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Performance of Oil Fired Steam Boiler (100 Kg / Hr)

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Abstract: Steam boiler or simply a boiler is basically a closed vessel into which water is heated until the water is converted into steam at required pressure. To study the performance, Graphs are to be plotted for Pressure , Temperature , Boiler Efficiency, Equivalent Evaporation.

Keywords: Dryness Fraction, Pressure, Boiler Efficiency, Equivalent Evaporation , Separating And Throttling, Condenser Efficiency.

I. INTRODUCTION

The basic working principle of boiler is very simple and easy to understand. The boiler is essentially a closed vessel inside which water is stored. Fuel is burnt and hot gasses are produced. These hot gasses come in contact with water vessel where the heat of these hot gasses transfer to the water and consequently steam is produced in the boiler . Boiler efficiency depends upon the size of boiler used . Actually there are some losses occur like incomplete combustion, radiating loss occurs from steam boiler surrounding wall, defective combustion gas etc. In water tube boiler the water is heated inside tubes and hot gasses surround these tubes. In sugar industries mostly water tube boiler is used.

To study the performance, Graphs are to be plotted for Pressure variation , Temperature variation , Boiler Efficiency , Equivalent Evaporation



Fig. 1 Boiler setup with condenser and Separating And Throttling Calorimeter

II. EXPERIMENTAL SETUP

The experimental setup consist of oil fired Non IBR Boiler of 100 Kg/Hr Capacity with economizer. To measure the dryness fraction of steam separating throttling calorimeter is provided . Shell and tube type condenser with reciprocating type vacuum pump. The whole setup is mounted on a self-contained sturdy iron Frame

III. FORMULAS USED

$$1) \text{ Boiler Efficiency} = (\text{Heat Exported by Outlet Steam} / \text{Heat Supplied by Fuel}) \times 100$$

$$= M_a(h_s - h_w) / M_f \times C_v$$

Where M_a is the mass of steam in Kg/hr = 100kg/hr

h_s is the final enthalpy of steam in KJ/kg (from the steam table corresponding to steam pressure (Absolute Pressure) in bar and dryness fraction, $(X=0.8)$, $= h_f + x h_{fg}$)

h_w is the initial enthalpy of steam in KJ/kg from the steam table corresponding to water inlet temperature to boiler

M_f is the mass of fuel in kg/hr = 5.25 kg/hr

C_v is the calorific value of fuel (Diesel) = 45980 KJ/kg.

$$2) \text{ Equivalent Evaporation} = M_a (h_s - h_w) / 2257 \text{ Kj / Hr}$$

$$3) \text{ Dryness Fraction} = (X_1) \times (X_2), \text{ Where}$$

$$X_1 = \text{Dryness fraction of steam by separating method} = M_T / (M_T + M_S)$$

(M_T = Mass of water collected in separating calorimeter, M_S = Mass of water collected in throttling calorimeter)

$$X_2 = \text{Dryness fraction of steam by throttling method} = (h_{g2} + C_p(T_2 - T_{s2}) - h_{f1}) / h_{fg1}$$

Where,

h_{g2} = Total Heat of Steam at Pressure P_2 in KJ/Kg.

C_p = Specific Heat Of Steam after Throttling(T_2) in KJ/Kg = 2.01 KJ/Kg

T_2 = Temperature of Steam Inside Throttling Calorimeter

T_{s2} = Saturated Temperature of Steam at Pressure P_2 in $^{\circ}\text{C}$

h_{f1} = Enthalpy of water at Pressure P_1 in KJ/Kg.

h_{fg1} = Enthalpy of Evaporation at Pressure P_1 in KJ/Kg.

$$4) \text{ Condenser Efficiency} = \text{Actual cooling water temperature rise} / \text{Max. Possible temperature rise}$$

$$= (t_{w2} - t_{w1}) / (t_s - t_{w1})$$

Where t_{w1} is the circulating cooling water inlet temperature

t_{w2} is the circulating cooling water outlet temperature

t_s is saturation temperature corresponding to Condenser pressure 0.2 bar = 60.09 $^{\circ}\text{C}$

(From steam table)

