Indian Best Practices for Efficient O&M Of Thermal Power Plants

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Controllable Plant Parameters

- M.S. & R.H. Steam Temperatures
- M.S. Steam Pressure
- Condenser Vacuum
- Final Feed Water Temperature
- DP Across Feed Regulation Station
- Auxiliary Power Consumption
- Make Up Water Consumption

Heat Losses Through Steam

- Cycle Efficiency is reduced by 1% with fall of inlet steam parameters as below:
  Temperature @40^{0}C
  Pressure @25Kg/cm^2
- Steam leakages from Main Steam line results into heat loss @3050-3260 KJ per Kg of steam or:

  1% Main Steam Loss = 1.15% Heat Loss

  1% Soot Blowing = 0.8% Heat Loss

Heat Losses Through Water

- 1%Condensate Loss = 0.1% Heat Loss
- 1% Feed Water Loss After Final Heater = 0.4% Heat Loss
- 1% Blow Down = 0.25 - 0.5% Heat Loss

Increase in Cost of Power for 210 MW Unit

- 100 Kcal/Kwhr increase in Heat Rate leads to @7.0 Million Rs. Increase in generation cost/annum
- 1% reduction in PLF results in @7.0 Million Rs. loss of revenue/annum
- 1 ml/Kwhr increase in specific oil consumption leads to a loss of @5.0 Million Rs./annum

Increase in Cost of Power for 210 MW Unit

- 0.1 bar deterioration of condenser vacuum results in @75 Million Rs./annum increase in fuel cost
- 1% increase in make up water consumption leads to a loss of @2 Million Rs./annum
- 1% increase in auxiliary power consumption of unit working at 70% PLF results in a loss of @1.5 lacks Rs./day (@3.0 Rs/Kwhr)

Optimum Condenser Back Pressure

- It is a misconception that minimum back pressure should be maintained at all loads
- The lower back pressure is justified only if the efficiency gain due to this is greater than power consumption of CW pumps & cooling tower fans

Optimum Condenser Back Pressure

- Merits & Demerits of Lower Back Pressure
- With the reduction in condenser back pr. the isentropic heat drop across the last stage increases & so additional work is done in the turbine
- With lower exhaust pr. Volumetric flow rate increases (high specific volume of steam),giving rise to more Leaving Losses

