B**			
	GAS FLOW	kg/hr	239519.5	239519.5
	GAS INLET TEMPERATURE	°C	252	252
	GAS EXIT TEMPERATURE	°C	166	166
	GAS DUTY	Mkcal/hr	5.8	5.6
	WATER FLOW	kg/hr	123712	123712
	WATER INLET TEMP	°C	146	146
	WATER EXIT TEMPERATURE	°C	190	190
	WATER DUTY	Mkcal/hr	5.8	5.8
	SURFACE AREA	m2	3807	3806

Review of Sulphuric Acid Plant Waste Heat Boiler System

Client: Technip Energies, Chennai

Project: IFFCO, Paradeep, Odisha

ADVANCED ENGINEERING SERVICES

Life Needs A Lot More Engineering...

PRESSURE PARTS TUBE THICKNESS CALCULATION AS PER IBR

PROJECT NAME :	**M/s.**		
BOILER PARAMETERS :	**1 x 121 TPH / 63 +/- 5 kg/cm^2(g) / 480 +/-5 Deg.C**		
DOCUMENT ID :	**-**		

BOILER TUBES

01. FORMULA: Eqn. : 87 : Reg. 338

Tm = WP x D / (2f + WP) + C

02. Reduction in thickness allowed at bends 100/(4R/D + 2)

t = Minimum required thickness, (mm)
WP = Maximum allowable working pressure, (Kg/cm^2)
D is the ordered outside diameter of the tube
f = Maximum allowable stress value at the design temperature of the metal as listed in the tables specified in PG-23, (Kg/cm^2)
R is the mean radius of the bend to the centre line of the tube (in mm)
C = 0 for the pressure above 70 kg/cm^2(g)

DESCRIPTION	O.D	Thick. Provided	Operating temp.	Temp. addition as per IBR	MATERIAL	Design pressure	Corrosion allowance	Min thk calculated as per IBR	Erosion allowance	Margin available on tube thickness after erosion allowance
	mm	(mm)	Deg.C	Deg.C		Kg/cm^2(g)	mm	(mm)	mm	Straight
ECONOMISER 5A TUBES	60.3	5.54	146	11.00	SA 210Gr.A1	86.5	1.85	3.95	0	1.59
ECONOMISER 5C TUBES	60.3	5.54	241	11.00	SA 210Gr.A1	86.5	1.85	3.95	0	1.59
ECONOMISER 3B TUBES	51	5.00	190	11.00	SA 210Gr.A1	86.5	1.85	3.63	0	1.37
SH.1C TOP BANK	60.3	5.54	440	39.00	SA 213 Gr.T22	75.9	1.85	4.37	0	1.17
SH.1C BTM BANK	60.3	5.54	480	39.00	SA 213 Gr.T91	75.9	1.85	3.81	0	1.73
SH.4B BANK	60.3	5.54	320	39.00	SA 213 Gr.T22	75.9	1.85	3.76	0	1.78

Review on Tube Thickness calculation

Review of Sulphuric Acid Plant Waste Heat Boiler System
Client: Technip Energies, Chennai
Project: IFFCO, Paradeep, Odisha

