Synopsis
on
“Energy Efficient Design & control of Auxiliary Systems in Fossil-Fuel Power Generating Power Plants”

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Introduction :

The Smart Grid begins with Efficient Generation Energy Efficient Design of Auxiliary Systems in Fossil-Fuel Power Plants. Energy efficiency is the least expensive way for power and process industries to meet a growing demand for cleaner energy, and this applies to the power generating industry as well. In most fossil-fuel steam power plants, between 7 to 15 percent of the generated power never makes it past the plant gate, as it is diverted back to the facility’s own pumps, fans and other auxiliary systems. This auxiliary equipment has a critical role in the safe operation of the plant and can be found in all plant systems. Perhaps the diversity of applications is one reason why a **comprehensive approach to auxiliaries is needed to reduce their proportion of gross power and to decrease plant heat rate**. In power plants, auxiliaries serve to keep the steam-water cycle safely circulating, and to return it to its thermodynamic starting point. Without these auxiliary systems, the steam-water cycle would suffer either an immediate collapse or a dangerous and non-sustainable expansion. The basic thermodynamic shape and efficiency of the cycle is the job of the cycle designer. The main purpose of the auxiliary systems is to preserve the designed shape of this cycle across a wide range of conditions and over time, using a minimum of input energy and with a maximum of availability. In power plant terminology, auxiliary power is sometimes referred to as ‘station load’, ‘house load’ or even ‘parasitic load’. Auxiliaries consume the highest quality energy in the plant, namely electrical energy. The power supplied to in-house loads is power that could otherwise have been saved (or sold, in the case of a power plant operating at full load). The convenience and controllability of electrical power is behind the trend towards **electric motors displacing other forms of auxiliary drive power**, such as steam for turbine-driven pumps. Auxiliary power consumption is ‘downstream’ power; efficiency improvements in auxiliary loads have a multiplier effect as one moves upstream to the primary energy Source, within or outside the plant. A **large motor, running constantly, uses its capital cost in electricity every few weeks**; this explains why more than 90% of the total cost of pump ownership (TCO) is energy consumption. Every one percent improvement in a continuous-duty induction motor system may save definite amount of money.

The wasted energy in industrial fan & pumping systems that allows such large savings is due to below mentioned reasons:

- **Oversized and under-loaded motors**.
- **Inefficient motors and couplings.**
- **Inefficient applications, especially those which use throttling for flow control.**
- **Equipment running unnecessarily, or for unnecessarily long hours, such as stirrers**
- **on empty tanks, deadheading pumps, and ventilation fans running continuously.**

Auxiliary drive power is used in a variety of applications in a steam generating plant, from coal conveyors, grinders and pulverisers to furnace draft fans, condensate and feed water pumps (when electrically driven), circulating water pumps, and various emission control equipment.
In power plants, **VFD type of pump control may be used in boiler feed and condensate pumping systems** to provide flow control. An improved design may make use of any existing, smaller and more responsive start-up pump instead of a recirculation loop.
In power plant combustion processes, the largest demands for auxiliary drive power come from the ID and FD fans. Typically, FD and ID fan motors consume enormous amounts of energy in a plant, with motor sizes approaching 14 MW to 18 MW in many larger plants. When a boiler is operating at non-peak loads and the **traditional fan-motor-damper system is in use, a good deal of energy is wasted in the fan/motor combination**. If a 15 MW motor is wasting 20 percent of its energy due to inefficient flow control, that waste amounts to 3 MWh during each hour of operation.
The energy impact of power services is growing due to increased proportion of auxiliary electrical loads as well as the increased variability of plant loading.
Poor design of in-plant power factor and power quality increases electrical losses, which reduces efficiency and also leads to increased maintenance costs – another good reason to look at power and its application.
The electrical power system has an impact on the reliability of almost all equipment in the plant. Instability in the power system has a multiplier effect that can incur energy penalties due to unstable production and reduced reliability in many other parts of the plant.
The purpose of the in-plant power services is to supply electrical power to plant auxiliary process loads, instruments and control systems. The criteria for delivery of this power are:

- **Power quality: allow only tolerable small amounts of harmonics, spikes, sags and swells or phase voltage unbalance.**
- **Power factor: control the power factor at all levels of the plant to reduce the losses associated with carrying reactive power.**
- **Power level and capacity: supply power to required capacity, at the voltage levels needed, through efficient, right-sized transformers.**
- **Power protection & control: allow full automatic or manual control of power distribution to serve the needs of the loads, while protecting those loads and the power system itself from harm.**
- **Power distribution & layout: carry power from the source to its destination at the load with minimal losses.**
- **Power reliability: supply all the above with high reliability**.