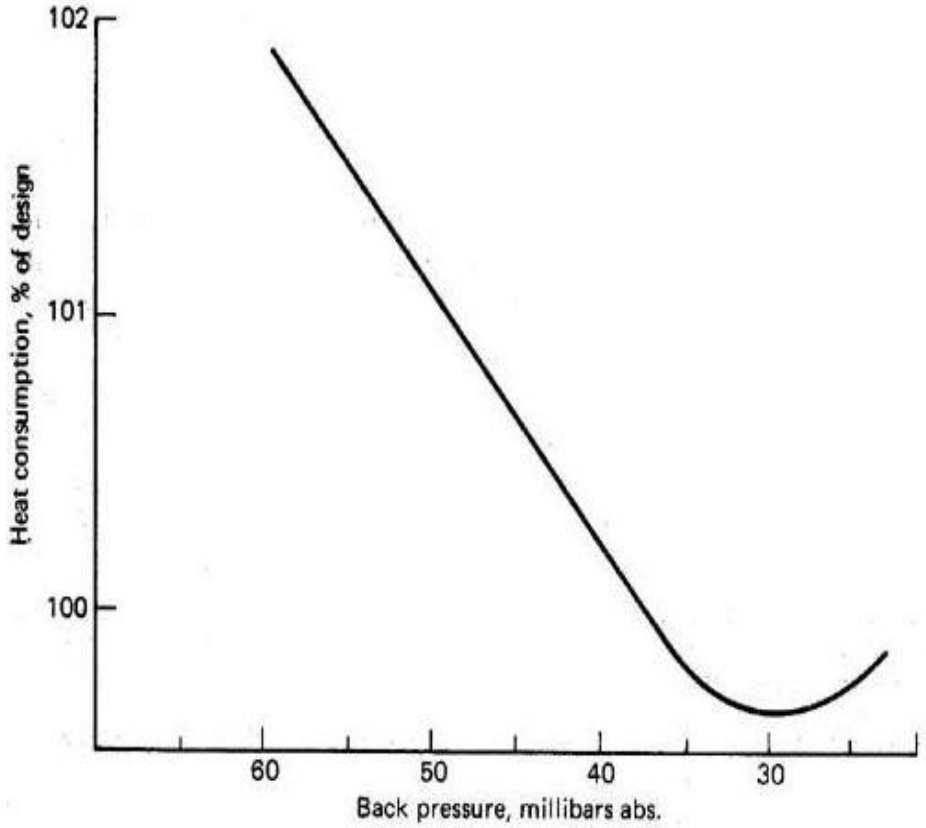
Optimum Condenser Vacuum

- With lower exhaust pr. Wetness Loss increases

  - CW pumping power increases

- Hence to overcome above problems optimum vacuum as shown in graph is maintained

Optimum Back Pressure

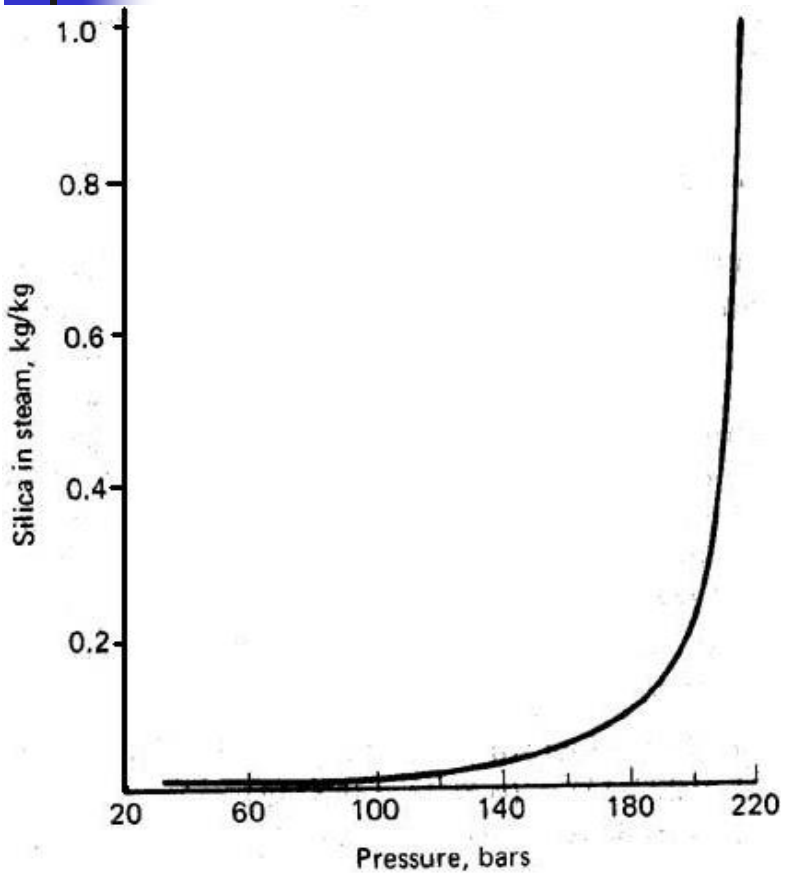


Optimum Back Pressure at Full Load

Effects of Silica Deposition on Turbine

- Silica deposition causes the passage areas between blades to progressively reduce
- Increases the first stage pressure of turbine progressively
- The Cylinder efficiency is reduced

Remedies to Reduce Silica Deposition



Silica in Steam with Boiler Pressure

- Do not raise the boiler pressure until Silica level is normal
- Give Blow down as required
- Minimum use of superheater & reheater spray
- Steam washing of turbine by wet steam at low speeds

