Performance Monitoring is an essential tool for Overall Heat Rate Improvement

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- Efficient power Generation in regulated tariff environment means
- running unit at best achievable Heat Rate.
- With highest availability.
- Achievement of High PLF in a unit may not necessarily result in Efficient Operation.

Achievable Level of Performance

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High PLF & availability does not translate into Optimum heat rate eventually.

Even at best Boiler Efficiency, Unit Heat rate can be worse by 10% due to high steam demand.

Even best run units have potential for Heat rate improvement.

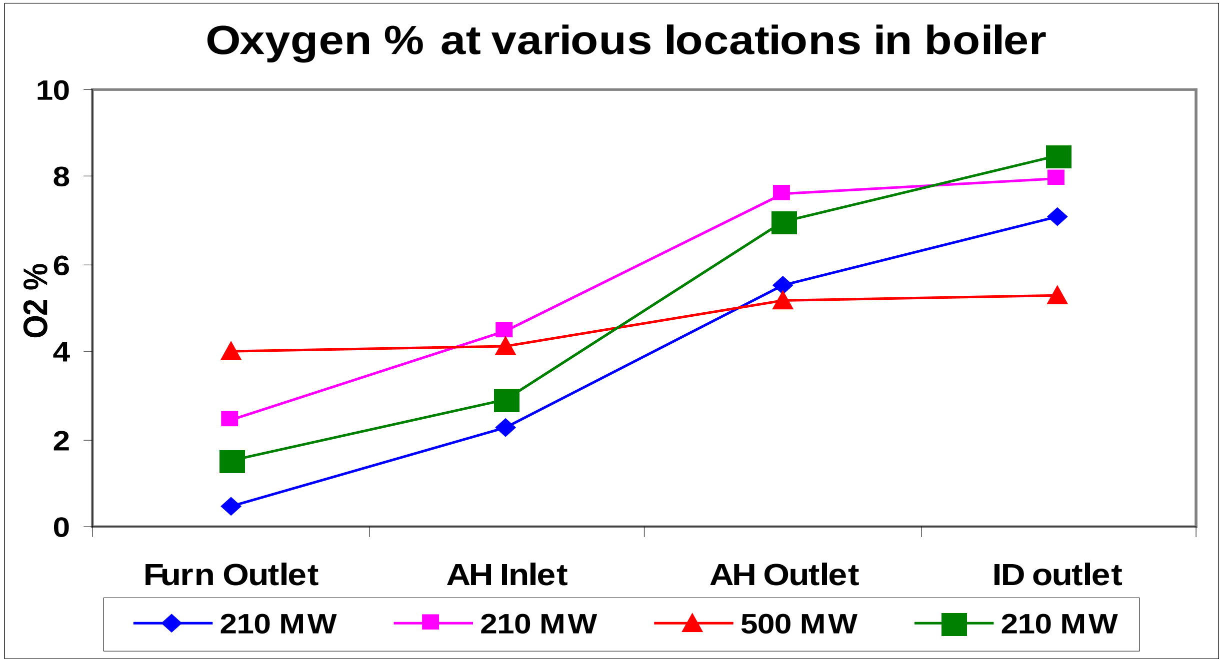
Achievable level of Performance of a unit could be better than design \ Guaranteed on account of margins.

Potential For Heat Rate Improvement

- Margins in equipment design create potential for heat rate Improvement.
- Margins come handy to generate 105% during low frequency period to earn extra revenue.
- Utilities sacrifice efficiency to generate extra during peak hours some times.
- Margins degrade & Unit would operate at less than optimum as Over Hauling requirement approaches.

Boiler Air Ingress

Air ingress can be quantified by the increase in oxygen % in flue gas; The temperature drop of the flue gas from air heater outlet to ID fan discharge also provides an indication of the same.



Margins Essential But They Do Introduce Complacency

- Margins introduce complacency and result in loss of efficiency.
- Fixing aggressive targets could bring around performance improvement .
- Heat rate loss on account of turbine degradations goes unnoticed, but its impact on boiler is very visible.
- Boiler operation at MCR loading is not uncommon.

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Summary -Boiler Performance Tests								
			Pre	Post				
Test Number		Predicted Data	Test 2	Test 2	Test 4	Test 5	Test 6	Test 7
Unit Load	MW	210	190	208	208	207	210	208
MS Flow	t/hr	662	625	690	680	680	700	690
MS Pressure	Ksc	136	115	121	121	122	125	124
MS Temperature	C	540	530	530	528	531	530	529
SH Attemporation	T/hr	---	16	5	10	35	18	0
RH Steam Temperature	C	540	532	530	528	531	530	528
RH Attemporation	T/hr	----	16	20	25	35	32	7
FW Temp at Econ. Inlet	C	246	235	240	240	240	240	240
PA Fan A Current	Amp	---	119	95	95	103	97	100
PA Fan B Current	Amp	---	114	100	95	105	93	105
FD Fan A Current	Amp	---	26	30	30	28	28	31
FD Fan B Current	Amp	---	26	34	30	30	34	31
ID Fan A Current	Amp	---	121	105	100	103	102	110
ID Fan B Current	Amp	---	123	100	105	108	102	110

Design Criteria

- Over all Efficiency of a Thermal power Station depends upon component’s Efficiency.
- Steam Cycle Efficiency-45%
- Boiler Efficiency based on HHV-88 to 89%
- Station Auxiliary Power Consumption- 5 to 8%
- Maximum potential for improvement is always in Turbine Cycle .

Operational Efficiency vs Design efficiency

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- Extent of difference between design & operational Efficiency would depend on
- Plant design/ Technology Maturity.
- Type of Coal / Range of Coals fired
- Site conditions
- Loading factor
- In a new plant, difference could be 3% where soot blowing is not excessive .
- 5% difference is nominal for old Units.

What Makes Operational Efficiency Worse Than Design

- Soot blowing / Blow downs.
- Operation at lower loading factors
- Variation in Steam Temperature & pressures due to load variation.
- Variation in flue gas oxygen content due to changing load and change in coal quality.
- Less than optimum operation of Feed water heaters, condenser and Air Pre heaters.
- Off design steam conditions due to normal inaccuracies in commercial instruments.
- Losses during startup and shut down.
- Off design SH & RH sprays.
- High make up water due to passing of drains and leakages.

Power plant Performance Analysis Base Index.

