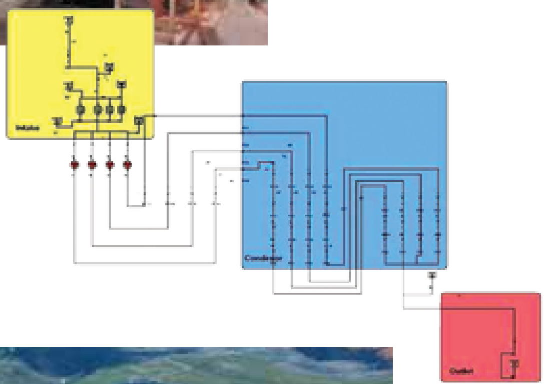
SERVICES AND SOLUTIONS

Technical Assessments for Fossil Fuel Power Stations

Experience In Motion

The mission of Flowserve is to help power station operators optimize unit performance and maximize profitability. This is accomplished by a team of more than 150 design and applications engineers stationed around the world. Comprehensive system assessments using advanced data collection tools and methods coupled with sophisticated modeling techniques provide the blueprint by:

- *Identifying opportunities to reduce energy usage of major systems and critical equipment*
- *Diagnosing the root cause(s) of underperforming systems and premature equipment failure, regardless of OEM or type*
- *Identifying opportunities to improve operator safety*
- *Developing solutions for chronically problematic equipment using life cycle cost (LCC) projections*



A Systems Approach

Flowserve is fully committed to maximizing station profitability by reducing the total life cycle costs of pumping systems. And while boiler-feed and circulating water pumps are critical components of any power station, Flowserve recognizes that no pump operates in isolation. It is part of a system with myriad other components, all with crucial roles in achieving optimal plant efficiency and availability. That's why Flowserve is system driven rather than component driven. Through this holistic approach, a truly effective solution can be implemented.

Assessments by Flowserve engineers can help plant operators optimize unit performance by identifying deficiencies in systems such as:

- Feed water
- Circulating water
- Auxiliaries

Feed Water System Assessments

Over a station's life, perhaps no single power plant system can impact plant efficiency more than the feed water system. Numerous factors – varying plant output, degradation of equipment and system modifications – lead to inefficient plant operation along with increased maintenance costs and, ultimately, reduced profits.

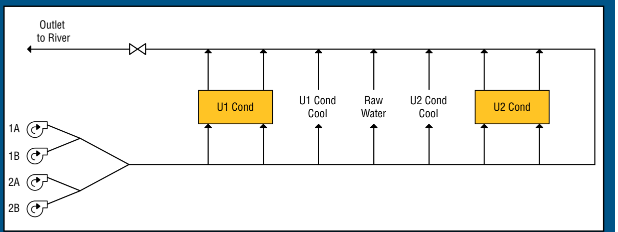
One example of this is the case of a main power turbine re-rate. Many power generating facilities re-rate their main power turbine with the expectation of a 5% to 10% increase in plant load rating. Once the re-rated turbine is up and running, however, they struggle to meet the proposed output. Often, the problem is not with the new turbine but with the condition of the systems that support it. In these cases it is common to find the original operational requirements of the supporting condensate pumps, high-pressure feed pumps, booster pumps, heater drain pumps and heater systems are no longer appropriately sized for the re-rated system.

Flowserve understands that to truly change a plant's output a complete system evaluation must be conducted. To that end, these experts analyze all systems and equipment in the steam cycle, focusing on energy and hydraulic optimization with the most advanced monitoring, diagnostic, modeling and analytical tools.

Flowserve Determines Cause of Circulating Water System Inefficiency

The Challenge: A multi-unit power station located on a large river suspected the circulating water system supplying Units 1 and 2 was operating inefficiently, resulting in derated performance. Consequently, the station's profitability was negatively impacted.

The Assessment: Flowserve engineers conducted a thorough assessment of the system which consisted of four vertical pumps operating in parallel. These pumps provide water to the Unit 1 and 2 condensers, condensate coolers, jacket water coolers and raw water pumps.



Using non-invasive flow monitoring instrumentation and state-of-the-art wireless technology, Flowserve engineers collected high-resolution data under various operational scenarios. A hydraulic study was performed from which a highly accurate model was developed. Validated with actual field data, this model was used to evaluate the system's response to multiple variables.

Flowserve engineers determined:

- Unequal flow distribution existed throughout the system. Flow to the Unit 1 condenser was greater than design in all field test scenarios. Flow to the Unit 2 condenser only reached design level when four pumps were in operation.
- A significant reduction of flow to both condensers occurred during periods of low river elevation.
- Low-flow caused increased condenser backpressure in both units, compromising unit power generation during low river level conditions.