Effect of Reheater Spray

- Reduction of cycle efficiency due to fresh steam bypassing the HP turbine
- Reduction of power output from HP turbine due to reduction of steam flow through HP turbine
- Higher Silica deposition in IP & LP turbine

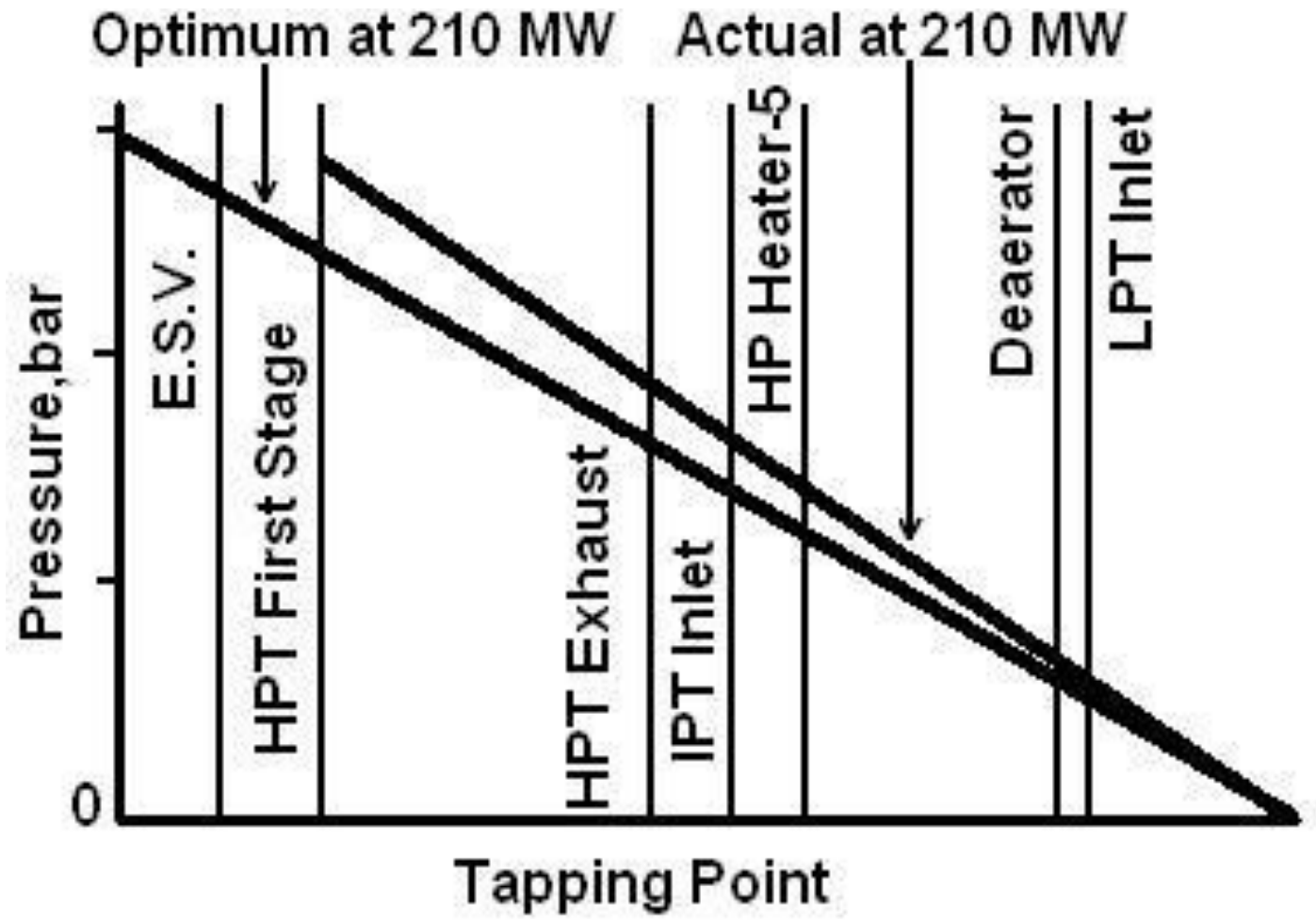
Turbine Performance Monitoring

- Indicators of Reduced Performance
  - Increase of turbine inlet Steam pressure
  - High exhaust steam temperature
  - Gland steam supply header leak-off valve opening increased
  - Increase of condenser back pressure
  - Higher MS flow at rated load
  - Increasing trend of bearing oil temperatures at outlet
  - Axial shift on higher side