TABLE I
Boiler Details

Sr No	Technical Specification	
1	Steam Output	100 kg/Hr
2	Working Pressure	10 kg/cm ²
3	Fuel Consumption (Diesel)	5.25 kg/hr
4	Blower and Fuel Motor	0.5 HP
5	Feed Water Pump	0.5 HP
6	Design	Three Pass

TABLE II
Boiler Observation Table

	Water Inlet temperature to economizer	Water outlet temperature from economizer	Steam Temperature	Steam Pressure (Gauge) Kg/cm ²	Exhaust Gas Outlet Temperature
1	28	36	123	1.5	194
2	28	42	138	2.5	204
3	28	50	157	5	212
4	28	55	166	6	218
5	28	56	170	7	220

TABLE III
Experimental Calculated values for Boiler Efficiency and equivalent Evaporation wrt observation Table

Sr No	Boiler Efficiency %	Equivalent Evaporation Kg/Kg of Fuel
1	88	17.84
2	83.14	16.96
3	78.79	16.02
4	76.92	15.64
5	75.83	15.44

TABLE IV
Observations for Separating and Throttling Calorimeter

Sr No	Separating Calorimeter Temperature T ₁	Separating Calorimeter Pressure kg / cm ² P ₁	Mass of water collected in separating calorimeter	Throttling Calorimeter Temperature T ₂	Throttling Calorimeter Pressure kg / cm ² P ₂	Mass of water collected in Throttling calorimeter	Dryness Fraction (X) Calculated
1	130	1.8	30	101	0.4	0.4	0.74
2	140	2.9	30	105	0.5	0.5	0.75
3	146	3.5	35	107	0.6	0.6	0.79
4	157	4.4	35	110	0.7	0.7	0.81

TABLE V
Condenser Details

Sr No	Technical Specification	
1	Shell Diameter	300 mm
2	Shell And Tube Length	1000 mm
3	Tube Diameter	20mm
4	No of Tubes	18
5	Water Inlet Pipe Diameter to Condenser	32 mm
6	Orifice Diameter in water supply Pipe	22 mm
7	Pressure Difference across orifice	0.2 Kg/cm ²

TABLE VI
Condenser Observation Table

	Steam Inlet temperature to condenser	Condensate outlet temperature from condenser	water inlet Temperature to condenser	water Outlet Temperature from condenser	Condenser Pressure Bar with reciprocating vacuum pump	Water Flow Rate to Condenser LPM	Condenser efficiency Calculated %
1	95	54	25	29	0.2	90	11.42
2	97	56	25	30	0.2	90	14.28

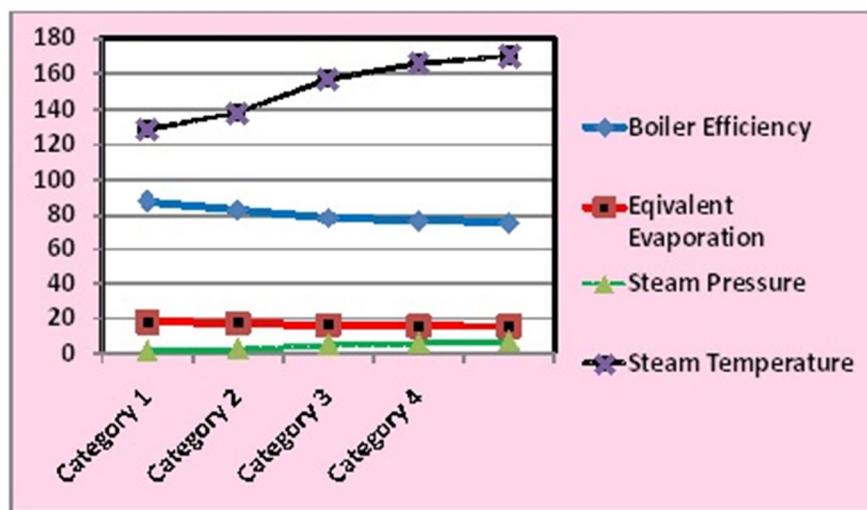


Fig. 2 Boiler Efficiency , Equivalent Evaporation, Steam Pressure , Steam Temperature Graph

IV. CONCLUSION

From the Graph of Boiler Efficiency and Equivalent Evaporation , It is observed that Equivalent evaporation increases with increase in boiler efficiency.

From the Graph of Pressure Vs Temperature , It is observed that as pressure increases corresponding temperature also increases.

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