The Solution: To correct the flow imbalance, Flowserve recommended two circulating water pump trains be retrofitted with higher speed motors to provide greater capacity when the river is low. The hydraulic model was used to verify that two higher speed motors the client already owned would provide the necessary increase in pump capacity. The resulting increase in flow would also reduce the condenser backpressure and improve steam cycle efficiency, increasing station profitability.

Circulating Water System Assessments

The thermal efficiency of a fossil power plant is largely determined by the pressure of the condenser to which the main power turbine is exhausting. When the actual condenser backpressure is above the design value, steam cycle efficiency declines, resulting in a net loss in power produced.

Increased condenser backpressure can be caused by any of several factors, including fouling, poor pump performance, low source water level and air leakage. And while reducing condenser back-pressure may seem straightforward, there are numerous pitfalls that must be recognized and avoided when engineering changes to this system. For example, increasing the circulating water flow rate may indeed reduce the condenser backpressure but it may also reduce pump efficiency and cause premature condenser tube failure due to velocity erosion.

Flowserve engineers use advanced hydraulic modeling tools and life cycle costing methodologies to evaluate system modifications using actual performance data. They then develop corrective action plans that maximize plant output without compromising equipment efficiency or component mean time between repair (MTBR).

Assessments by Flowserve engineers can help plant operators identify and rectify the root causes of problems such as:

- Low circulating water capacity
- Inefficient condenser performance
- High condenser backpressure
- Low component MTBR

Auxiliary System Assessments

Frequently overlooked, auxiliary systems are integral to a station's overall performance. Flue gas desulfurization systems, heater drain systems, boiler circulating water systems, closed cooling water systems and the like are critical in supporting the primary plant systems and, therefore, need to perform well and efficiently.

Flowserve brings the same level of expertise, practical know-how and state-of-the-art technology to optimizing auxiliary systems as they do the feed water and circulating water systems. Comprehensive systems assessments can:

- Optimize system and component performance
- Improve system and component efficiency
- Increase component MTBR
- Reduce operations and maintenance (O&M) costs

The Assessment Process

The life cycle of a well-engineered utility pump can easily exceed 35 years. Over time, however, changing operating conditions coupled with equipment degradation can result in operation far off best efficiency point (BEP). Pump reliability and efficiency are negatively affected and system performance suffers. The impact also extends to the bottom line, where increased maintenance and operating costs can significantly depress plant profitability.

Increasing plant profitability is no easy task though. Maximizing unit power generation is key and to do this the performance of the system and all its components must be optimized. Focusing efforts on any single piece of equipment may provide some relief, but the results are marginal at best and typically short lived. Meaningful and lasting improvements can be achieved only by analyzing the system as a whole.

The Flowserve five-step assessment process has proved highly successful in optimizing the thermal efficiency and increasing the profitability of conventional coal fired units and cogeneration facilities alike.

1. Evaluate symptoms of deficient equipment or under-performing systems by forensically auditing current process parameters, maintenance history and operational demands.
2. Implement a testing methodology utilizing proprietary and non-proprietary collection hardware and software tools to generate actionable data.
3. Analyze data, technical documentation and interviews to delineate root cause solutions.
4. Generate a comprehensive report with recommendations supported by life cycle cost analysis that enables the customer to achieve operational and reliability goals.
5. Provide continued technical and commercial support to secure sustainable and measurable results.

Knowledgeable People With Powerful Tools

In addition to their pump expertise, Flowserve engineers have extensive experience with power plant systems and process applications. These credentials are augmented with state-of-the-art monitoring, diagnostic and modeling technologies, including proprietary Flowserve engineering software and evaluation methods. The result is actionable information that plant operators can use to optimize system performance.

Acquiring the Data

Performing an in-depth analysis of any fossil fuel power plant system requires the collection of a large amount of historical information and actual current performance data.

Experienced Flowserve engineers perform extensive on-site audits to define pump reliability issues and maintenance history, operating issues and possible system and component design weaknesses. This is accomplished in part by interviewing power plant staff and by collecting historical data like maintenance files, design and construction data.

Flowserve engineers also conduct comprehensive field testing to establish actual performance data. This testing may include the company's proprietary IPS Wireless monitoring and diagnostics hardware and software. Data including pressure, temperature, mass flow, etc., can be recorded in real time at various unit loads. This data is used to validate high-resolution thermodynamic and hydraulic models which are used to identify system deficiencies and predict changes in system performance.