Turbine Pressure Survey

- The internal condition of turbine can be predicted by noting down the steam pressures at various tapping points at different loads & plotted on graph
- Comparing the actual curve with optimum curve the condition of turbine can be depicted
- Pressure values should be noted when all the heaters are in service & load is steady

Turbine Pressure Survey



Feed Heaters Survey

- Feed heaters survey evaluate the performance of heaters & predicts the deterioration causes
- Following parameters are noted down
  - Steam pressure at heater
  - Steam temperature at heater
  - Feed water inlet & outlet temperature
  - Heater drain temperature

Feed Heaters Survey

- Evaluate the steam flow to each heater by heat balance
- Compare the flow values with optimum
- Calculate T.T.D. for each heater
- The results indicate following problems

- The elevated TTDs on the heater train suggests water side contamination (oil)
- The high steam flow to particular heater may be due to lower feed water inlet temperature,suggesting the problem in previous heater

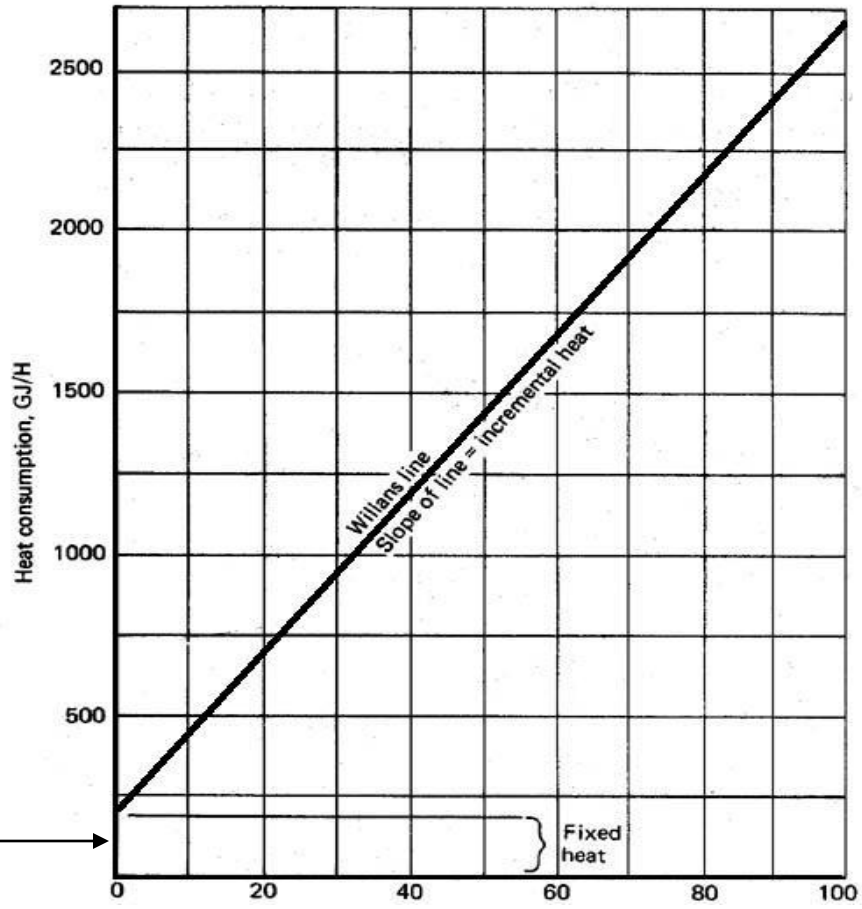
Steam Turbine heat Consumption Test

- These tests are conducted for acceptance purpose or for routine assessment of turbine performance
- The objective of test is to determine required heat input to the turbine for an output on the machine
- The heat rate is calculated from the data & compared with optimum
- The tests are conducted at 40%,60%,80% & 100% load

