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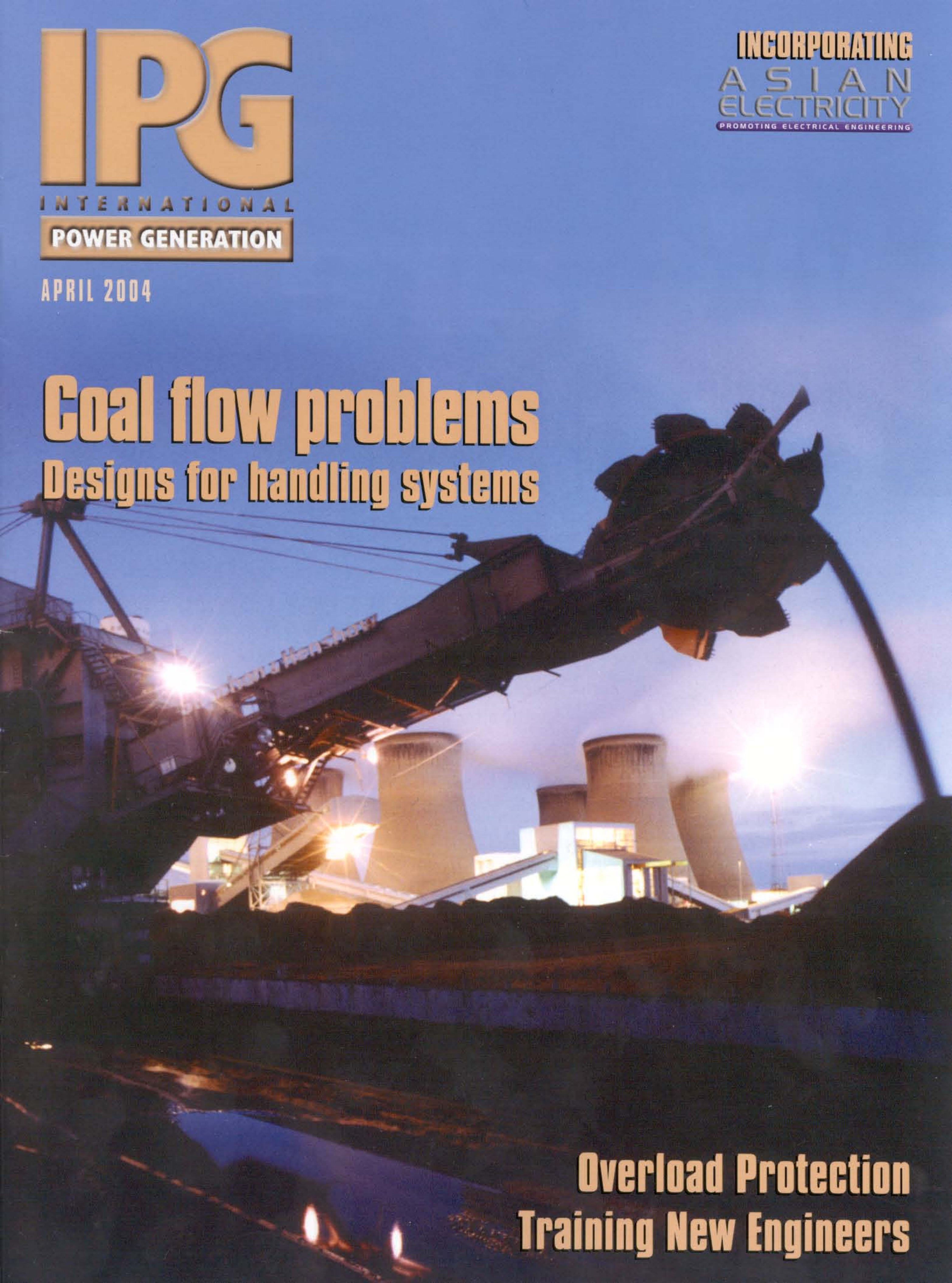
Coal flow problems

Designs for handling systems



Overload Protection

Training New Engineers

Regaining control

Improvement in plant output, performance and efficiency can often be achieved by addressing problems with control valves. John Wilson, severe service manager at Fisher Controls International, reports.

Control valves represent an area of untapped potential for upgrading an existing plant. Whether discussing conventional power plant, supercritical plant, combined-cycle plant or nuclear plant, the message is the same. The control valves in the feedwater system are one of the easiest ways to improve plant performance.

