Major concerns for a station's performance are thermal efficiency, maintenance loss, plant load, forced outages and plant availability.

Operating power plants at the highest PLF

In view of the massive investments (Rs 5-8 crore per MW), it is vital that a power station operates at the highest plant load factor (PLF). **Sanjivrao Katakam** speaks of the automation and IT systems that are employed by companies to make their plants more efficient.

Generation of electricity is a very complex process involving many sub-processes and has multiple critical parameters. Generating 1 MW of thermal power requires around Rs 5-8 crore of investment depending upon whether it utilises coal or gas. Considering the massive investment for generation and the power shortage situation in the country, it is important to give a thought to returns obtained from power stations. Once the power station is commissioned, the biggest challenge is to operate the station at a high plant load factor (PLF), which is a measure of the output of a power plant compared to the maximum output it could produce. Higher load factor usually means more output and a lower cost per unit, which means an electricity generator can sell more electricity at a higher spark spread. So, the power plant performance is very important for having higher PLF. Power plant performance at various steps help in improving the power generation capacity.

SECTOR	OPERATING AVAILABILITY (%)
Central	87.59
State	82.67
Private	92.73

Source: CEA 2009

Major concerns for a station's performance are thermal efficiency factors, maintenance loss, plant load factors, forced outages and plant availability

Equipment	Problem	Signs	Solution
Boiler	Heat loss due to Dry Flue Gas (DFG)	Flue gas exit temperature and excess air quantity increases	220^0 C in flue gas temperature increases boiler efficiency by 1 per cent. Proper monitoring and optimisation.
			5 per cent reduction in excess air increases boiler efficiency by 1 per cent. Proper monitoring and optimisation.
			1 per cent reduction of residual oxygen in flue gas increases boiler efficiency by 1 per cent. Proper monitoring and optimisation.
	Heat loss due to unburnt carbon	Unburnt carbon percentage in ash	Appropriate air supply and coal quality monitoring
	Heat loss due to moisture in fuel	Moisture percentage in fuel	Fuel preheating
	Heat loss due to hydrogen in coal	Hydrogen percentage in coal	Quality monitoring of coal
	Heat loss due to moisture in air	Moisture percentage in air	Quality monitoring of air
	Boiler combustion	Secondary air dampers openings	Combustion optimisation
		Fuel air dampers openings	Combustion optimisation
		Air distribution dampers openings	Combustion optimisation
		Improper total air flow	Combustion optimisation
		Uneven fuel distribution	Combustion optimisation
		Firing zone location	Combustion optimisation
		Primary air dampers	Combustion optimisation
		Primary air heater pressure	Combustion optimisation
		Economiser O_2 imbalance	Combustion optimisation
		High metal temperature	Combustion optimisation
		High NOx	Combustion optimisation
		High carbon in ash (LOI-Loss On ignition)	Combustion optimisation
		Increased excess O_2	Combustion optimisation
		Local hot spotted	Combustion optimisation
		Local corrosion	Combustion optimisation
		Increased furnace exit gas temperature	Combustion optimisation
		Local fouling	A 3 mm thick soot deposition on the heat transfer surface can cause an increase in consumption to the tune of 2.5 per cent. Regular maintenance.
Turbine	Turbine heat rate level	Main steam pressure at HPT (High Pressure Temperature) inlet	5 kg/cm^2 difference causes 6.25 Kcal/KWh difference in HR. Proper monitoring.
		Main steam temperature at HPT inlet	10^0 C difference causes 6 Kcal/ KWh difference in HR
		Re-Heater (RH) spray flow	1 per cent difference of RH spray flow has effect of 4 Kcal/ KWh in HR proper monitoring.
	Turbine cylinder efficiency	Improper HPT	1 per cent of HPT efficiency has 0.16 per cent effect on turbine gross (TG) HR and 0.3 per cent effect on KW. Proper monitoring.

Equipment	Problem	Signs	Solution
		Improper Intermediate Pressure Temperature (IPT)	1 per cent of IPT efficiency has 0.16 per cent effect on TG HR and 0.16 per cent effect on KW. Proper monitoring.
		Improper Low Pressure Temperature (LPT)	1 per cent of LPT efficiency has 0.5 per cent effect on TG HR and 0.5 per cent effect on KW. Proper monitoring.
Condenser	Condenser vacuum	Condenser back pressure	10 mm HG improvement in condenser vacuum leads to 20 Kcal/KWh or 1 per cent improvement in HR for a 210 MW unit. Proper monitoring.
	Condenser saturation temperature	Condenser back pressure	Maintain back pressure
	Condenser temperature difference	Saturation temperature	Maintain cooling water inlet and outlet temperature
	Condenser approach	Saturation temperature	Maintain cooling water inlet and outlet temperature
Economizer	Less effectiveness in heating feed water	Flue gas inlet and outlet temperature	Temperature control over economiser
		Feed water inlet and outlet temperature	
Feed water heater	Feed water heaters terminal temperature difference (TTD)	Extraction pressure and temperature	Continuous monitoring extraction pressure and temperature, feed water pressure and temperature.
	Feed water heaters DCA (Drain Cooler Approach)	Extraction pressure and temperature	
Air heaters	Percentage of air leakage	Flue gas temperature at air pre-heater inlet	Continuous monitoring of air inlet and outlet temperature of air heater and flue gas inlet and outlet temperature of air heater.
	Test X ratio	Flue gas temperature at air pre-heater inlet	