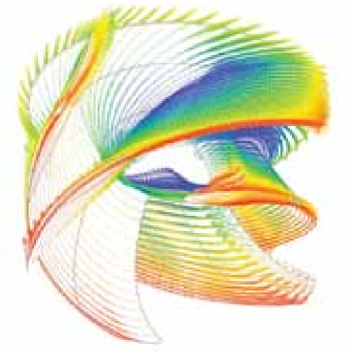
The Right Tools for the Job

Flowserve engineers use numerous analytical tools for system assessments, including:

- Powerful elimination schemes (rather than truth tables) to diagnose root cause for vibration-pulsation problems
- A 48-channel vibro-elastic data acquisition system to allow signature analysis, ODS, field model analysis, etc.
- Water-steam cycle thermodynamic modeling software
- Software to model steady state and transient pipe flow in complex pump systems
- Hydraulic design CFD analysis, flow visualization, energy optimization, erosion modeling, etc.

Hydraulic Modeling Removes Guesswork

Flowserve uses sophisticated software and techniques to develop highly accurate hydraulic models of plant systems. Validated with real-time field data, these models enable Flowserve engineers and plant operators to:



- Analyze actual system performance
- Establish system head loss curves and any process variable, e.g., flow, head, velocity, pressure drop, etc., at any location within the system under various modes of operation
- Run "what if" scenarios to determine the impact of proposed modifications
- Develop a cost-effective action plan that achieves real and measurable improvements in the performance and profitability of the plant

Thermodynamic Model Tests Efficiency

Using actual performance data obtained during testing, Flowserve engineers can develop a thermodynamic model of a unit's entire steam-water cycle. This model simulates pump and system operation under various system loads. Armed with this information, Flowserve engineers and plant operators can then develop detailed corrective action plans for optimizing system performance, reducing fuel costs and increasing plant profitability.

An advanced thermodynamic model also addresses with a high degree of confidence questions regarding:

- Changes in steam flow to the turbine and its new output, exhaust steam properties and efficiency
- Changes in feed water heating in terms of new turbine extraction steam flow parameters, steam pressure, turbine operating values, plant output and efficiency
- Changes in circulating water flow through the condenser and its effect on heat removal capability, backpressure reduction and condensate temperature

Flowserve Identifies Root Cause of 30 MW Derate

The Challenge: While running on a single train, a large East Coast power station experienced an unexplained 30 MW derate in its 800 MW unit. The associated loss in revenue is conservatively estimated at $470 000 (U.S.) per month.

The Assessment: Flowserve engineers performed a study of the feed water and LP heater drain systems. Wireless technology was employed to obtain performance data under varying unit loads, producing a high-resolution profile capable of capturing transient conditions. This data was utilized to validate a hydraulic model which was then used to evaluate the system's response to multiple variables.

Analysis of the model revealed:

The heater drip pump was underperforming the OEM curve by 15% due to reduced system demand.

Level instability in the undersized heater drip tank caused excessive dump valves cycling to maintain the desired level.

Hot water from the heater drip system was being dumped into the condenser instead of the feed water system, reducing the thermal efficiency of the unit.

The Solution: Flowserve engineers recommended replacing the heater drip pump with a smaller, vertical inline model fitted with a variable frequency drive (VFD). The VFD will allow the pump to operate even at low flows, stabilizing the heater drip tank level and restoring the thermal efficiency of the unit.

In addition to the revenue made on the restored 30 MW, Flowserve estimates the plant will realize energy cost savings of $1.3 million (U.S.) per year due to this change.

The Maintenance and Modifications Supervisor at the plant said: "Flowserve's system review has enabled us to make maintenance and operations decisions based on real data and analysis, rather than assumptions and history."

FLOWSERVE

USA and Canada
Flowserve Corporation
5215 North O'Connor Blvd.
Suite 2300
Irving, Texas 75039-5421 USA
Telephone: +1 937 890 5839

Europe, Middle East, Africa
Flowserve Corporation
Parallelweg 13
4878 AH Etten-Leur
The Netherlands
Telephone: +31 76 502 8100

Latin America
Flowserve Corporation
Martín Rodriguez 4460
B1644CGN-Victoria-San Fernando
Buenos Aires, Argentina
Telephone: +54 11 4006 8700
Telefax: +54 11 4714 1610

Asia Pacific
Flowserve Pte. Ltd.
10 Tuas Loop
Singapore 637345
Telephone: +65 6771 0600
Telefax: +65 6779 4607

Bulletin FSG-109a† (E/A4) Printed in USA. December 2010.

To find your local Flowserve representative:

For more information about Flowserve Corporation,
visit www.flowserve.com or call +1 937 890 5839