Council of Enviro Excellence

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FLEXIBLE OPERATIONS IN THERMAL POWER PLANT

Challenges of Flexiblisation & mitigation. Impact on Plant Life & Mitigation

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Challenges of Flexiblisation & mitigation.
Impact on Plant Life & Mitigation

The challenges of flexibilisation & Mitigation

- ❖ Operation of TPPs as base load stations in the past so as to cater to unceasing power shortages.

It has resulted in:

- Low automation levels
- Low optimization of plant operation beyond the rated load
- Low ramping capability

Flexibility of operation is limited due to :

- Lack of some control logics.
- Lack of enough tuning at test operation.
- The inferior quality of coal impacts the stabilization of flame at low loads.
- Meeting NOx limits at low operating loads is a matter of concern.

The challenges of flexibilisation & Mitigation

The roadblocks faced in flexibilisation & the possible mitigation strategies

1. Plant Capabilities

Design- Thin-walled components/special turbine design will be better at flexing, shorter start-up time, higher ramp rate.

- Boiler drum in Sub-critical units can pose challenges during flexible operation.
- Super-critical units are better for load ramping operations but flexible operation at lower minimum load is challenging below benson point.
- Operating the super-critical units on sub-critical mode has a very high impact on efficiency.

2. Vintage- In older units the damage will be faster.

3.Milling System- The start-up time and load ramp-up depends on the time taken to start the mills. It can vary from 10 minutes to 15 minutes.

4.Control system- A good control system offers a huge advantage for maintaining parameters during flexible operation and reduces the operational delays.

The challenges of flexibilisation & Mitigation

2. Impact of fuel quality

During low load operation with poor coal quality, the combustion stability of the boiler is severely affected and require additional support of secondary fuel. Challenges with poor coal quality include:

- Boiler slagging and fouling
- Increased corrosion and erosion
- Boiler tube metal temperatures excursion
- Lower boiler efficiency
- Overloading ash handling system
- Overloading of dust removal system and increased emissions.
- Wide variation in coal. GCV varies from 2500 to 6000 Kcal/kg, Moisture - 8% to 15%, Volatiles- 18 to 30%, Ash- 25 to >50%.

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3. Moisture –

High Moisture content:

- Has a flame quenching tendency, flame stability is threatened and absorbs latent heat.
- Lowers the GCV of coal leading to increased quantity of fuel to be fired for the same heat input to the unit.
- Reduces boiler efficiency.
- Affects the pulveriser capacity /affects the coal handling capability.
- may lead to Choking in coal pipes.
- Deteriorates ESP efficiency

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4.Ash -

Ash quality affects the following:

- Mill wear
- Erosion
- Slagging and fouling
- Cold-end corrosion, stack emissions
- Ash handling equipment performance
- Increased deterioration in APH performance
- Duct leakages
- SH/RH steam temperatures
- Increased water consumption
- ESP Performance & Particulate emissions.
- Capacity of CHP, bunkers, mills, boiler hoppers, ESP etc.

The challenges of flexibilisation & Mitigation

5.Volatile Matter -

- The volatile matter is an index of the gaseous fuels produced upon heating of the coal as it enters the furnace, mainly hydrogen and hydrocarbons that sustain ignition.
- Typical range of VM is 18% to 30%.
- Higher VM coals generally produce less NOx and are also easier to control in the combustion system, especially at low load operation.

The challenges of flexibilisation & Mitigation

5.Volatile Matter -

- **Combustion stability is threatened**, even at higher load **when VM of coal is low** (say15%). Increased occasions of unit trips on flame failure (even during base load operation) when using low VM coal.
- The problem gets aggravated further when coal fineness, A/F ratio and/or distribution of A/F is non-optimal and increased amounts of de-volatilized carbon char seeking oxygen in the upper furnace and resulting in secondary combustion.

The challenges of flexibilisation & Mitigation

6. Sulphur Content -

- Sulphur in coal determines the degree of expected corrosion in the high/low temperature regions of the boiler.
- A small part (2-3%) of the Sulphur in coal converts to SO3, and the amount of SO3 produced and retained in the flue gas determines the dew point of the flue gas and the collection efficiency of the precipitator.
- Sulphur content affects APH corrosion, duct & ESP corrosion.
- **The problem is further aggravated during flexible operation when maintaining the flue gas temperature above the dew point becomes challenging.**

The challenges of flexibilisation & Mitigation

7. Nitrogen Content-

- Nitrogen content (in volatile and fixed carbon) causes NOx formation.
- Fuel NOx ranges from 60–80% of the total NOx in pulverized coal units. The NOx formation is reduced with staged combustion.
- **During flexible operation, without sufficient automation for air flow control and combustion optimization NOx control becomes challenging.**