- Unit Heat Rate
- Net Unit Heat Rate
- Turbine Heat Rate
- Boiler Efficiency
- Unit Auxiliary Power Consumption

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Indian Jharsuguda IPP 4×600MW Project

PG Test Confirmation Signature Sheet

Test content	The Unit#1 Heat Rate		
Turbine Heat Rate	kJ/(kw.h)	8008.47	Turbine Test result
Boiler Efficiency	%	88.9%	Boiler Test result
Piping System Efficiency	%	99%	Contract data
Net output	MW	581.8MW	Electrical Test result
Unit Heat Rate (Heat Rate (Gross) at MCR and 0% Make-up basis)	kJ/(kw.h) kcal/(kw.h)	Process 8008．47/（88.9%*99%）	Calculation result 9099kJ/kWh 2173kcal/kWh
Heat Rate (Net) at MCR and 0% Make-up basis	kJ/(kw.h) kcal/(kw.h)	Process 9099*600/581.8	Calculation result 9383.63kJ/kWh 2241kcal/kWh
Plant Heat Rate	%	Process 3600*0.889*0.99/8008.47	Calculation result 39.56%

As per contracted, the above tests of Unit #1 performance are confirmed to have reached the requirement as per contracted.

	SEPCO III	STEAG	SEL
Signature			
Name			
Date			

Load (MW)	Design Turbine Heat Rate (kCal/kWh)	Design Boiler Efficiency %	Design Unit Heat rate (kCal/kWh)	Expected Operating Heat rate (kCal/kWh)
600	1947.45	87.49	2225	2294
480	1975.87	87.55	2257	2327
360	2049.2	87.80	2352	2425
Avg. Load - 506 MW	1968	87.52	2249	2316
Based on PADO Computation - 506 MW	1968	87.55	2248	2315
Operating Heat Rate (kCal/kWh)				2387
Designed GCV (kCal/kg)	3300	----	Actual GCV (kCal/kg)	3099

REMARK – As Unit-1 meets the Aux. Steam requirement of Units - 2 & 3, Operating Heat Rate was worse than expected. Avg. GCV for July was 3099 (kCal/kg) as against Test GCV of 3250 kCal/kg used for PADO computation.

Heat Rate Deviation Assessment - 600 MW

Load (MW)	Designed Turbine Heat Rate (kCal/kWh	Designed Boiler Efficiency %	Designed Unit Heat rate kCal/kWh	Expected Operating Heat rate kCal/kWh
600 MW	1947.45	87.49	2225	2294
360 MW	2049.2	87.8	2334	2406
Avg. Load - 334 MW	2090	87.9	2378	2449
Based on PADO Computation - 334 MW	2086	87.0	2397	2469
Operating Heat Rate (kCal/kWh)				2458
Designed GCV (kCal/kg)	3300	-	Actual GCV (kCal/kg)	2668

REMARK – Avg. GCV for July was 2668 as against Test GCV of 2770 kCal/kg used for PADO computation.

Improving Turbine Efficiency

- The four primary causes of losses in steam turbine efficiency and performance are,
- Chemical deposits in the steam path; nozzle and bucket surface erosion; mechanical damage to nozzles and buckets due to foreign objects;
- Steam leakage through the unit's shaft packing, tip seals, and inlet steam pipes – with packing and tip seal losses accounting for more than 50% of a steam turbine's efficiency losses.
- As steam turbines ages, extreme operating temperatures and other conditions gradually cause internal components to deteriorate, resulting in losses.

Evaluating Performance Impacts

- Specific system conditions that a station must evaluate to improve steam turbine efficiency should include:
- Poorly maintained steam seals; eroded/damaged first stage nozzle block; damaged rotating elements and diaphragms;
- Feed water heaters in/out of service; Low load operation;
- Manual turbine control; Valve and horizontal joint leakages;

Evaluating Performance Impacts

- Turbine operation at unusually low steam flows; and operating low pressure turbines in condensing mode.
- Turbine cycle improvements could include a program to monitor leaking valves and replace them when necessary (valve cycle isolation).
- Weekly schedule could be very productive. Some stations have a separate DAS for this monitoring.

Heat Rate Deviation System- Cause & Effect

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- Heat rate deviation system is an important component of HR Improvement Program.
- Success of the HR deviation program depends upon the accuracy with which HEAT RATE and parameters affecting HR DEVIATION are measured.
- Heat rate deviation components enable us to focus on areas of heat losses and action plan made to serve priority areas.
- Difference between expected HR and operating HR should be fully accountable.

HEAT RATE DEVIATION SYSTEM

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- High Unaccounted component of deviation can be high due to poor data base.
- IMPROVING ACCURACY of UNIT HR requires intensive efforts
- However, accuracy of parameters affecting heat rate can be improved at nominal cost.
- Operation of unit at optimum parameters would result in achieving best from unit.

HR DEVIATION - CONTROLLABLE PARAMETERS

- List of parameters to be monitored , tracked for HR Deviation has been Standardized /identified for most cycles.
- These parameters are monitored very accurately during PG & routine tests.
- Upgradation of station instruments used for monitoring these parameters essential.
- This requirement has been confirmed based on recent testing done at various stations.

Controllable Parameters

- Maximum heat rate deviation could be on account of degradation of vacuum.
- UNDER WORST condition, back pressure would affect unit output as well.
- Deviation on account of HP & IP efficiency goes unnoticed due to lack of feedback.
- Auxiliary power consumption has a trade off, however , 2nd highest rank.

- HR deviation programs are available on DAS
- Ideal location for Real time program.
- Software should be user friendly and it should be possible to change the targets.
- Reliability of station instruments shall have to be maintained through rigorous efforts.
- Off line PC based system can work in old units with a data link to DAS.

