STEAM TURBINE PERFORMANCE MONITIRING & ANALYSIS

EEC WORKSHOP
16.09.2013-17.09.2013

WHAT STEAM TURBINE DOES

Steam Turbine gets Heat Energy in the form of Superheated Steam from Steam Generator and converts it into mechanical energy to drive the Generator to generate Electrical Energy

CONVERSION OF HEAT TO ELECTRICITY

- 1 KJ/S = 1 KW
- 3600 KJ/H = 1 KW
- 3600 KJ = 1 KWH
- Heat Rate = 3600 KJ/KWH if 100% Heat Energy could be converted into Electricity
- = 3600/4.1868 = 859.85 Kcal/KWH

Turbine Heat Rate as per CERC

Pressure ata	150	170	170	247	247
SH/RH T degC	535/535	537/537	537/565	565/565	565/593
BFP Type	MDBFP	TDBFP	TDBFP	TDBFP	TDBFP
Heat Rate Kcal/Kwh	1955	1950	1935	1900	1850

Efficiency = 859.85/1955 = 0.4398 = 43.98%

= 859.85/1850 = 0.4647 = 46.47%

We need to concentrate on Condenser where this enormous energy is wasted to recover whatever is possible

Condenser Vacuum versus MSL

Altitude	Barometric Pressure	Barometric Pressure	Condenser Vacuum		
metres	KPa	mmHg	Kg/cm2 g	Kpa g	mmHg g
0	101.32	760	-0.930	-91.2	-684
50	100.73	755.6	-0.924	-90.6	-679.6
100	100.13	751	-0.918	-90.0	-675.1
150	99.54	746.6	-0.912	-89.4	-670.6
200	98.95	742.2	-0.906	-88.8	-666.2
250	98.36	737.8	-0.9	-88.2	-661.8
300	97.77	733.4	-0.894	-87.6	-657.4
350	97.19	729	-0.888	-87.1	-653
400	96.61	724.7	-0.882	-86.5	-648.7
450	96.03	720.3	-0.876	-85.9	-644.3
500	95.45	716	-0.87	-85.3	-640
550	94.88	711.7	-0.864	-84.7	-635.7
600	94.32	707.5	-0.859	-84.2	-631.5

Example of JSW Energy

	Altitude metres	Condenser Vacuum KPa
Vijaynagar	520	-85
Barmer	180	-89
Ratnagiri	50	-91

Lesson: Always convert gauge pressure to absolute to analyse.

Effect of CW Inlet Temp

CW Temp	Kpa abs	Kpa g at Ratnagiri	Kpa g at Vijaynagar
33	10.2	-91.12	-85
32	9.69	-91.63	-85.51
31	9.21	-92.11	-85.99
30	8.74	-92.58	-86.46
27	7.46	-93.86	-87.74
34	10.73	-90.59	-84.47
35	11.29	-90.03	-83.91
36	11.87	-89.45	-83.33
37	12.47	-88.85	-82.73
38	13.11	-88.21	-82.09

Importance of CW Chlorination

- If you are not getting Condenser Vacuum check that residual Chlorine is maintained.

- If Condenser Vacuum deteriorates after a few months after tube cleaning it means Chlorination is not being maintained

Measurement of Vacuum

- If you compare Vacuum of two units and find a difference of 1 Kpa i.e.
- Unit 1 -90 Kpa
- Unit 2 -89 Kpa
- Before concluding check Condensate Temperature in Hotwell

Kpa g	Kpa abs	Sat Temp	Hotwell Temp
-90	9.32	44.44	46
-89	10.32	46.43	45

- Accuracy of Hotwell Temp is more than Vacuum
- because Vacuum Transmitter is not calibrated

Calibration of Vacuum Transmitter

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- ✓ The C&I should have facility to calibrate the Vacuum Transmitter creating actual vacuum upto -96 Kpa

Monitoring of Condenser Fouling

- Convert Vacuum gauge pressure to absolute
- Determine Saturation Temperature for the absolute pressure (Tsat)
- Compare Tsat with Hotwell Temperature and decide what to do
- CW Outlet Temperature (To)
- TTD of Condenser = Tsat-To
- Compare TTD with the one noted after Condenser Cleaning

Talk of poor Condenser Vacuum

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- This will generally start after Winter season is over and you approach summer and mansoon and people will forget in Winter.
- Because Wet Bulb Temperature is maximum in mansoon.

Effect on Heat Rate

Vacuum Kpa	Heat Rate Kcal/Kwh	
10.2	1950	Design
7.0	1911	2% Better
13.4	1999	2.5% Worse
15.0	2023	3.75% Worse

Loss due to Make up

Heat Rate at 3% Make as per HBD
MS Flow = M1 MS Enthalpy = H1
FW Flow = Mf FW Enthalpy = Hf
RH Flow = M2 HRH Enthalpy = H3
CRH Enthalpy = H2
Generator Output = P
Heat Rate at 0% Make up = 1950

Supplier	Formula	Heat Rate
BHEL	(M1*(H1-Hf)+M2*(H3-H2))/P	1958
Chinese	(M1*H1-Mf*Hf+M2*(H3-H2))/P	1943
Actual	(Mf*(H1-Hf)+M2*(H3-H2))/P	1984

Loss due to valve passing

- This is a silent loss because it does not appear in parameters.
- Monitoring is done by temperature measurement on down streame (flash tank) side which is supposed to be cold.
- Passing through Main Steam, HP Bypass drain valves may cause huge losses.

Loss due to Main Steam Pressure

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- Keeping Rated Main Steam Pressure results into throttling loss.
- Modern trend recommends Sliding Pressure Operation.
- Pure Sliding Pressure Operation will result into fluctuations in Load with Main Steam Pressure.
- To reduce fluctuations a pressure buffer over Sliding Pressure is used.

Loss due to partial Loading

Load	Heat Rate Kcal/Kwh	Loss Kcal/Kwh
100%	1950	0
80%	1990	40
60%	2064	114
40%	2201	251
VWO 106%	1943	-7

Loss due to Low Reheat Temperature

- Sometimes it is not possible to Maintain Hot Reheat Temperature and there is loss:

Reheat Temperature	Loss Kcal/Kwh
Rated 538 degC	0
525	23

Summarize Losses

Design	1950	No Loss
CW Inlet 38 degC	1999	49
Make up 1%	2011	12
Loading Factor 80%	2051	40
Low Reheat Temperature say 528 degC	2069	18
Total Loss		119