The challenges of flexibilisation & Mitigation

8. Gross calorific Value (GCV) -

- The heat produced by combustion of unit quantity of a fuel when burned at constant volume in an oxygen bomb calorimeter under specified conditions, with the resulting water condensed to a liquid.
- There is a large variation of GCV in Indian Coal, typically varying from 2500-6000Kcal/kg.
- **During flexible operation, running power plant with low GCV coal at technical minimum load is a challenge?**

The challenges of flexibilisation & Mitigation

9. Ash fusion temperatures

- Ash fusion temperatures can be exacerbated by reducing atmospheres that are related with penthouse or convection pass air in leakage that is upstream of the boiler O2 probes.
- This can be a serious problem in Indian power stations with increased flexing and combined with high ash Indian coals.

The challenges of flexibilisation & Mitigation

Impact on plant life

- Flexible operation increases the **creep-fatigue damage caused by thermal stresses**, especially in units originally designed for base load operation.
- The creep-fatigue is a dominant failure mode for damage and failures of many fossil plant components.
- Accelerated Corrosion fatigue damage during flexible operation is another common factor.
- Maintaining optimum water and steam chemical parameters is challenging during frequent cycling.
- Almost all components of the Boiler, turbine and generator are affected ranging from severe to moderate.

The challenges of flexibilisation & Mitigation

Impact on plant life

Some of the severely affected components area as under:

Thick wall components	▪ Casting such as turbine valves and casings ▪ Turbine Rotor ▪ Thick-walled vessels ▪ MS, CRH, HRH headers (especially Y-piece section)
High temperature component	▪ Superheater, Reheater ▪ Ties used to support SH, RH tubing ▪ Tube to header joints etc. ▪ Gas duct work
Corrosion and scaling prone component	▪ Water wall tubing at attachments (wind box, corner tubes, wall box opening, buck stay) Heater tube ▪ APH - cold end ▪ Condenser tube ▪ Welded joints
Degeneration of insulation due to thermal transients	▪ Generator insulation ▪ Transformer insulation ▪ Insulation of HV drives (FD, ID, PA fans, mills motor)

The challenges of flexibilisation & Mitigation

Impact on plant life

The deviations/damage mechanisms observed during flexible operation are as under:

1) High exhaust hood temperatures
2) High steam seal temperatures
3) High rate of change of metal temperatures
4) Last stage blade vibration
5) Solid particle erosion
6) Main steam and reheat steam temperature differential
7) Internal corrosion and oxygen pitting of waterwall tubes
8) Higher rates of internal corrosion of steam tubing due to increased exfoliation
9) Accelerated creep damage to steam (superheater and reheater) tubing
10) Chemistry upsets/excursions resulting in hydrogen damage
11) Fatigue corrosion due to cycling stresses on waterwall tubes
12) Furnace subcooling resulting in external tube failures
13) Overheating during low load operation by improper burner configuration
14) Steam line quenching
15) Higher risk of furnace explosion due to low turn down of fuel capabilities
16) Economizer inlet header thermal fatigue cracking

The challenges of flexibilisation & Mitigation

Impact on plant life

These damages impact the thermal units by:

1) Increased life consumption leading to increased maintenance, operation (excluding fixed costs), and overhaul capital expenditures.

2)Increased time-averaged replacement energy and capacity cost due to increased Equivalent Forced Outage Rate (EFOR).

3) Efficiency loss- Increased cost of heat rate changes due to low load and variable load operation.

4)Increased cost of start-up fuel, auxiliary power, chemicals, water, and extra manpower for start-ups.

5) Environmental Impacts

The challenges of flexibilisation & Mitigation

Impact on Environment

ESP

- **At low loads, Flue gas temperature in the ESP may fall below the dew point** and there is a **built up of ash** due the moisture, which becomes difficult to remove.
- Moreover, with high Sulphur coal there can be **severe acid corrosion due to maintaining lower flue gas outlet temperature.**
- During frequent start-ups, the ESPs are kept out of service during oil firing. During this period, **maintaining the particulate emissions becomes challenging**.
- Due to lower efficiency of the thermal units during minimum loads, **the specific CO2 emissions increase.**

The challenges of flexibilisation & Mitigation

Impact on Environment

FGD operation during flexibilization

- ❖ Frequent start-up can have issues of solidification of slurry and accumulation of start-up oil on the linings.
- ❖ Long period of shutdown will require proper lay-up and flushing of slurry in order to ensure that lime slurry does not solidify.
- ❖ During load variations and frequent low loads, the operation of different streams and CW pumps need to be optimized through automated controls.