Parameter	Heat rate Deviation Per cent change	Typical Deviation from expected	Heat Rate Deviation
Back Pressure	0.6	50.7	29.5
Auxiliary Power	1.3	11.6	14.9
Excess Oxygen	0.3	36.9	10.3
Make up	0.6	13.0	7.8
Unburnt carbon	0.1	72.7	5.1
Coal moisture	0.2	16.6	2.4
Throttle temperature	3.4	-0.7	2.2
Hot Reheat Temp.	3.6	-0.6	2.2
Feed water Temp	11.1	-0.2	1.9
HP efficiency	4.3	-0.3	1.2
IP efficiency	3.2	-0.9	-2.8
Main Steam Pressure	1.7	0.7	1.1
Flue Gas Temp	2.5	-2.0	-5.1

Unit No. 2 Heat Rate Deviation

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SELECTED DURATION REPORT - EFFICIENCY							
Jharsuguda Unit-2							
						Date:	8/1/2011
SL. No.	Description	Unit	Availibility (Hr)	No of samples (5m)	Average	Min	Max
1	ACTIVE POWER -	MW\MWh	14.00	168	344.50	330.95	354.18
2	Unit efficiency, net (calc.)	%Vol	13.92	167	34.47	32.91	35.96
3	Unit heat rate, gross (calc.)	kcal/kWh	13.92	167	2298.83	2201.82	2398.99
4	Boiler efficiency British standard (calc.)	%	13.92	167	87.38	86.87	88.11
5	Dry gas loss (calc.)	%	13.92	167	4.73	4.11	5.18
6	Loss due to moisture in fuel (calc.)	%	13.92	167	2.12	2.10	2.14
7	Loss due to moisture in air (calc.)	%	13.92	167	0.07	0.06	0.08
8	Loss due to unburnt carbon (calc.)	%	13.92	167	1.25	1.24	1.25
9	Radiation loss (ABMA curve) (calc.)	%	13.92	167	0.16	0.15	0.16
10	Other losses (sensible heat of ash etc.) (calc.)	%	13.92	167	0.77	0.74	0.78
11	Total losses (calc.)	%	13.92	167	12.80	12.08	13.32
12	Gross heat rate, actual (calc.)	kcal/kWh	13.92	167	2077.43	1996.59	2169.32
13	Gross heat rate, net (calc.)	kcal/kWh	13.92	167	2255.13	2166.01	2356.43
14	Gross heat rate, reference (calc.)	kcal/kWh	13.92	167	2053.35	1975.86	2147.5098

Please Enter the Start time :-	7/31/2011 15:00	MM/DD/YYYY HH:MM
Please Enter the End time : -	8/1/2011 5:00	MM/DD/YYYY HH:MM

SELECTED DURATION REPORT - CONTROLABLE LOSS							
SL. No.	Description	Unit	Availability (Hr)	No of samples	Actual average	Reference average	Deviation average in kcal/kwh
1	Throttle temperature	[°C]	14.00	168.00	540.31	538.00	-1.30
2	Throttle pressure	kg/cm^2	14.00	168.00	131.42	103.91	22.69
3	Reheat temperature	[°C]	14.00	168.00	534.66	537.00	1.92
4	Reheat pressure drop	kg/cm^2	14.00	168.00	1.54	2.22	-5.96
5	Condenser back pressure	[bar]	14.00	168.00	-0.89	-0.91	0.13
6	Superheater spray flow	[tph]	14.00	168.00	155.00	126.00	4.66
7	Reheat spray flow	[tph]	14.00	168.00	21.17	0.00	7.07
8	Final FW temperature	[°C]	14.00	168.00	251.62	239.61	-14.93
9	Blow down flow	[tph]	13.92	167.00	0.39	0.00	0.49
10	Auxiliary steam flow	[tph]	13.92	167.00	0.04	0.00	-1.98
11	Frequency	[Hz]	14.00	168.00	49.89	50.00	0.01
12	Make-up flow	[kg/s]	14.00	168.00	0.00	0.00	-0.01
13	Turbine Heat Rate Gross	kcal/kwh	13.92	167.00	2077.43	2053.3479	
14	Turbine Heat Rate Net	kcal/kwh	13.92	167.00	2255.13		

Operating parameters evaluation

1. Steam pressure and temperature — Superheated steam supplied to the power cycle above its saturation point will raise the thermal efficiency.
2. Increasing the pressure at which the boiler evaporates steam raises the system’s saturation temperature, thus increasing the average temperature of heat added to the cycle, in turn, raising the cycle’s thermal efficiency.
3. Exhaust pressure — Reducing condenser pressure (and temperature) also increases power cycle efficiency by capturing some of the previously unavailable work; and a lower exhaust pressure adds a very small amount of steam input.

Main Steam Temperature

Normative Steam Temperature - 535 C +/- 5c.

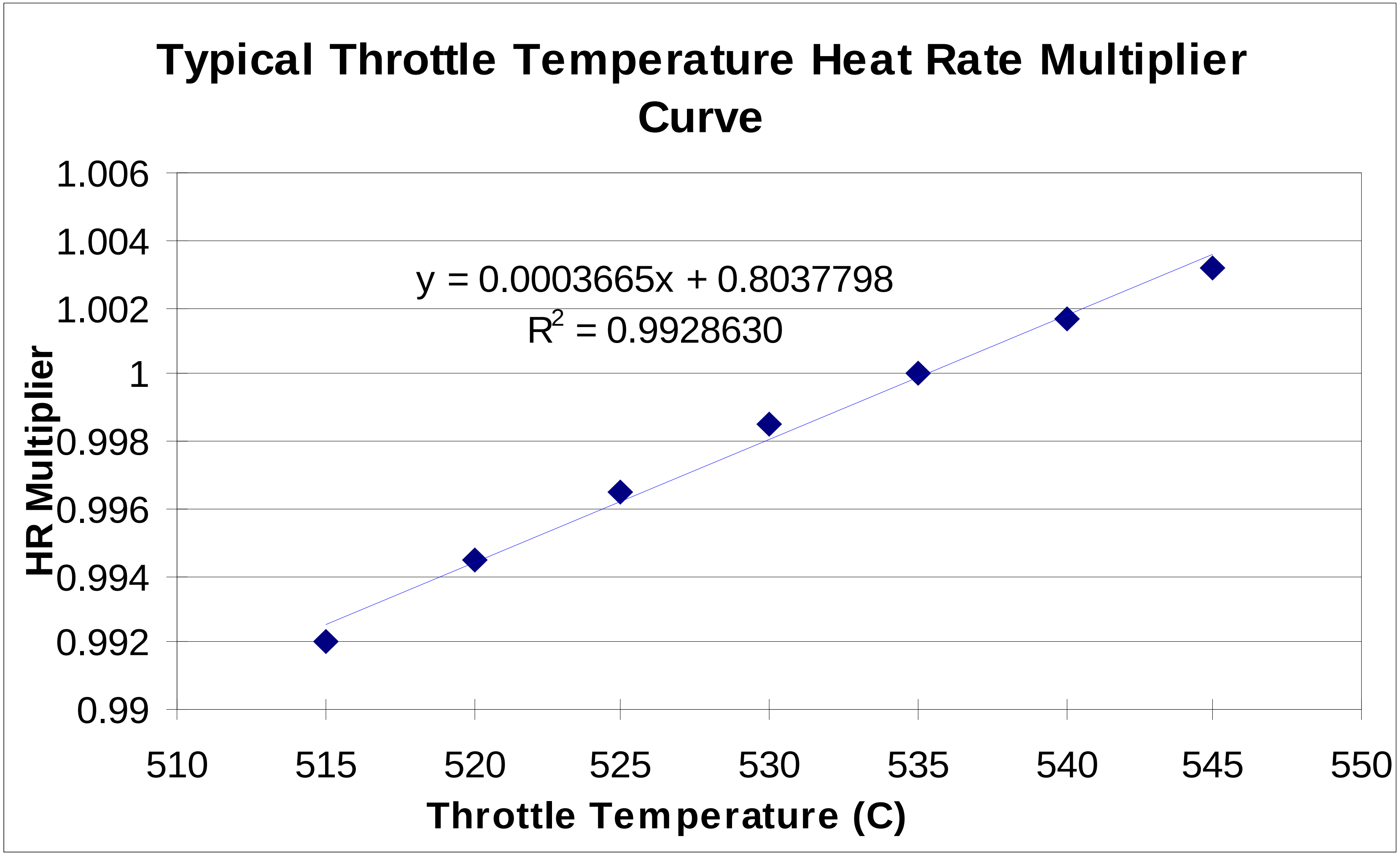
Rated Temperature not Achieved in Many Boilers Due to Process Problems.