The main feedpump minimum flow valve is used to pass a given amount of flow around the feedpump to prevent the pump from cavitating and overheating. as flow is being recirculated around the pump, energy is constantly being lost while this valve is in operation.

While this is expected during start-up and shutdown conditions, an excessive amount of energy can be lost through the valve when not operated properly during normal plant operating conditions.

Difficult conditions

No matter the plant type, this valve is subjected to some of the most difficult service conditions of any valve in the entire facility. As it recirculates a portion of flow around the pump, it is usually required to take the entire pressure drop across the valve. If not properly addressed, damaging cavitation can affect the operation of the valve.

Given the damaging potential in this application, the most common issue noted in many facilities is a lack of shut-off. As this valve is normally closed, it is imperative that this valves shuts tightly for extended periods. If the valve leaks, the feedpump has to work that much harder to meet the flow demands since a portion of the flow is constantly recirculated. Depending upon the type of driver, the associated cost can be several thousand dollars in electricity costs ($8,000-10,000 per pump per year if motor driven pumps are used) to several hundred thousand in excess fuel and lost production (per pump per year if steam turbine drive pumps are used).

A 450MW subcritical coal-fired plant in Wisconsin recently replaced the recirculation valves in their start-up and main feedpumps because of leakage issues. Replacement of the valves yielded a 1.8MW improvement in overall plant output and had a 0.2 per cent impact on plant heat rate.

Another set of critical valves in the feedwater system is the start-up and feedwater control valves. These valves can have a dramatic impact on start-up time and ramp rate of the plant.

Many existing plant utilise a two valve arrangement that utilises a small start-up valve in combination with a large regulating valve. During plant start-up, the small valve is used to address the high pressure drop, low flow conditions. When a certain downstream pressure or flow rate is achieved, control is switched from the start-up valve to the main valve. Depending on the type of plant, this operation can take several hours as unit pressure and load increases.

There are several ways to improve the start-up time and ramp rate of the unit when confronted with this type of arrangement. The first is to ensure that the valves are properly selected to operate with one another. A common configuration incorporates a 2" start-up valve with a 6" or 8" regulating valve. When the capacity of the 2" valve is exhausted, control is transitioned to the 8" valve. However, because the equivalent capacity of the 2" valve to the 8" valve is minimal, the controllability of the 8" valve can be compromised. In order to control the load requirement at this point, control usually flips between the two valves for a certain amount of time until the downstream pressure builds, thus dramatically increasing start-up time.

When issues like this occur, the inherent flow characteristic of the main valve can be altered to better match that of the small start-up valve. By smoothing the transition, the start-up time can be improved significantly.

Some of the recently added combined-cycle power plant in the United States utilise a two-valve feedwater control arrangement. In these cases, the two-valve arrangement was chosen to achieve high turndown ratios. It may seem that two valves may give better turndown, but this is not always the case.

One common misconception in the industry is that when two valve arrangements are used, only the start-up valve needs tight shut-off because it will experience the high pressure drop, potentially damaging conditions. Because the main valve experiences low pressure drops, tight shut-off is often ignored.

Mistakes

As witnessed in many combined-cycle plant, making this type of mistake can impact start-up of the unit to the point that it may not occur. This is because the main valve is exposed to high pressure drops and high leakage rates while the start-up valve is in operation. This leakage can cause severe erosion to the trim in the main valve. When the unit starts up, it is not uncommon that the main valve will be leaking more than the start-up valve can pass. When this occurs, start-up of the unit is unlikely to occur due to the inability to control feedwater flow.

Another option similar to that previously noted is to combine the functions of

Above: An LP alternate heater drain letdown. This valve lets down to condenser and is a great source for improving plant performance. Reduced leakage through the valve improves plant heat rate and reduces fuel costs.

Left: Three of the four superheater bypass valves replaced at a 750MW Babcox and Wilcox Universal Pressure Boiler supercritical plant in Kansas, USA. The effect of the valve replacement work saw one of the largest one-time improvements ever seen in a power plant.

the start-up valve and the main valve into one valve. This is accomplished by using what is called a characterised trim that incorporates anti-cavitation trim to address start-up conditions and regular trim that is used for flow control.

By eliminating the transition function between the two valves, start-up time of a conventional 600MW unit can be decreased by 30 minutes to one hour. As these valves have turndown requirements of 100:1 or greater, the ramp rate of the unit can be improved because of the ability of the valve to control to incremental signal changes of 1 per cent or less.

