Challenges of Coal base Thermal Plants operating in India

Description

Across the Globe Coal fired Plants used to be treated as base load Power Stations. This means that these Plants will be operated at rated load on continuous basis with very little variation in Load. Coal Plants in India were not exception to that. But with the implementation of Stringent Environment parameters and large scale integration of Grid connected PV Solar Plant, the base load tag of Coal fired in India will not continue in the long run. Though Coal Fired Power will be the primary source of Power but the Plants will not run at steady load. These units have to face wide variation in Load. But to run the existing Units are at varied Load a number of issues will surface.

Issues

Coal based Power Plants with higher Size Unit capacity, eg, 500 MW, 660 MW & 800 MW were /are traditionally treated as base Load Power Stations and are operated on 24X7 basis with little variation in Load or in other words, these Units were/are operated at steady load . These Units have been designed for steady state of operation.

With the opening of Power sector to IPP, it has been observed that during last five years, Capacity additions has been done at rapid pace but the demand did not pick up at the same pace as envisaged leading to surplus capacity. As per CEA Report, Total installed capacity in India was 3, 56,100 MW up to 31st march-2019. Out of this figure, Coal Capacity alone was /is 1,94,444 MW whereas the Max Demand met was around 1,81,000 MW. This trend shows that the Golden Tag of Coal fired base load power Station is going to be the tag line of past. Normally Gas Fired Combined Cycle Power Plants act as Peaking Plant but due less availability of domestic Gas, existing Gas base Power Plant will not be able to act as peaking Plant.

This means that very soon, Coal fired units also face daily start and stop mode of operation for which the existing units are not designed. If the existing units are operated in daily start/stop mode of operation i.e. in cyclic mode of operation, then these units will impact on the following parameters.

1. Unit Heat Rate

Unit is designed for base load operation but when unit is run at off design conditions the heat rate and thus the first law efficiency of the plant deviates from the design value. The unit heat rate of coal-fired power plant is defined in terms of amount of Coal burnt multiplied by Gross Heating Value divided by Power produced.

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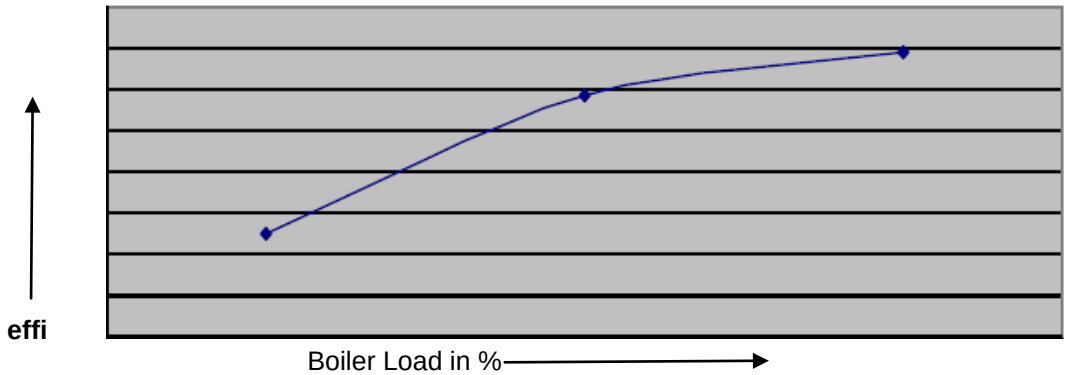
$$\text{Unit Heat rate} = \frac{\text{Coal Burnt X GCV}}{\text{Power Produce}} \quad \text{Kcal/kwh}$$