Temperature Transients are Faced During Mill Change Overs & Load Variation.

Availability of Burner Tilt Control Essential to Achieve & Maintain Temp.

5c Drifit in Steam Temp. Can Cause Efficiency Loss Of 0.2%.

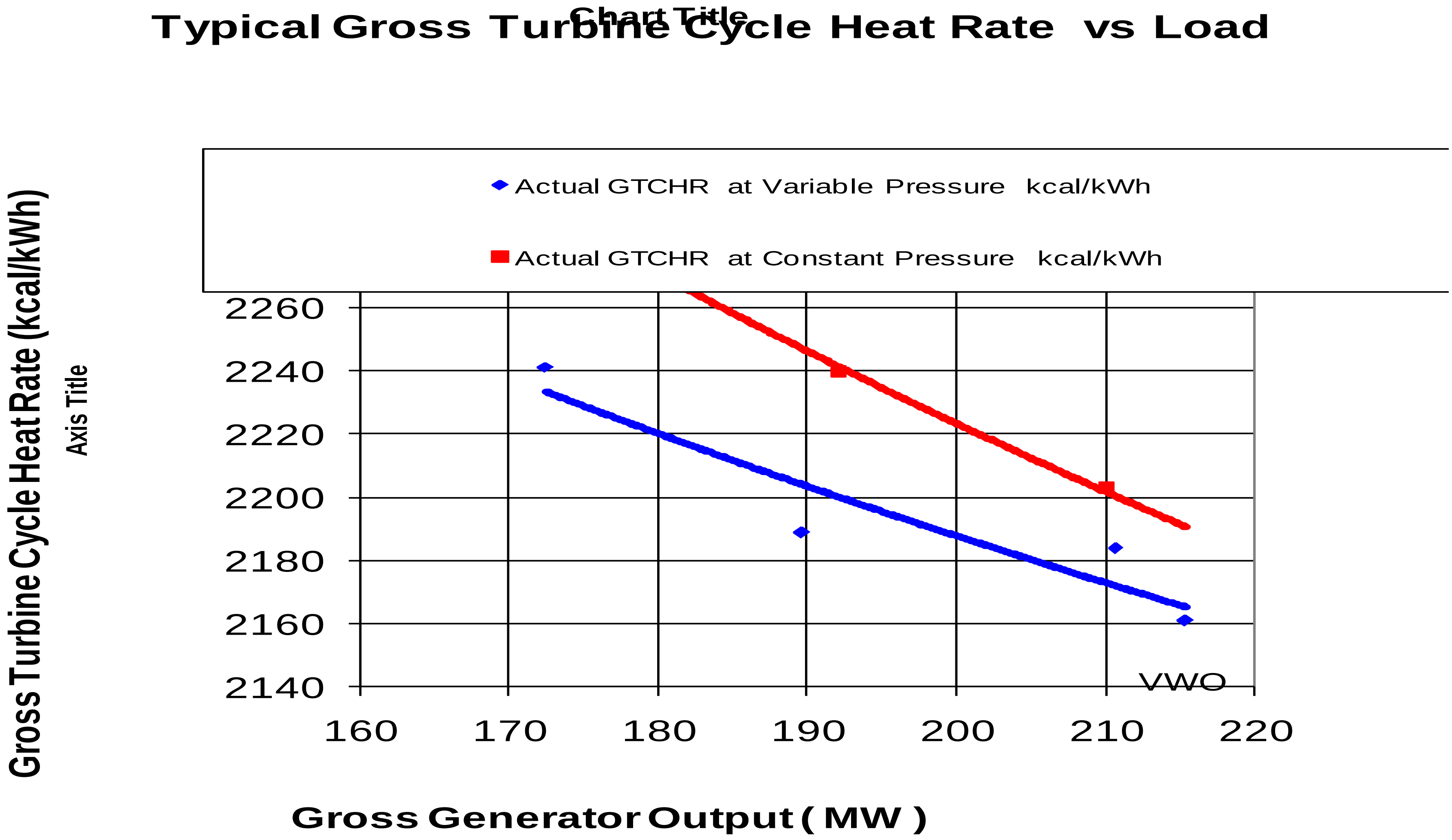
Temp Difference Between Boiler Outlet and Turbine Inlet to be tracked.