Source: BEE and Kalkitech

factor. A decline in thermal efficiency leads to a higher cost of electricity generation due to more fuel usage and will also result in much higher carbon footprints. Therefore, it is very important to stress on the performance of power plants. The performance of a power plant can be expressed through some critical performance factors such as

- Heat rate (energy efficiency)
- Thermal efficiency
- Capacity factor
- Load factor
- Economic efficiency
- Operational efficiency

In order to optimise efficiency, it is essential to optimise the terminal conditions of the unit. A majority of the power stations burn low-priced, inferior quality coal with the limited combustion efficiency of boilers, due to unavailability of good quality coal and increasing coal prices. Cheap fuel outweighs the increase in the fuel consumption due to limited combustion efficiency and it will lead to increasing boiler losses. So to optimise the boiler performance, losses must be optimised. Hence, this aspect is of great importance in the Indian power scenario, as inferior and low grade coal is used for thermal generation. The steam turbine efficiency plays an important role in maximising unit efficiency. If the turbine's efficiency is lesser than the boiler or generator efficiency, it is necessary to optimise its performance by properly controlling the terminal conditions of the turbine.

Major critical parameters that can affect the power plant's efficiency are:

Efficient operation of the thermal unit is very critical due to cost and reliability factors. The cost implication due to an increase in the heat rate, oil consumption, make-up water consumption, excess air, condensed back pressure, etc, indicate the urgent need to control these parameters within the designed ratings. All these checks and controls will lead to improved availability due to better steam conditions and better heat transfer conditions.

Studies were conducted in the first phase of Indo-German Energy Programme (IGEN) across 14 states in over 80 numbers of thermal plants. Results

of these studies indicated that there were substantial deviations (up to 20-25 per cent) between the designed and operating parameters such as boiler efficiency, turbine heat rate (THR), gross heat rate (GHR), coal consumption, etc. In addition, studies also observed problems such as combustion control of the boilers was not proper, air-fuel ratio was not maintained and high amount of un-burnt carbon content was released from boilers. The air ingress into the furnace from outside was also observed to be very high.

At the ash-handling plants of these units, the outlet air temperature was found to be low, while the flue gas temperature was high. Besides, air pre-heater seals at most of these units required adjustments. The induced draft fan was mostly found to be overloaded with no operating margins. The steam temperature and pressure were generally lower than the rated value, which can be attributed to the non-functional auto control and ineffective spray control. Soot blowers were not available at most units and where installed, they were not deriving optimal benefits due to a lack of online monitoring and control. It was also observed that the temperature at the cooling tower was high and the condenser cleaning system was either not provided at most of the units or was non-functional. The study observed that the turbines needed a steam path audit to determine their actual status.

Automation and IT systems have made modern power plants much more efficient and faster. Power plants today are equipped with modern systems like data acquisition systems (DAS) and distributed digital control systems (DCS) to monitor all the parameters of the plant, which continuously record a number of parameters and sequence of various events happening during abnormal conditions in a power plant. However, only monitoring cannot help accomplish the ultimate objective of increasing the efficiency of a power plant. Tracking the parameters and taking appropriate action on the events on a real-time basis would result in maximum benefits.

Currently, decisions are taken by plant operators or executives on real-time as per events occurring during plant operations. These decisions may be far from accurate since they depend upon the skills, experience and presence of mind of the plant operator. Even high-end technologies like SCADA do not provide open decision support facilities. So there is need for a solution with open decision support systems to guide the system and its stakeholders across various decision scenarios so that accurate decisions can be taken. These models should be open and transformable such that they can be modified to new scenarios so that the decisions result in achievement of end-goals for utilities or consumers. The solution will equip plant operators to take proper decisions. Majority of the solutions available in the market are equipment or a set of equipments specific. They only consider major equipment like boilers, turbines and generators (BTG) and a few others. However, decision support should cover complete plant and auxiliary equipment like economisers, superheaters, evaporators, engines, condensers, feed water heaters, de-aerators, air heaters, pumps, cooling towers, etc.

“A majority of the power stations burn low-priced, inferior quality coal with limited combustion efficiency of boilers, due to unavailability of good quality coal and increasing prices. Cheap fuel due to limited combustion efficiency leads to higher boiler losses.”

The solution should also monitor equipment stress and be able to calculate its lifetime. The solution should have design tools for plant connectivity modifications or should be able to import the model from DCS over an object linking and embedding process control—unified architecture (OPC-UA) interface (as per CIM). The solution should be capable of carrying out heat balance analysis, impact analysis and should have the what-if analysis to test different situations.

India is quite price sensitive but at the same time techn-savvy and demands cutting edge technology at most competitive prices. The government has accorded high priority to automation and IT systems in renovation and modernisation (R&M) as well as life extension programmes for old thermal power plants. These initiatives are aimed at improving the PLF of thermal power plants for their optimum utilisation.

There is a noticeable shift in power companies towards the adoption of more efficient technologies across the entire value chain in the sector. PT

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