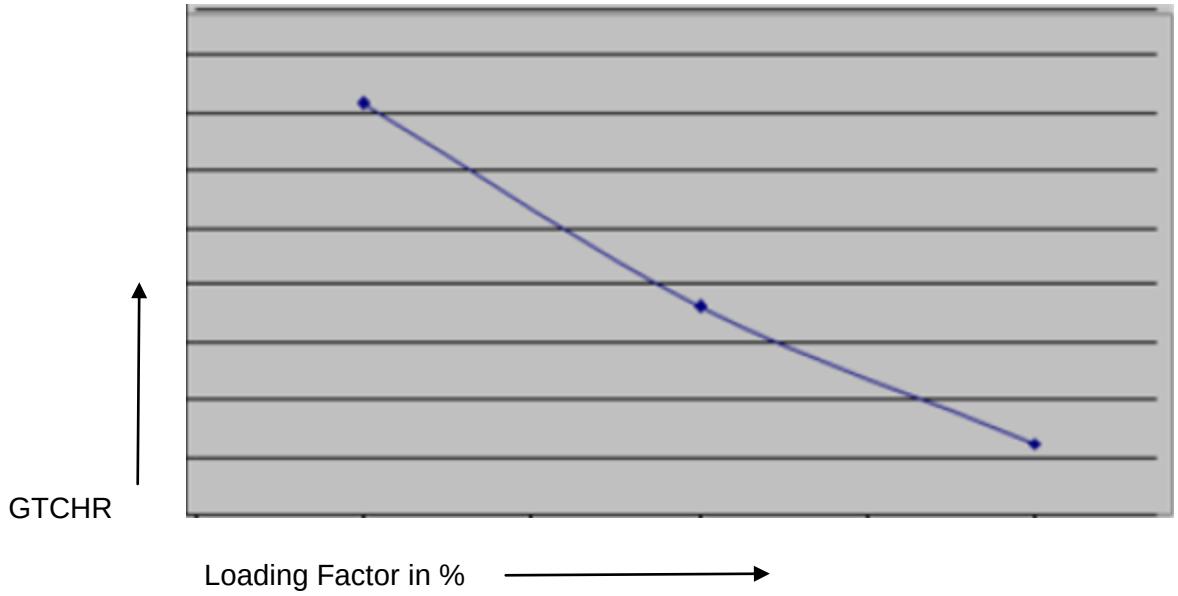
2. Boiler efficiency

Performance of boiler is calculated as a ratio of steam enthalpy output of boiler and input heat value of the coal fired. According to the manufacturer provided data the boiler efficiency increases with the Turbine maximum continuous rating (TMCR); as shown in Fig- this variation is steep in the beginning and slows down near the full load.



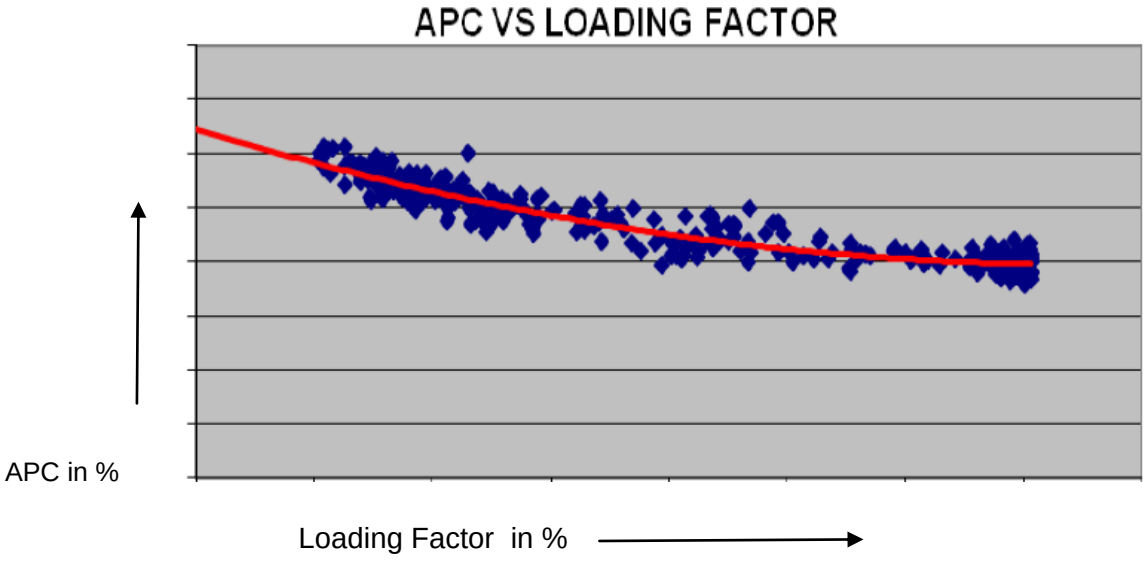
3 Gross Turbine Cycle Heat Rate (GTCHR)

Turbine along with its auxiliaries working in closed cycle is called Turbine cycle and its performance is measured in terms of GTCHR. GTCHR is nothing but the heat input given to turbine in the form of steam enthalpy to generate one kWh of electrical energy at the generator output terminals.