Whether using one valve or two valves it is always key to look at shut-off in the valves. For example, looking at drum style boilers in general, if the main valve has excessive leakage when the feedpump is in operation, the drum level will continue to rise. If the drum level rises too high, the blowdown valves will have to be open thus dumping treated water to the water recovery system. A leaking 6" valve can cost a plant at least $10,000 each year in wasted water treatment costs.

Heater drain system

The heater drain system in non-combined-cycle plant and blowdown valves in combined-cycle plant contain the valves most often overlooked in the entire system. The heater systems consist of normal drain, alternate drain and heater bypass valves.

A great deal of time can be spent on accurate heater level to optimise heat transfer, but the most opportunity lies in the valves not normally used; the heater bypass and alternate heater drains.

Both valves are normally closed, but historically have experienced issues with leakage. The alternate drains, sometimes called emergency drains, present the greatest opportunity for unit improvement since depending on plant type, they either dump to the deaerator or condenser.

Since the alternate drains dump either to the deaerator or the condenser, they represent a great deal of potential heat loss from the turbine extraction lines. Looking solely at fuel costs, each low pressure heater drain valve at a 500MW Midwestern power plant was costing the plant nearly $9,500 each year. Given that there were ten valves, this translated into nearly $100,000/yr in lost fuel costs.

In this case, the valves had inadequate seating force allowing leakage to continue to occur even after the trim in the valves was replaced. After replacing the existing actuators with those sized for adequate seating force, the heat rate improved between 0.08-0.10 per cent per valve.

While not as dramatic, similar results can be found by reviewing valve selection in the high pressure heater drain valves and the alternate drum blowdown valves. Looking at the entire heater system and blowdown system in a 600MW system, a 5-10MW improvement can be achieved by ensuring tight shut-off in the alternate drain and blowdown valves.

Sliding pressure control

While limited only to once-through subcritical or supercritical designs, these few valves can arguably have the greatest impact on plant performance. In either design, the superheater bypass valves are used during start-up of the unit to control unit ramp rate. After the start-up function is complete, the valves remain closed until the next start-up unless a situation occurs where the valves are opened to prevent over-pressurisation of the unit.

At a 750MW Babcox and Wilcox Universal Pressure Boiler supercritical plant in Kansas, replacement of four valves had one of the largest one-time improvements ever seen in a power plant. The plant had been living with four leaking BW-202 and BW-207 valves. Initial calculations estimated that the plant could gain at least 12MW by replacing the existing 8" valves.

After replacement of the valves, the easiest way to gauge success was by looking at the pressure of the flash tank during normal plant operation. At this time, the flash tank is almost completely isolated except for pegging steam to keep tank pressure at 50psig in case of an over-pressurisation situation where the bypass valves would open suddenly. Prior to valve replacement, the flash tank pressure would be at 450-650psig during normal plant operation. After valve replacement, the flash tank pressure hovered between 50psig and 75psig.

There were numerous quantifiable results from this situation. First off, the required feedwater flow at maximum unit output dropped by 10 per cent (~250,000 pounds/hour). Next, the start-up time to bring the unit to full load was decreased by at least one hour. Total unit power output increased by nearly 20MW. The greatest achievement, however, was that the heat rate of the unit decreased by over 3 per cent. This translated into a $4,000,000/yr savings for the plant.

Japanese plant

Also seen in once-through subcritical and supercritical designs, the ability to slide pressure allows the plant to achieve greater efficiencies while also equipping the plant to better respond to load changes.

A recent experience in two Japanese power plant may revive the interest in improving performance. These two 600MW plant utilised a Combustion Engineering supercritical design that had sliding pressure control up to 30 per cent load. Sliding pressure operation allows the main turbine throttle valves to remain fully open during turbine operation. Installing the valves ahead of the primary superheater allows for accurate temperature control prior to the high-pressure turbine inlet. Another benefit is that because of the higher inlet temperature into the HP turbine, the outlet temperature is higher yielding better maintenance of hot reheat temperature, dramatically improving the plant heat rate.

At these two Japanese plant, the boiler throttle (BT) valves were replaced with valves that had a specially designed trim characteristic that matched the desired ramp rate of the boiler and the ability to provide accurate control with small step changes. After installation, the plant was better able to respond to load changes and the plant heat rate in each facility decreased by 0.8 per cent.

There are many other valves that can be used as examples of potential operational improvements and cost reductions, but as shown by these examples, upgrading or replacing the existing control valves with the latest technology can dramatically improve the performance of a power plant. IPG

* Abridged from a paper given by the author at Power-Gen International 2003, Las Vegas.