DESCRIPTION	PIPE SIZE (DN x SCH)	O.D	Provided thk	Inside Dia	Operating Pressure	Operating Temp	MATERIAL	Design pressure	Design Temperature	Corrosion allowance (CA)	Min thk calculated As per IBR	Thk Considered (12.5% '-ve' Tolerance)	Margin available on Thickness	REMARKS
		mm	mm	m	Kg/sq.cm	Deg.C		Kg/cm^2(g)	Deg.C	mm	mm	mm	mm	mm
ECONOMISER														
ECO 3B INLET HEADER	250x100	273	18.26	0.2365	70	284.00	SA 106 Gr.B	86.5	290	0.00	14.707	15.978	1.271	SAFE
ECO 3B OUTLET HEADER	250x100	273	18.26	0.2365	70	284.00	SA 106 Gr.B	86.5	290	0.00	14.707	15.978	1.271	SAFE
ECO 5A INLET HEADER	250x100	273	18.26	0.2365	70	284.00	SA 106 Gr.B	86.5	290	0.00	14.707	15.978	1.271	SAFE
ECO 5A OUTLET HEADER	250x100	273	18.26	0.2365	70	284.00	SA 106 Gr.B	86.5	290	0.00	14.707	15.978	1.271	SAFE
ECO 5C INLET HEADER	250x100	273	18.26	0.2365	70	284.00	SA 106 Gr.B	86.5	290	0.00	14.707	15.978	1.271	SAFE
ECO 5C OUTLET HEADER	250x100	273	18.26	0.2365	70	284.00	SA 106 Gr.B	86.5	290	0.00	14.707	15.978	1.271	SAFE
SUPERHEATER														
SH 1C INLET HEADER	300x140	323.8	28.58	0.2666	65	320.00	SA 335 Gr.P22	75.9	510	1.85	23.746	25.008	1.262	SAFE
SH 1C OUTLET HEADER	300x140	323.8	28.58	0.2666	65	400.00	SA 335 Gr.P22	75.9	510	1.85	23.746	25.008	1.262	SAFE
SH 1C INLET HEADER	300x100	323.8	21.44	0.2809	65	480.00	SA 335 Gr.P91	75.9	545	1.85	17.519	18.760	1.241	SAFE
SH 1C OUTLET HEADER	300x100	323.8	21.44	0.2809	65	480.00	SA 335 Gr.P91	75.9	545	1.85	17.519	18.760	1.241	SAFE
SH 4B INLET HEADER	300x120	323.8	25.40	0.2730	65	297.00	SA 335 Gr.P22	75.9	420	1.85	16.851	22.225	5.374	SAFE
SH 4B OUTLET HEADER	300x120	323.8	25.40	0.2730	65	320.00	SA 335 Gr.P22	75.9	420	1.85	16.851	22.225	5.374	SAFE
SH 5A INLET HEADER	300x160	323.8	33.32	0.2572	65	284.00	SA 106 Gr.B	75.9	420	1.85	22.526	29.155	6.629	SAFE
SH 5A OUTLET HEADER	300x120	323.8	25.40	0.2730	65	297.00	SA 335 Gr.P11	75.9	420	1.85	18.964	22.225	3.261	SAFE

Review on Header Sizing

Review of Sulphuric Acid Plant Waste Heat Boiler System

Client: Technip Energies, Chennai

Project: IFFCO, Paradeep, Odisha

PROJECT NAME : IFFCO
BOILER PARAMETERS : 1 x 121 TPH / 63 +/- 5 kg/cm^2(g) / 480 +/-5 Deg.C

DRUM THICKNESS CALCULATION - SA 516 GR. 70

STEAM DRUM

S.No.	Description	Units	
1	Design pressure, Wp	Kg/cm^2 (g)	79.5
2	Maximum Working Temperature, T1	°C	294
3	Metal Temperature, T2 = (T1+0) Outside the Gas path	°C	294
4	Steam Drum I/D	mm	2400
	PREMISSIBLE WORKING STRESS (f) = Et / 1.5		
5	f = Allowable stress at 300 deg.C	Mpa	136
6	f = Allowable stress at 250 deg.C	MPa	138
7	Allowable stress at metal temperature	MPa	136.24
9	f = Allowable Stress at Metal temperature (From ASME Section - II D)	Kg/cm^2	1388.77
10	Thickess of Steam Drum Shell, T1	mm	75
11	Premissible Working Stress (f)	Kg/cm^2	**1388.77**
	LIGAMENT EFFICIENCY (LONGITUDINAL LIGAMENT OF MAIN BANK TUBES)		
16	(E) Longitudinal = (p - d) / p		**1.0000**
	MINIMUM THICKNESS		
17	Tmin, ((Wp x I/D) / (2 x f x E - Wp)) + 0.762	mm	**71.48**
21	Rolling Allowance	mm	**0.0**
21	Corrosion Allowance	mm	**1.6**
22	Total Required thickness	mm	**73.08**
23	Thickness Provided, T2	mm	**75**
24	Allowance = T2 - Tmin	mm	**1.920**