Typical Throttle Temperature Heat Rate Multiplier Curve
y = 0.0003665x + 0.8037798
R2 = 0.9928630
HR Multiplier
1.006
1.004
1.002
1
0.998
0.996
0.994
0.992
0.99
510
515
520
525
530
535
540
545
550
Throttle Temperature (C)

Main Steam Pressure

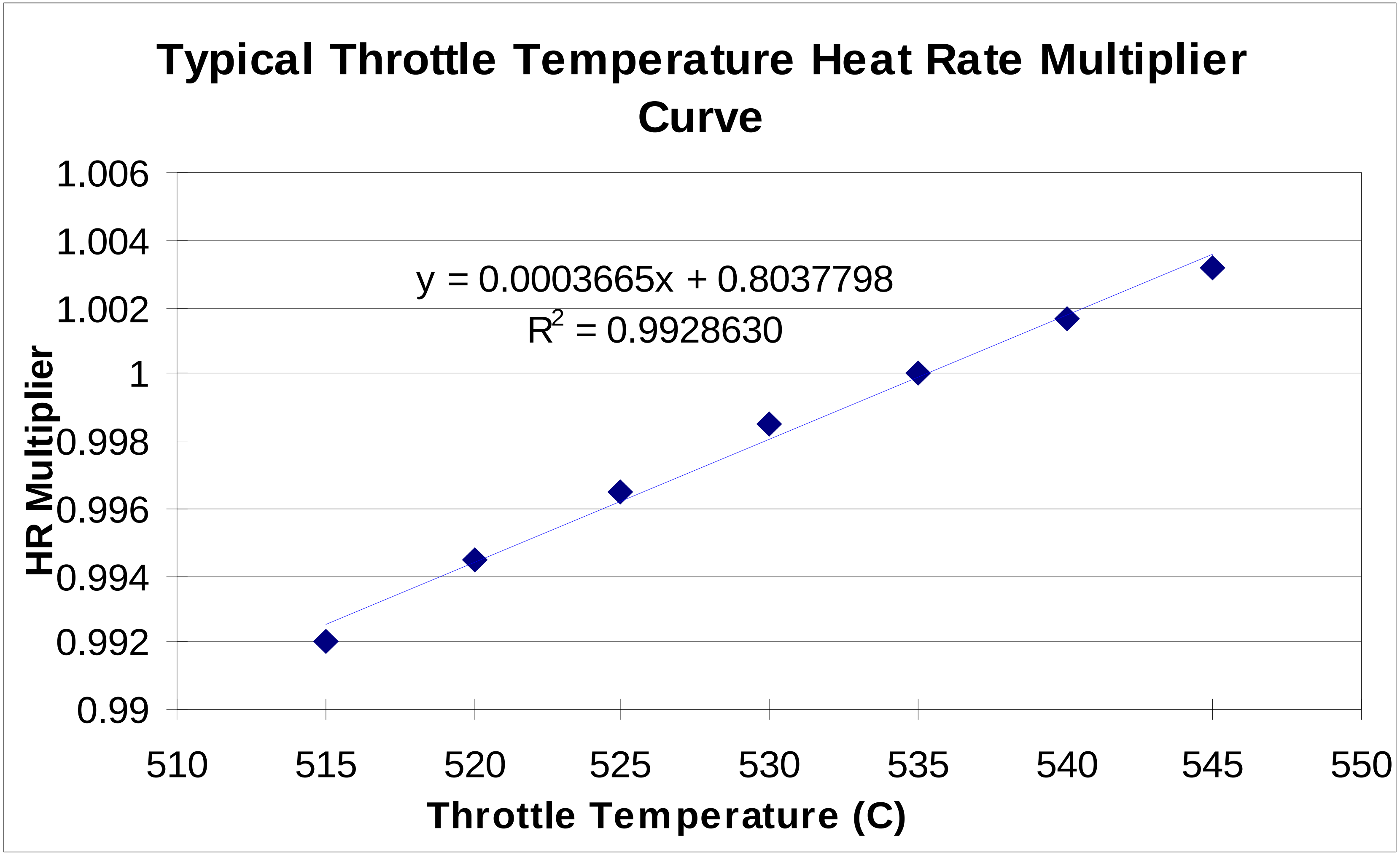
1. Unit to be Run at Nominal Load Without any Throttling.
2. Heat Rate Guarantee is Normally Verified at Rated Pressure.
3. Even Vendor Would not be Averse to Operating at Lower Pressure to Minimize Throttling.
4. Vwo Operation has Economical Pay Back , However, Controls May Need to be Modified.

Typical Gross Turbine Cycle Heat Rate vs Load



Operating parameters evaluation

- Reheat temperature — Raising the average temperature will increase the power cycle.
- Reheating the steam after it has partially expanded through the turbine also provides drier steam in the turbine's last stages.
- Additional reheating will further increase cycle efficiency, the gains will diminish with each additional reheat.
- Re heater pressure drop — A one percent decrease in re heater pressure drop improves heat rate and output approximately 0.1 percent and 0.3 percent, respectively.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y = 0.0003665x + 0.8037798
R^2 = 0.9928630
HR Multiplier
1.006
1.004
1.002
1
0.998
0.996
0.994
0.992
0.99
510
515
520
525
530
535
540
545
550
Throttle Temperature (C)

Operating Parameters Evaluation

- Regenerative feed water heating, some of the partially expanded steam from the turbine is diverted to a heat exchanger to heat the boiler feed water.
- Increasing the number of feed water heaters improves cycle efficiency, the incremental heat rates diminish with each additional heater.
- Raising the temperature of feed water entering the boiler increases the average temperature of added heat, thereby improving cycle efficiency.

FW Outlet Temperature

1. On line FW Temp. Measurement can be made more reliable.
2. Hr deviation corelation based on assumption that flow integrity is maintained.
3. Individual heaters testing to focus on performance degradation.
4. Variation of individual heaters , TTD, DCA to be considered for hr improvement.

Operating Parameters Evaluation

- Extraction line pressure drop — An increase of 2% in extraction line pressure drop, for all heaters, results in approximately 0.09% lower output and heat rate.
- Cycle makeup — water is necessary for offsetting cycle water losses , energy extracted from the power cycle to pump and heat the additional water is wasted in the boiler blow down, resulting in a negative impact on performance.
- Makeup cycle impact on net heat rate is 0.4% higher per percent makeup; and on output, approximately 0.2% lower per percent makeup.

Make Up Water Consumption

- Effect of Make Up Water Variation On HR Deviation Is Very Complex.
- No Standard Guidelines Can be Worked For This Degradation.
- Pepsi Model Software Can Be Used To Study The Specific Impact.
- Component Loss Determination Could Simplify The Assessment.
- Isolation Checks To Be Implemented
- Temperature Monitors To Be Installed In All Critical Flows.

