BOILER EFFICIENCY OPTIMIZATION

PROJECT ID:			US Dept of Energy						EQUIP No:	B-4			
PLANT LOCATION:			Anytown						DATE:	9/10/2007			
SERVICE:			Gas fired boiler (baseload)						ENGR:	J D Kumana			
COLOR CODES:	123	measured value (input)											
	321	iteration parameter											
	456	design paramter (input)											
BASIC DATA													
Fuel =	mixed hydrocarbon gases with composition as below										Stoich		
		atoms per mole							HHV	LHV	oxygen		
	MW	C	H	lb/scf	scf/lb	Vol %	lb/h	mol/h	Btu/scf	Btu/scf	mol/h		
Inerts	36	0	0	0.0950	10.5	4.3	1470	40.8	0	0	0		
CO	28.01	1	0	0.0739	13.5	0.2	53	1.9	321	321	2		
H_2	2.016	0	2	0.0053	188.0	0.5	10	4.7	324	274	2		
CH_4	16.04	1	4	0.0423	23.6	84.5	12874	802.6	1010	911	1605		
C_2H_6	30.07	2	6	0.0793	12.6	8.0	2285	76.0	1769	1622	266		
C_3H_8	44.1	3	8	0.1164	8.6	2.0	838	19.0	2516	2318	95		
C_4H_{10}	58.12	4	10	0.1534	6.5	0.5	276	4.7	3255	3015	31		
C_5H_{12}	72.15	5	12	0.190	5.3	0.0	0	0.0	3978	3682	0		
					20.2	100.0	17806	949.9	1064	963	2001		
HHV reported by Lab Analysis				1060	Btu/scf		37432	Btu/nm3 (HHV)					
Deviation from calculated value =				-0.4	%	OK							
Ambient (basis) temp			80	F			**Stm gen rate (trial)**			**283.9**	Klb/h		
Fuel Gas firing rate			6000	scfm (plant data)			Calculated Stm Gen			283.9	Klb/h		
			17806	lb/h			Boiler steam gen capacity			375	Klb/h		
Gas molecular weight			18.7	lb/mole						188	TPH		
Stoichiometric air (dry)			9.96	scf/scf gas			Full-load heat input (fuel)			506	MMBtu/h		
			15.41	lb/lb gas			Boiler operating load			76	%		
Relative Humidity of air			54	%						142	TPH	OK	
Water vapor partial press			0.51	psia			Steam pressure			625	psig		
Moisture content			1.92	lb H_2O/100 lb dry air						640	psia		
Measured oxygen in FG			3.03	%			Steam sat temp			493	F		
Calc Oxygen in fluegas			3.03	%			Steam superheat			235	F		
Measured CO in flue gas			400	ppm			Steam temp (actual)			728	F		
Excess air			16.0%				Sat steam enthalpy			1201	Btu/lb		
Actual air flow			318.3	Klb/h (dry basis)			Cp of superheated steam			0.6944	Btu/lb-F		
Water vapor in supply air			6.1	Klb/h			Superheated stm enthalpy			1364	Btu/lb		
Air preheating			0	F			BFW flow			285.9	Klb/h		
Air supply temp			80	F			BFW temp			308	F	OK	
Flue gas flow (dry)			336.1	Klb/h			BFW enthalpy			278	Btu/lb		
Water of combustion			34.8	Klb/h			Blowdown, % of steam			0.7	%		
Flue gas temp, F			400	F			Blowdown enthalpy			480	Btu/lb		
water vapor enthalpy			1241	Btu/lb									
Combustibles in Flue Gas			600	ppm					Boiler dimensions, ft				
Unburned fuel			0.21	%					Height	60			
									Length	40			
Wall surface material			1	Use 1 for metal, and 2 for brick					Width	25			
Wind velocity			3	ft/sec									
Boiler surface area			7800	ft2 (vertical faces only)				Boiler wall temp			140	F	
Convective Coeff (still air)			0.98	Btu/ft2-h-F				Amb temp in boilerhouse			97	F	
Convective losses			0.5	MMBtu/h				Temp diff vs ambient			43	F	
Estimation of Radiative losses:													
Emissivity of boiler walls:			0.9				Number of Openings in boiler wall				6		
Radiant heat flux			52	Btu/ft2-h			Diameter, or width (if rectangular)				8	inches	
Radiant heat loss (walls)			0.40	MMBtu/h			Approx area of opening/peephole				60	sq in	
Radiant heat loss (holes)			0.61	MMBtu/h			Boiler wall thickness (incl insul)				4	inches	