STEAM DRUM ENDS THICKNESS CALCULATION - SA 516 Gr. 70

S.No.	Description	Units	
1	Thickess of SteamDrum Dished endsl, T1	mm	90
2	Steam drum Drum I/D	mm	2400
3	Working Pressure (Wp) = Design Pressure	Kg/cm^2 (g)	79.5
	Design temperature	deg.C	294
4	Inside Diameter of man hole nozzle, I/D	mm	410
5	E		1
7	Premissible Working Stress of SA 105 material	Kg/cm^2	1323.93
8	Tmin (for nozzle), ((Wp x I/D) / (2 x f x E - Wp)) + 0.762	mm	**13.45**
9	Outside Diameter of Nozzle (d)	mm	500
10	Thickness of nozzle (Tt)	mm	45
11	Maximum Length of nozzle reinforcement (L2) = Sqrt (d x Tt)	mm	150
12	As per Drawing Maximum Length L2'	mm	135
	L2''	mm	95
13	(L2' (Tt-Tmin) + (L2'' x Tt)) x 2	mm2	16270.8745
14	Tmin = Steam drum Dishend thickness	mm	72.0000
15	Imaginary diameter (d1) = d - (A / Tmin)	mm	274.0156
16	Outside Diameter of Head (D) = Steam drum I/D + (2 x Steam drum thickness)	mm	2580
17	d1 / (sqrt (D x Tmin))		0.6358
18	H1 (From Std. Dished End - A4 / SK - 903)	mm	421.00
19	H = H1 + T1	mm	511.00
20	H / D Ratio		0.198
21	Shape factor (k) from IBR Figure No.: 23D		0.79
22	Stress value for Dished end material at drum design temp		1388.8
23	By Reducing the stress values by 1% every 5mm thickness after 60mm thickess	%	0
24	Stress value for Dished end material at drum design temp	Kg/cm^2	1388.7656
	Minimum Thickness Required (Tmin)		
22	Tmin = (Wp x D x k / (2 x f)) + 0.75	mm	**59.09**
23	Thickness Provided, T2	mm	90
24	Margin in Thk = T2 - Tmin	mm	**30.91**
25	Thinning Allowance	%	**34.35**

**Minimum 15% allowance required.

Review on Steam Drum thickness And Dished Ends Thickness calculation

Review of Sulphuric Acid Plant Waste Heat Boiler System

Client: Technip Energies, Chennai

Project: IFFCO, Paradeep, Odisha

	PROJECT:	IFFCO						
	BOILER PARAMETERS :	1 x 121 TPH / 63 +/- 5 kg/cm^2(g) / 480 +/-5 Deg.C						
SL.NO	DESCRIPTION	MATERIAL	Size in mm				WEIGHT in MT	REMARKS
			ID / OD in mm	THK in mm	LENGTH in mm	WIDTH in mm		
PRESSURE PARTS								
WASTE HEAT BOILER - SHELL & TUBES								
1	Shell	SA 516 Gr 70	3807	110	8372		93.25	242.72
2	Tube (Seamless)	SA 210 Gr A1	57	5	8200		101.47	
3	Tube sheets in single pass	SA 516 Gr 70	3800	36			8.16	
4	Intermediate Tube sheets	SA 516 Gr 70	3800	36			8.16	
5	Internals (spargers etc.,)	-					5.44	
6	Stubs&AttachmentsNozzles, Stubs & Attachments, Insulatio cleats	SA 106 Gr B					13.99	
7	Support Saddles, lifting lugs	IS 2062						
8	Base plate, SS liner, PTFE pad, Anchor plate, Anchor bolts, Hold down cum guide clamps for each support	IS 2062					12.22	
9	Manholes & hand holes	IS 2062						
10	Ceramic Ferrules	Zirconium Silicate	1754	nos				Loose supply by TSPL
11	Heat Resistant castable on end tube sheets (76 mm thick)						0.00	Not in TSPL scope
12	Anchors for HR castables	SS 310	1100 nos	4mm T x 64 mm L			0.03	Welded with tube sheets at shop
13	Rolling charges							
14	Tube sheet drilling charges							
15	Heat treatment charges							
WASTE HEAT BOILER - SHELL VESTIBULE-1								
1	Shell	SA 516 Gr 70	4352	14	4500		7.08	13.06
2	Dished end	SA 516 Gr 70		14			1.63	
3	Support Saddles, lifting lugs	IS 2062					2.93	
4	Manholes & hand holes	IS 2062					1.00	
5	Stubs&Attachments, , Insulatio cleats	SA 106 Gr B					1.31	
6	Brick lining, (115 mm thick, 3 layers)							Not in TSPL scope
7	Anchors for brick lining	SS 310	2700 nos	4mm T x			0.13	Welded at shop