Operating Parameters Evaluation

- Reducing turbine exhaust pressure increases power cycle efficiency.
- However, last stage blade design , exhaust area and the unit’s size tend to affect the impact of changing exhaust pressure on performance.
- Preheating combustion air, with flue gas exhaust from the steam generator, improves boiler efficiency by lowering the flue gas exit temperature.
- Combustion air, however, must be preheated before it enters the air heater so as to maintain flue gas air heater-exit temperature above its dew point temp.

Operating Parameters Evaluation

- Condensate sub-cooling — Cooling cycle condensate temperature below the saturation temperature, corresponding to the turbine exhaust pressure, decreases turbine output.
- The sub-cooling process increases duty on the first FW heater, causing an increase in extraction flow to the heater that, in turn, increases the turbine heat rate.
- Top heater removal — Removing top heater(s) for servicing (such as for tube leaks) results in poorer turbine and plant heat rates.

Operating Parameters Evaluation

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- Heaters removal eliminates turbine extraction thereby increasing steam flow through the turbine's remaining sections.
- For a given throttle flow, the greater flow increases turbine output while the lower final boiler feed water temperature increases turbine cycle heat input.
- Plant operators should check with the turbine manufacturer for limitations on operation with heaters removed from service.
- Alternatives include dumping heater drains to the condenser, or flashing heater drains to the condenser, both less effective than a pump for improving cycle heat rate

Operating Parameters Evaluation

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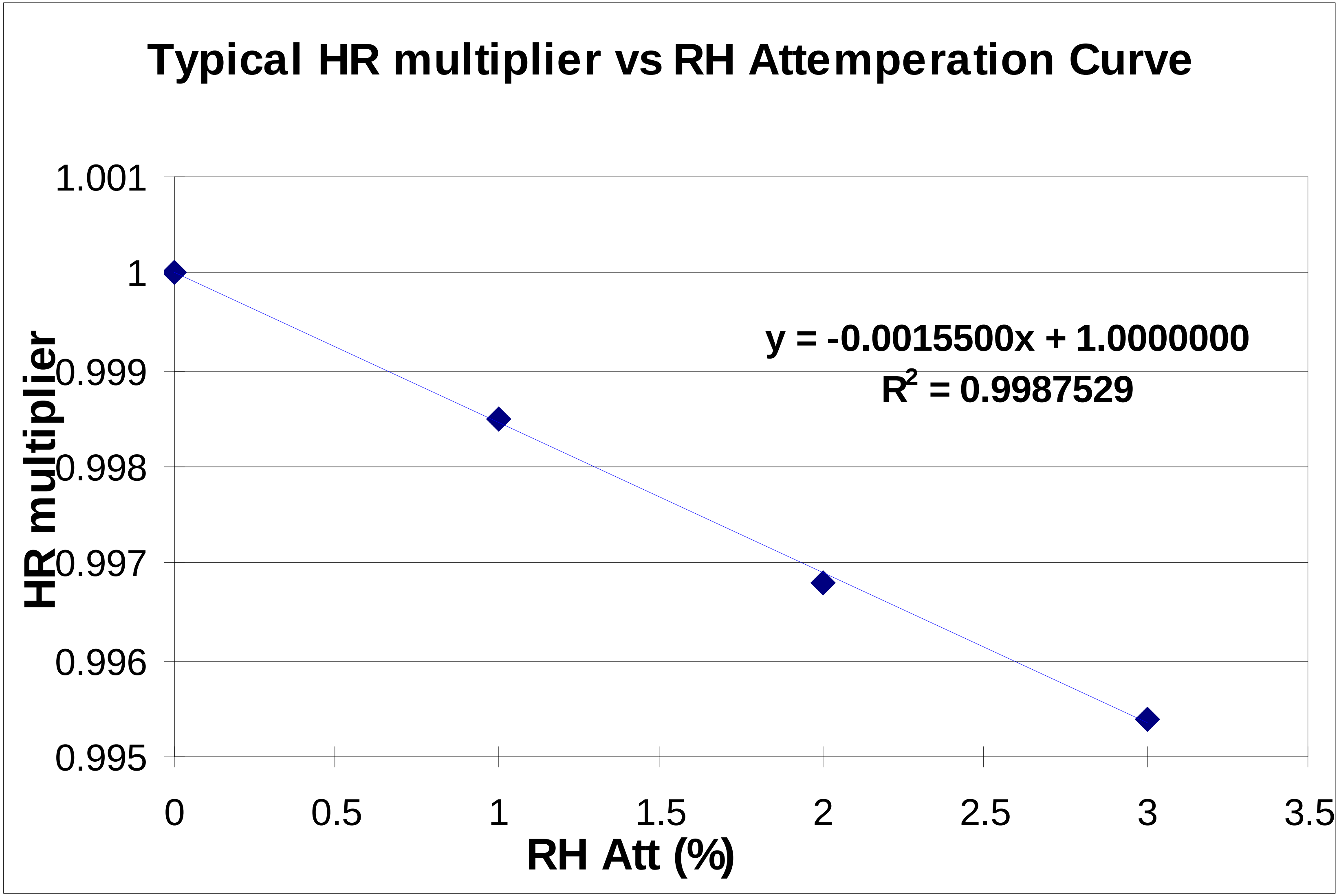
- Superheat and reheat spray flows — Extracting main steam and reheat spray flows from the boiler feed pump discharge adversely impact on turbine heat rate.
- For main steam spray, the flow evaporates in the boiler and becomes part of the main steam flow, which bypasses the high-pressure feed water heaters making the cycle for this fraction of steam flow less regenerative.
- For RH spray, not only does the cycle become less regenerative, but RH spray flow bypasses the high-pressure turbine expanding only through the reheat turbine section. Thus the cycle is non-reheat for the reheat spray portion of steam flow.

SPARAY RATES

- H. R. Deviation on account of variation in spray rate should be investigated.
- Spray rate - deviation is dependent on type of coal, excess air level , mill combination & availability of burner tilt control.
- Furnace cleanliness affect spray rates which is coal dependent. This could be even a design problem.