Constant Pressure Operation

- In throttle governed machine ,the load is directly proportional to first stage pr.
- In constant pr. Operation load reduction is achieved by throttling the steam flow through control valves
- Throttling increases the Entropy & reduces temperature & available energy in the steam
- The exhaust steam wetness is reduced
- Net effect is to reduce the cycle efficiency

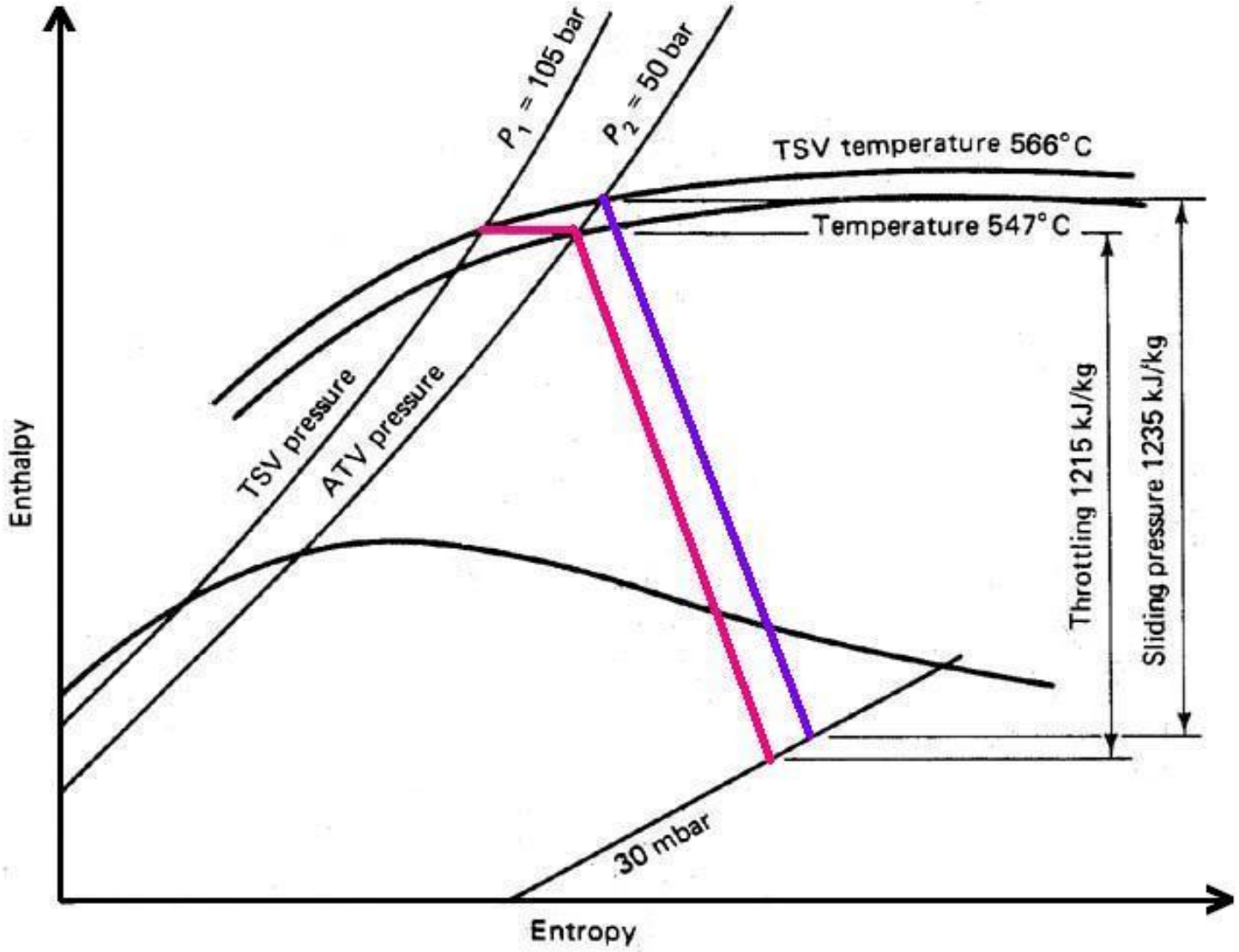
Heat Consumption vs Load



7% for throttle governed machines →

Sliding Pressure Operation

- In sliding pressure operation,the control valves are kept wide open & the pressure before the stop valves is varied through boiler to achieve required part load
- This reduces throttling losses across control valves
- The initial temperature is maintained at reduced pressure unlike throttling process
- The net effect is to improve cycle efficiency as compared to constant pressure operation



Sliding Pressure Operation

Summary of H.R. Improvement

- Always maintain MS & RH temperatures at 540 ± 5^0C
- Maintain rated MS pressure of 150 Kg/cm^2