4. Auxiliary power consumption (APC)

To run the coal-fired plants various fans and pumps are required to be in service; the power consumed by these auxiliary equipments is called APC of the plant and is calculated as a percentage of the gross generation at the generator terminals. With reduction in plant load the power consumption of the auxiliaries also reduces but it is not proportional to reduction in load, in fact it is less than the percentage change in load, because of this , APC of the coal-fired plant increases.



5. Carbon Emissions

This performance parameter is in fact a derived performance parameter as it is calculated only with the help of Unit heat rate and APC of the plant. The logic goes like this-with reduction in plant load the Unit heat rate increases and APC also increases. Increased value of both these parameters calls for increase in coal consumption with same net energy export from the plant and the increased coal consumption leads to increased values of CO2 emission and other pollutants.
Thus flexible and partial load operation of coal-fired plants leads corresponding increase in the emission rates of these plants which partially offsets the environmental benefits associated with installing renewable energy sources.

6.0 IMPACT OF CYCLIC ? FLEXIBLE OPERATION ON THE RELIABILITY OF THE PLANT

Flexible cyclic mode of operation of coal-fired power plants involves rapid increase and decrease in process temperatures and pressure, which create significant thermal stress on pressure boundaries. When unit load changes, the consequences are numerous, e.g. pulverizes goes off and on, furnace temperatures and heat profiles are altered, steam and flue gas velocities also vary. All these changes have a bearing on the life cycle of the component in question and build up thermal stresses which may also lead to premature failure of the components. This directly affects the reliability of the coal-fired power plants. Some of the dominant abnormal phenomena associated with load variation are-

6.1 Corrosion Related Issues

Cyclic operation challenges the ability of a plant to maintain water chemistry, which lead to increased corrosion and accelerated component failure. Increased levels of dissolved oxygen in feed water may result in condenser leakages. Other factors affecting chemistry include the increased need for makeup water and the interruption in operation of the condensate polishers and deaerators. Corrosion and fatigue can combine to accelerate damage to water walls.

6.2 Thermal fatigue

The effects of cycling on the steam generator usually materialize as stress cracking in the water wall tubing at attachments like the wind box, corner tubes, and wall box openings. Also affected are boiler super heater and Re heater headers, where ligament cracking is commonly seen between tube stubs. Header cracking is caused by frequent, large temperature swings associated with flexible and cyclic operation.

6.3 Rotor Bore Cracking

When subjected to transients in the temperature of the admitted steam, the high-pressure and intermediate-pressure steam turbine rotors can suffer thermo-mechanical stress excursions, resulting in low-cycle fatigue damage.

MITIGATION STRATEGIES

To completely outcast these issues of performance deterioration and reliability loss certain design changes are required to be made in the process which will require big investments. But there are some low hanging fruits as well, like changing certain operation and maintenance strategies, which can be plucked very easily to improve the performance and reliability of the plants. One such front is that of APC. APC of the coal-fired plant can be reduced at partial load by switching off certain auxiliaries and shifting their load to running ones. Also installation of Variables frequency drives reduces throttling losses considerably in various HT drives.

Similarly condition monitoring of major drives and preventive maintenance can go a long way in improving the reliability of the plant. Since the aspects like long term degradation of equipment are more subtle and latent so to judge the condition of equipment, in that perspective, would require extensive data collection from the equipment and its analysis. Some of the condition monitoring systems which can be installed are- a stress monitoring system for boiler pressure part, turbine blade vibration monitoring system.

CONCLUSIONS

Large scale integration of Renewable energy sources with the electric power grid is inevitable and thermal power plants have to find their way in the troubled water to maintain their economic viability and thus to sustain in the market. Further as the penetration of renewable sources in the electric power grid increases, the requirements of flexible / starting and stopping of the coal-fired plants will become more frequent.

Due to the very fact that coal-fired power plants are highly reliable in comparison to renewable sources coal-fired power plants, in future, may be playing the role of load balancing plants only and the operators must prepare themselves for this. All these developments will pose a great threat for economic viability of these plants and to their long cherished high reliability.

To deal with the challenges of flexible and low load cyclic operation, coal-fired power plants need to adopt best operation practices, proactive and preventive maintenance practices. In addition to this the upcoming coal-fired power plants should be designed considering these specific objectives in the mind so that the plants can take on the challenge of flexible operation.