ADVANCED ENGINEERING SERVICES WEIGHT COMPARISON SHEET			
Sl.No.	Description	AES Estimated Fabrication Weight in MT	OEM provided Empty Weight in MT
1	WHB	280	280
2	Steam drum	81	85
3	Riser DC piping	6	5
4	Steam Seperator	10	10
5	SUPERHEATER. 1C		
	Top Vestibule	4	4.5
	Top Tube bank	38	35
	Bottom Tube bank	43	40
	Bottom Vestibule	8	8
6	SUPERHEATER. 4B		
	Top Vestibule	4	3.5
	Tube bank	29	24
	Bottom Vestibule	5	20
7	SUPERHEATER. 5A		
	Top Vestibule	8	3.5
	Tube bank	21	28
	Bottom Vestibule	5	20
8	ECO 5C		
	Tube bank	61	60
9	ECO 5A		
	Tube bank	79	93
10	ECO 3B		
	Top Vestibule	4	3.5
	Top Tube bank	81	51
	Bottom Tube bank	29	71
	Bottom Vestibule	6	20
		802	865

Review on Weight Estimation and Comparison

Review of Sulphuric Acid Plant Waste Heat Boiler System

Client: Technip Energies, Chennai

Project: IFFCO, Paradeep, Odisha

SL.NO	DESCRIPTION	MATERIAL	Size in mm				WEIGHT in MT	Basic Matl. Rate (Lakh per MT)	Basic Fab. Rate (Lakh per MT)	Basic cost in Lakhs	REMARKS
			ID / OD in mm	THK in mm	LENGTH in mm	WIDTH in mm					
STEAM DRUM											
1	Drum shell	SA 516 GR 70	2475	75	9000		45.61	0.83	1.00	83.46	
2	Dished end	SA 516 GR 70		90			12.13	1.04	1.25	27.78	
3	Internals (spargers,Vortex Breakers, Demisters, Dash plate for Risers)	CS / SS					5.85	2.30	1.00	19.31	
4	Stubs & Attachments, lifting lugs	IS 2062					8.66	0.95	0.55	12.99	
5	Nozzles & Flanges	SA 106 Gr B / SA 105					2.28	1.20	1.00	5.02	
7	Down Comers	SA 106 Gr B	273.1	12.7	7000	8	5.12	1.10	0.75	9.48	
8	Risers	SA 106 Gr B	508	26.19	1000	2	0.70	1.70	0.75	1.71	
9	Risers	SA 106 Gr B	355.6	19.05	1000	2	0.35	1.50	0.75	0.80	
10	Saddles	IS 2062					6.84	0.60	0.80	9.58	
11	Rolling charges								Included		
12	Dishing charges								Included		
13	Heat treatment charges								Included		
STEAM SEPARATOR											
1	Separator shell	SA 516 GR 70	1550	50	2000		4.41	0.98	0.70	7.39	
2	Dished end	SA 516 GR 70		50			3.36	0.98	1.25	7.48	
3	Internals	CS / SS					1.30	2.30	1.00	4.29	
4	Stubs & Attachments, lifting lugs, Nozzles & Flanges	SA 106 Gr B / SA 105					1.17	0.75	0.55	1.52	
5	Rolling charges								Included		
6	Dishing charges								Included		
7	Heat treatment charges								Included		
SUPERHEATER. 1C											
1	Tubes - Top bank	SA 213 T22	60.3	5.54			17.49	1.45	1.00	42.85	
2	Fin weight	SS 409					7.37	3.50	1.15	34.27	
3	Tubes - Bottom bank	SA 213 T91	60.3	5.54			21.86	4.50	1.20	124.63	
4	Fin weight	SS 410 S					9.21	3.75	1.15	45.13	
5	Tube bends in top bank	SA 213 T22	60.3	8.7			0.87	1.50	1.00	2.18	
6	Tubes outside gas path in top bank	SA 213 T22	60.3	5.54			1.35	1.45	1.00	3.30	
7	Tube bends in bottom bank	SA 213 T91	60.3	8.7			1.09	4.60	1.20	6.32	
8	Tubes outside gas path in bottom bank	SA 213 T22	60.3	5.54			1.35	1.50	1.00	3.37	
9	Inlet header - Top bank	SA 335 P22	323.8	28.58	3780		0.87	1.50	1.00	2.16	
10	Outlet header - Top bank	SA 335 P22	323.8	28.58	3780		0.87	1.50	1.00	2.16	
11	Inlet header - Bottom bank	SA 335 P91	323.8	21.44	3780		0.66	5.00	1.20	4.12	
12	Outlet header - Bottom bank	SA 335 P91	323.8	21.44	3780		0.66	5.00	1.20	4.12	

Review on Cost Estimation