- Adopt sliding pressure operation at part loads
- While loading the set check that IP control valves are full open after approx. 20% load
- Check that HP-LP bypass valves are closed
- Put LP & HP heaters in service at appropriate time
- Avoid Reheater spray

Steam & Water Leakage Loss

Dia. of Hole	Steam at 7 bar	Steam at 20 bar	Water at 1.5 bar	Water at 7 bar
0.2 cm	7 Kg/hr	17 Kg/hr	10 Kg/hr	23 Kg/hr
0.3 cm	28 Kg/hr	66 Kg/hr	40 Kg/hr	90 Kg/hr
0.6 cm	112 Kg/hr	265 Kg/hr	160 Kg/hr	360 Kg/hr
2.5 cm	1790 Kg/hr	4225 Kg/hr	2560 Kg/hr	5760 Kg/hr

Steam & Water Leakage Loss

- Water will leak from a given size opening at a greater rate than steam as shown in table
- Notice that doubling the size of the hole increases the loss by four times

Maloperation/Passing of Valves

- Passing of water or steam to drains to waste due to leakage of drain valves, steam traps,safety valves on the piping
- All the steam line drain valves of turbine side should be closed immediately after rolling
- Check that MAL drain valves of turbine system close on temperature criteria
- Close warm-up valves of HP-LP bypass after charging