Typical HR multiplier vs RH Attemperation Curve
y = -0.0015500x + 1.0000000
R2 = 0.9987529
HR multiplier
1.001
1
0.999
0.998
0.997
0.996
0.995
0
0.5
1
1.5
2
2.5
3
3.5
RH Att (%)

Operating Parameters Evaluation

- Ambient wet-bulb temperature — Rising ambient wet bulb temperature results in an increase in condenser backpressure that adversely affects output and HR.
- As the ambient wet bulb temperature increases, CW temperature to the condenser increases in power plants having evaporative cooling towers for cycle heat rejection, resulting in output and heat rate impacts of up to 1.5% to 2% .

Restore Plant to Design conditions

➢ Reinstall F. W. Heaters.	➢ 0.46 to 1.67%.
➢ Reduce Turb. Gland Lkg.	➢ 0.84%.
➢ Reduce Steam Leakage.	➢ 1.1%.
➢ Install new High Efficiency Blades.	➢ 0.98%.
➢ Install on line condenser ➢ Tube cleaning System.	➢ 0.85%.
➢ Install new cooling Tower Film Pack.	➢ 1.97%

Components Of Heat Rate Improvement

- Performance Guarantee testing (Bench Marking)
- Performance monitoring system (Tracking)
- Heat rate deviation system (PUNCH LIST)
- Routine Performance testing/ Energy Auditing
- Performance optimization.
- Unit /equipment Overhauls/ Retrofits

Performance Guarantee Testing

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- PG testing is undertaken to comply with contractual requirement at a cost to utility.
- Data base established is not meant to close contract alone , it could serve as a Bench mark for performance monitoring & testing
- PG tests confirm availability of margins so essential for optimization initiatives.
- Routine performance testing confirms the degradation with respect to a bench mark .
- Units which are being subjected to R & M also need a bench mark feedback.

Performance analysis requires learning right from commissioning

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- Steag closely involved in PG Testing work at different sites where we are working as O&M service provider.
- One area we cannot outsource, we could always go back to OEM for spares & drawings but not performance analysis.
- Performance analysis needs to be learned from our own experience and its consolidation.

Performance analysis requires learning right from commissioning

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- Station O & M generally not interested in compliance of PG Testing work to confirm Guarantees.
- It is considered a Project work to close the contract.
- Steag has learned great deal while helping SEL to confirm Guarantees.
- Since Steag had given back up Guarantees to SEL in O&M contact, this experience was useful in understanding China Equipment

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What are its objective?

- ✓ System serves to generate feedback for developing strategies for improvement.
- ✓ Parameters to be trended and compared with target so that corrective action can emerge.
- ✓ Parameters trended should be based on reliable measurements.

Monitoring Primary Process Indicators

- Primary process indicators are logged in log sheets, scanned using DAS and deviation highlighted in log books by Control engineer
- Primary process indicators should be divided into three specific categories such as H , M & L categories with respect to effect on heat rate.
- DAS can be used to highlight deviation in process performance indicators like pressure drop across condenser which are derived from primary indicators.

Feedback From Pg Tests to Be Used

- Maintenance funds approved should have cost benefit clause and data should be based on actual tests.
- Routine performance test would generate a new data base.
- EEMG group should be manned by experienced performance engineers.
- System being incorporated using PADO should help strengthen O & M requirement.

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Routine Performance Monitoring System

- Performance mimics on DAS have enabled introduction of fault analysis.
- Performance monitoring need to throw right numbers for corrective action.
- Credibility of on line system is poor on account of poor usage by user and matching response from C&I maintenance.
- State of art system for Performance monitoring can be introduced using PADO.

GROSS POWER GENERATION

- Gross power generation to be measured with instruments of same class as export.
- Rated Generator output demands very high through put from Boiler under adverse regime.
- Unit operation at optimum boiler loading would facilitate trouble free operation.
- Units operating at High boiler output, result in high Heat Rate.
- Boiler slagging and tube failures outages could be ascribed to high boiler loading.

Unit Auxiliary Power Consumption

- Unit Aux. Power consumption has direct co-relation with Net heat Rate.
- Higher aux. power consumption basically reflects degradation of equipment.
- High ID fan loading is construed as deterioration of fans performance.
- It is generally on account of High flue gas volume being handled and associated high pressure drop.
- Deviation from target Aux. power consumption could be on account of change in oper. regime.

HP & IP Turbine Efficiency

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- HP & IP efficiency degrades with time . on line instruments trending would not high light the change.
- STAGE efficiency should be determined every six months
- change in stage efficiency can be co related with hr deviation.
- HR Deviation without this would increase unaccounted loss.

Turbine Cycle Improvements.

- Turbine Performance degrades with time.
- Machines with a higher VWO Capability are operated at nominal loads under degraded conditions.
- Deterioration in efficiency would be known only from specific assessment tests.
- Many a Capital Overhauls scheduled for Turbine refurbishment go unused due to non availability of spares for recovery of Heat rate loss.

Turbine Cycle Improvements

- Steam turbines can be re bladed with aerodynamically improved blades to improve .
- However, poorly maintained seals, eroded/damaged first stage nozzle blocks, damaged rotating elements and diaphram are the main factors for loss of turbine efficiency.
- Turbine cycle Improvements includes a program to monitor leaking valves and valve cycle isolation checklist.

Auxiliary Power Consumption

- Auxiliary power consumption is a process requirement to convert fossil fuel into Electricity- a most efficient form of Energy
- Aux. Power consumption as a %age of Generation Capability decreases with increase in Unit size.
- In a 600 MW unit, with Turbo driven feed pumps – auxiliary power consumption is around 6.0% & it rises to 9% with installation of SO2 Scurbbers.

The breakdown of auxiliary power loads for a large coal-fired power plant is presented in the Table . The feed water system loads are determined by operating parameters of the Rankine cycle (where boiler feedwater pump power depends on the main steam pressure), and there is little opportunity for reducing these auxiliary power loads except in the selection of drives. The feed water system loads include the main feedwater pumps and condensate booster pumps. Auxiliary power use in coal-fired power plants by technology.

Component	Technology			
	Subcritical	Supercritical	Ultra-supercritical	Future ultra-supercritical
Feedwater system	32.2	40.9	42.2	48.3
Cooling water system	17.1	14.9	14.6	13.0
Pollution control system	13.3	11.6	11.4	10.2
Combustion air and flue gas	18.8	16.4	16.0	14.3
Fuel handling	5.0	4.3	4.2	3.8
Other loads	13.6	11.9	11.6	10.4
Total	100.0	100.0	100.0	100.0

BOILER FEED PUMP

steag

- Boiler feed pump is not a boiler auxiliary and its power consumption varies in response to turbine mode of working and its degradation
- BFP power consumption can be optimized using variable pressure operation; reduction of spray rates would also help.