The challenges of flexibilisation & Mitigation

Mitigation strategies

S.no.	Roadblocks	Mitigation plan	Remedial measures
A	**Equipment Operating Mode:-**		
1	Achieving >1% Ramp rate (up and/or down); Increasing number of ramps up/down during the day.	Address excursions w/metal and steam temperatures, pressure swings, poor grid frequency response; condenser vacuum; limits on load range.	Advance process control loop tuning, Mill automation, providing additional tube metal sensors, heat flux sensors etc.
2	Minimum load program is not in place; Difficult to reduce load below 55% of MCR without oil support	Establish program; Implement a Systematic Approach to Minimum Load Reduction	Control loop tuning upto 40% MTL, mill automation, single fan/pump operation, implementation of hardwares like Variable Orifice in coal flow pipes-, coal pipe flow measurement, low load scanners.
3	Heat Rate at low operating loads w/ varying fuels; Net heat rate >2% deviation from design due to running at reduced loads; Influence on the Energy Charge Rate and overall production costs. Increase in Auxiliary Power	Benchmark performance; Evaluate controllable losses vs. fuel quality, Modified Sliding pressure operation during ramp up/down. Installation of VFDs for high energy drives.	Top heater installation, single drive operation pumps and fan, installation of VFDs for high energy drives.

The challenges of flexibilisation & Mitigation

Mitigation strategies

B	**Pressure Parts and Life Availability**		
1	Flow Accelerated Corrosion (FAC) inEconomiser tube	FAC programintegration	Top heater installation, Automation in maintaining Boiler water pH
2	No thermal gradient measurement on economizers	Pegging/heating in deaerator and fillingof hot water in boiler filling during light up.	Installation of additional thermocouple in economiser tube
3	Thermal Fatigue	Possibility of inter connection of drains to hot fill the boiler tobe explored;	Interconnection of Deaerators among theunits. Thermal Fatigue can be minimized through maintaining the Startup/Shutdown curve provided by OEM. This can be done through plotting design Vs Actual curve during startup/ shutdown in the dashboard so that immediate correction canbe made in case of anomalies.
4	Steam Temperature control needs improvement following synchronization to mitigate reported excursions in major SH/RH/LTSH components; Mismatch in heat pick up in MS left & right.	Close monitoring of deviation of MS/HRH and metaltemp during ramping.	Advance process controlof steam/ water cycle and load control. Installation of additional metal temperature sensors.
			SH/RH spray controlvalves upgrade.

The challenges of flexibilisation & Mitigation

Mitigation strategies

S.no.	Roadblocks	Mitigation plan	Remedial measures
1	High pressure control valves are passing e.g. sprays ,BFP recirculationvalves , high energy drains etc.	Integrate high pressure control valves modernisationplan.	Phased replacement. Changing on-off BFP re-circulation valve with modulating control valves.
2	Frequent problem in PA fans as they run close to stalling zone.	Continuous tracking of PA fan characteristics curve and provisioning of alarm much before fan operating near the stalling zone.	Single PA fan operation, automated single drive control package to avoid stalling.
3	Thermal Fatigue and Creep Damage	Integrate thermal mitigation strategy.	Boiler fatigue monitoring system and Turbine stress monitoring system.

The challenges of flexibilisation & Mitigation

Mitigation strategies

Combustion & Boiler Performance

1	Furnace exit O2, Furnace Exit Temp measurement are not taken.	Furnace Exit O2 measurement and Furnace Exit Temp measurement to be done. Furnace Exit O2 measurement and Furnace Exit Temp measurement to be done.	Furnace exit O2% probe installation and Furnaceexit temperature measurement.
2	Mill Performance; No provision to measure fuel flow imbalance in mills; Frequent burner choking; Coal rejects from mill hoppers.	Mill performance mapping at various load & coal quality tobe done to identify best & worst mill; Need to establish mechanical blue-printideal for flexible operations. Mill performance evaluation, finesses measurement and coal flow balancing.	Milling system coal pipe measurement system installation. Installation of coal flow sensors and variable orifices* in coal pipes. (* may be only useful below 30% operation)
3	Implement program and strategy for low load and reduced mill operations	Optimize mill operations and/or identify roadblocks and/or issues during planned shut-downs (record observations)	Optimising no of milling operation with milling automation

Thanks

Any question?

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THANKING YOU!
ON BEHALF OF

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