Radiant heat loss (total)			1.01	MMBtu/h			Radiant loss factor (average)				0.722	
							Temp in combustion space				3271	F
(a) Stefan-Boltzmann law:			0.26	% of fuel heat input			Blackbody radiant flux				335204	Btu/ft2-h
(b) empirical correlation:			0.47	%								
(c) ASME correlation			0.34	% (without ΔT or air velocity corrections)								
			▼									
Radiant heat losses			0.40	% (choose value based on three alternative estimates above)								
HEAT BALANCE												
Heat in fuel (HHV)			383.0				Unburned fuel		0.8			
Heat in combustion air			3.7				Radiant loss		1.5			
Heat in air moisture			0.1				Convective loss		0.5			
Heat in BFW			79.4				Flue gas		75.1	(including water vapor)		
Total heat inputs			466.2	MMBtu/h			Blowdown		1.0			
							Total heat losses		79.0	MMBtu/h		
Heat in steam			387.3	MMBtu/h								
EFFICIENCY CALCULATION (modified ASME method)												
					MMBtu/h		JDK Note					
Primary Input (Fuel, HHV)					383.0		ASME method takes credit for heat					
							content of condensed moisture in flue					
Losses:	Flue gas (sensible)				27.8		gas as if it were a useful output.					
	Flue gas (moisture of combustion)				41.5		Same for boiler blowdown.					
	Radiation				1.5		These are not realistic assumptions.					
	Convection				0.5							
	Unburned fuel				0.8		Boiler Efficiency =		**81.2%**	by ASME method		
	Total				72.2				**80.4%**	by heat balance		
Useful Output (net steam vs BFW)					308.7		Optimum air flow =		316	Klb/h		
									4124	Kscfh		
NOTE:	Strictly speaking, the power consumption for BFW pumps, ID/FD fans, etc should also be included											
	as part of the total energy input required to run the boiler. The electric power consumed should be											
	traced back to the point of generation, and the effective heat rate for power gen should be used.											

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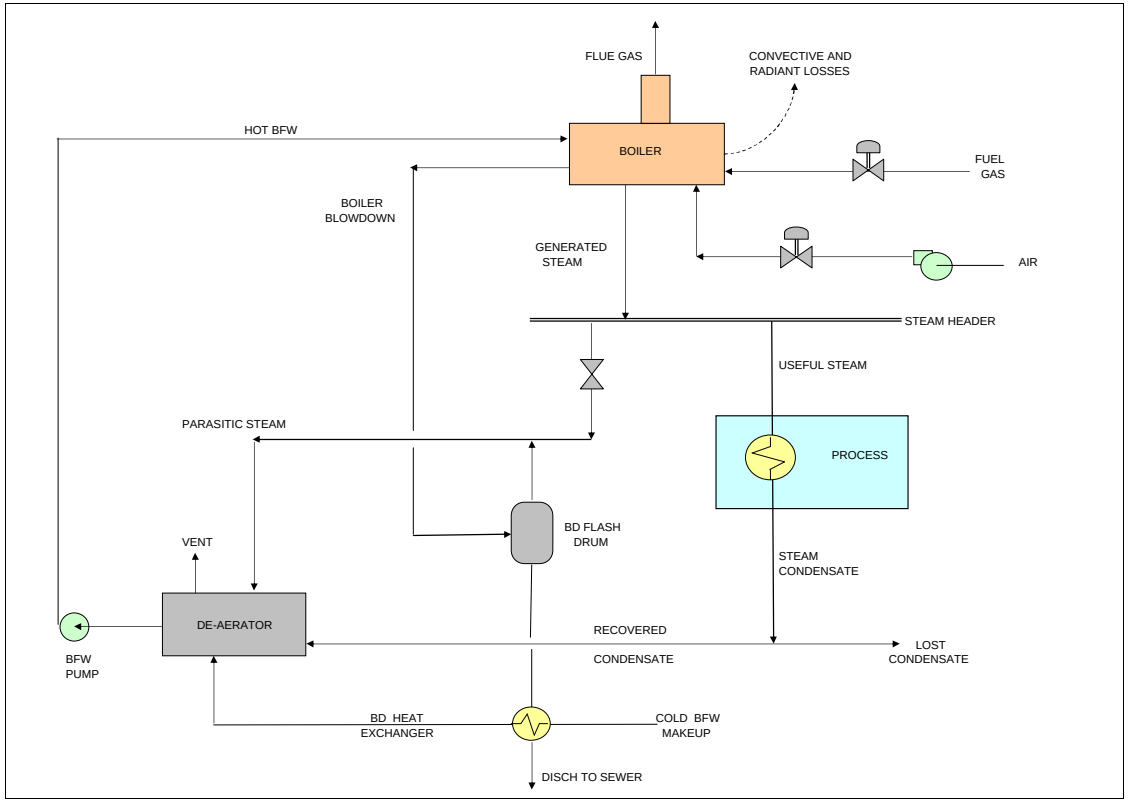

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