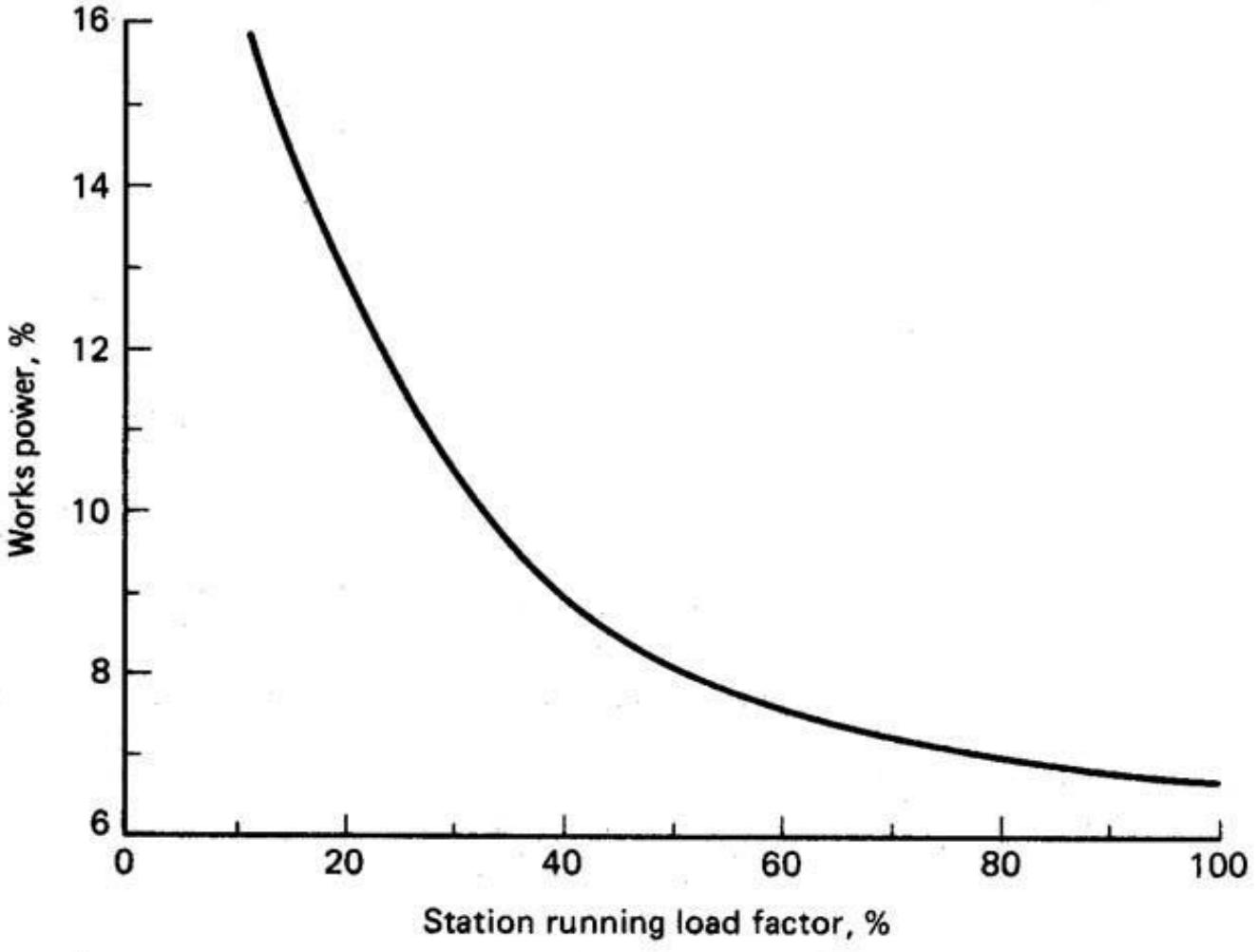
Maloperation/Passing of Valves

- Close all vents of condensate line ,feed water line, heaters after charging
- Check that bypass valves of main control lines are closed
- Check the orifices of Deaerator vent,BFP balancing leak-off for erosion ,replace them if necessary

Auxiliary Power Consumption Optimisation

- In old power stations aux.power consumption used to be >11%, which has been now reduced to 7-8% by dispensing of some pumps,providing efficient auxiliaries etc
- However, the reasons for higher works power are:
  - Partial loading of generating unit
  - Keeping more auxiliaries in service,or at higher load than needed
  - Poor condition of equipments