In a power plant, most of the auxiliary power demand, up to 80% of total auxiliary load, is used by large MV electric motors that are typically connected to the medium voltage switchgears/switchyards supplied through unit auxiliary transformers. Between 6 to 15% of gross electrical output can go to auxiliary power, depending on the type of prime mover for large pumps and fans, the type of fossil fuel, and the required environmental control systems.
The power system is stressed by direct on-line (DOL) motor starts; large **induction motor DOL startups draw 5 to 8 times the normal operating current** for a sustained period and at low power factor. Soft-starters typically reduce individual startup currents to only 1.5 to 2 times the operating current, improving PF during startup, but without speed control capability during normal operation. The reduced inrush current reduces the heat load on the motor, allowing more frequent starts between cool-down periods. Soft-starting also allow the engineer more flexibility in right sizing the components of electrical power system by reducing the peak loading. The term ‘**soft starter**’ usually refers to a class of power electronics devices capable of ramping up voltage to achieve a smooth motor start-up. It is important to note that VFDs can also provide soft-starting capability, along with the added benefit of high and constant PF across the operating speed range. When operational speed control is not required, however, soft-starters may be the more economical choice. Static Synchronous Compensators (**STATCOMs**) also provide soft-start capability. Unlike most VFDs, however, compensators can be serviced

while the motor is running. **VAR compensators** can be placed at any point in the electrical power system;
near the generator source, in the grid, or near the large consumer loads. VAR compensators can increase the net real power output of the generator, but they are not without small losses. These small losses can be further minimized by specifying more, smaller increments of capacitive and reactive elements, based on an LCC analysis.

The largest power transformers are "probably the most efficient machines devised by man" .Modern large GSU transformers can achieve efficiencies of up to 99.75% at full load. Despite an impressive efficiency rating, there is still a large incentive for improvement. The throughput of these large transformers can be up to 1000MVA, so even small, fractional percentage gains translate into MW of saved power. Smaller transformers are less efficient (99.0% to 99.5%), but have a smaller throughput. The incentive to seek improvements at this lower scale comes from the fact that most power consumers (at least in distribution networks) receive their power after it has passed through several transformers, which means that **savings of reduced loss transformers are compounded.**

Transformer electronic control for modern transformers can provide advance warning of degradation and eventual failure, and provide optimal cooling control. The **enhanced, real-time monitoring capability allows transformers to be overloaded when required**, reducing the need to oversize the unit for these transient situations. Overload capability forecasts can be made, in which the estimated thermal aging is also taken into account. The monitoring software will the extent to which the transformer can be overloaded, and provide the financial impact of this overloading due to any extra aging of the insulation. Modern transformers can be equipped with the monitoring and diagnostic functions
covering critical performance parameters. Older transformers, which are most in need of improved monitoring and control, can be retrofitted with such a package.

Automation allows faster and more consistent response to changing load conditions compared to open loop (or human in the loop) control methods. Automation also enables the process to operate in a more stable way, and thus can be safely operated closer to its constraints for optimum energy efficiency.

Boiler-turbine coordinated control combines the two control strategies by distributing some demand responsibility to both boiler and turbine for improved overall response and stability. The distribution of demand provides advantages similar to that of feed forward control and reduces continuous interactions between these control loops; an advantage for precise load control in a wide-area load dispatch system Coordinated control can be used with either constant or sliding pressure operation. Coordinated control is especially suited for load-following operation, where maintaining efficiency at low loads is important for a unit's economic viability. This operating mode responds well to load dispatcher signals which allocate more generation capacity to plants with higher efficiencies. Coordinated control provides the operator with the flexibility to choose between base-loading and ramp-loading (load following). The control technology may be either model-based or using feedback loops. Feedback control is improved by using feed forward and adaptive tuning techniques. The increased stability of coordinated control allows the unit to be operated closer to its optimum at base loads, and more efficiently under low loads.

Lighting control of main plant and auxiliary area may be controlled by control system. Having automation of the same group/start/stop programming, wastage of power may be ensured in an efficient and better way.

Objective :

To control auxiliary power consumption by improving efficieny, introduction of better technologies, improve methods and having better designs before it is engineered.

Operational definition :

Because of low auxiliary power consumption auxiliary power can be saved and more power can given to grid thereby the net outcome will be extra earning of money and reducing wastage of energy. In other words, producing same amount of energy, less coal needs to be burn and thereby less emission will be done and thus friendly to nature.

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Conclusion :

To control APC, Technological up gradation of many systems may need capital investment once but the same cost can be recovered in few weeks by having higher efficiencies, better process and lower power consumption.