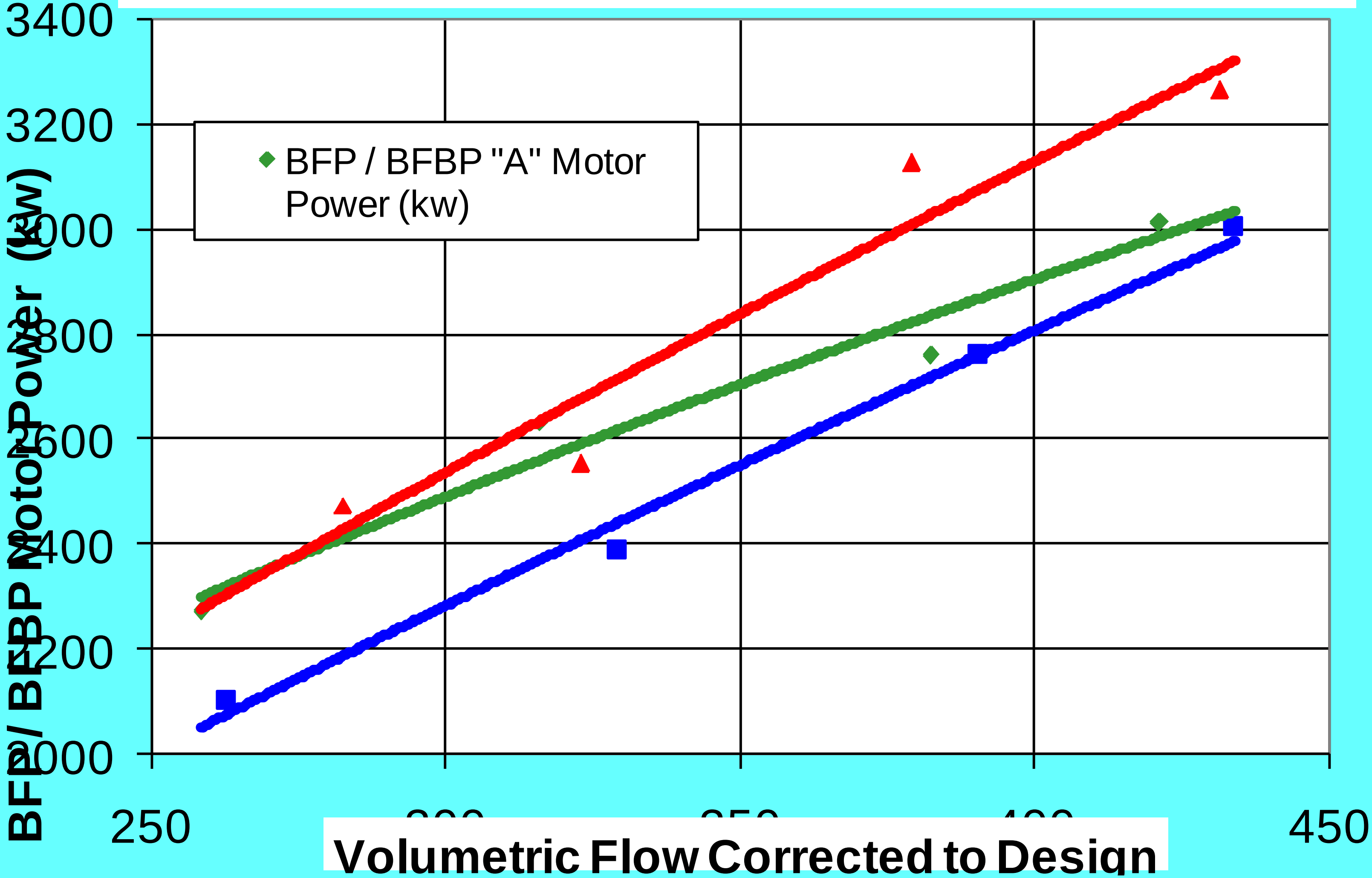
BOILER FEED PUMP

- BFP power consumption constitute a major chunk of power consumed by unit auxiliaries.
- Usage Of Steam Driven Feed Pump Results In Reduction Of Apc %.
- Usage Of Turbo Driven Feedpump Improves Cycle Efficiency .
- Any Feedback On TDBFP Performance Due To Condenser Degradation !

Boiler Feed Pump Performance Testing

BFP	F low t/hr	Train Efficiency %	Power Consumption kw	BDLO flow t/hr
A	327	61	2761	29.4
B	337	62	2760.8	28
C	319	51.4	3128	42.2

Wanakbori Unit 5 BFP Performance Test



Energy Efficiency Management System.

- ✓ Energy Efficiency Management system needs to be adopted in power stations.
- ✓ Using standard guidelines & test procedures, performance tests on individual equipments are conducted.
- ✓ Based on performance tests, gaps are identified & corrective action planned.
- ✓ Energy Efficiency Management is a domain which requires expertise in area of equipment design & performance analysis.

Energy Efficiency Management System.

- A “Plug List” is formulated to highlight performance gap, schedule for recovery of Performance.
- Action for procurement of Material & services is followed very closely.
- Target is to bring current Performance level closer to expected level based on Ambient conditions, coal fired giving due allowance for normal degradation.

Performance Enhancement Through Technology Upgradation – NTPC Example

- R& M route is being adopted in units taken over from Orissa & UP.
- 200 MW units commissioned by NTPC during 1980-87 are being subjected to Performance improvement through technology up gradation.
- Improved Performance Monitoring system & Controls systems have been installed.
- Capitalization of expenditures towards improvement is a necessary incentive for utility to make that kind of investment.

Overview - Turbine Performance Assessment Modules

1. Condenser Performance Testing
2. HP Heaters Performance Tests
3. HP & IP cylinder Efficiency Tests (Pre & Post Outage)
4. Turbine Heat Rate Performance Tests
5. Boiler Feed pumps.

Conclusions

- Mega projects with super critical conditions would enhance Thermal Efficiency of New Capacity being set.
- Sustaining Optimum Efficiency of existing capacity would come through regular investment in quality Overhauls.
- Regular equipment up gradation through technology interventions would help extend unit life and mitigate CO2 emissions as well.