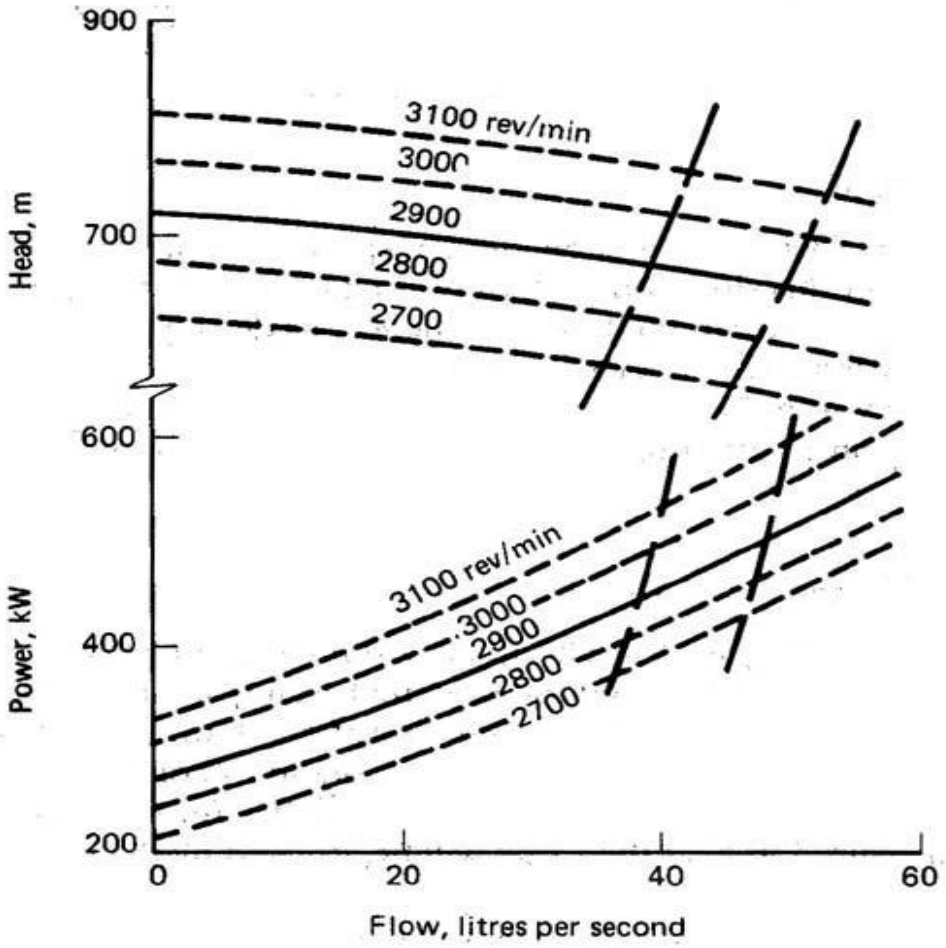
Requirement of Works Power with Load



Measures to be Taken

- At loads lower than 60% Switch off one auxiliary & load the running one fully
- CW pumps should be operated only in accordance with optimisation curve so that benefit achieved from running the pump is greater than the cost of running it
- The power consumption of variable speed drives varies as the cube of the speed
- Doubling the power requires eight times power

Head & power characteristics at Variable Speeds



Optimisation of Works Power

- Whenever a variable speed pump or fan is in service it should be operated at minimum possible speed that will do the job
- During parallel operation of both the equipments should be loaded equally
- In case of BFP keep watch on Balancing Leak off pressure & thrust bearing temp.
- Check that recirculation valve closes at 220 t/hr

Optimisation of Works Power

- Working oil temp. less than 90^0C at rated load
- Strainer DP should be less than 0.5 Kg/cm^2
- Never overload BFP otherwise Cavitation will be promoted due to deterioration of NPSH at high flows
- Always maintain the DP across the Feed Regulation Station about 5-6 Kg/cm^2. Higher DP will increase throttling losses

Good Operational Practices

- Prevent sudden changes in steam parameters,particularly temperatures
- Never cross the temperature limits
- Low steam temperature leads to cooling of rotor resulting negative diff. Expansion & chances of condensation in last stages
- Strictly follow start–up curves/ criteria curves during unit start-up
- Never bypass the TSE influence & do not violate TSE temperature/load margins

Good Operational Practices

- Do not cut-short soaking time during turbine start-up,otherwise this will lead to lower load margins later
- Ensure closure of all MAL drain valves as per temperature criteria.Close steam line drain valves after rolling
- Do not hold the turbine below block load (10%)
- Maintain lube oil inlet temperature between 42-45^{0}C
- Establish feed heaters as soon as NRV releases are available

Good Operational Practices

- Normally avoid use of CRH spray for reheater temperature control
- Ensure regular cleaning of CW system strainers
- Try to reduce make-up water consumption (normal 3%) by checking water & steam leakages in the system
- Change over the auxiliaries time to time to maintain their running hours
- Perform ATT once in a fortnight

THANK YOU