FLOWSERVE

SERVICES AND SOLUTIONS

Technical Assessments for Refinery and Petrochemical Operations

Experience In Motion

The mission of Flowserve is to help refinery and petrochemical plant 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*
- *Determining actual system head curves for re-rating or replacing existing pumps*

A Systems Approach

Flowserve is fully committed to maximizing plant profitability by reducing the life cycle costs of pumping systems. And while charge pumps and cooling water pumps are critical components of any refinery or petrochemical plant, 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.

Flowserve can help refinery and petrochemical plant operators optimize unit performance and reduce energy usage by performing assessments of critical systems and determining the root causes of chronically problematic equipment.

Assessments include:

- Asset optimization
- Steam and cooling water system
- Firefighting system

Asset Optimization Assessments

Regardless of plant size, empirical evidence reveals that 5% to 10% of the installed pump base will consume 40% to 50% of the maintenance budget due to short mean time between failure or poor performance. Whether the causes are hydraulic or mechanical, a disciplined, methodical program to eliminate bad acting pumps will result in significant and rapid savings.

Flowserve asset optimization assessments identify the pumps that most negatively affect the refinery's operating expenses. This typically entails:

- Analysis of energy utilization rates to identify the highest energy usage pumps
- Confirmation of current operating characteristics of identified assets
- Audits of equipment reliability records to determine which pumps have the highest incidences of unscheduled outages
- Reviews of maintenance methodologies (i.e., run-to-failure, preventative, predictive, etc.)
- Analysis of other items such as LCC database, parts inventory, operational issues, etc.

Once the list of offending pumps is established, Flowserve engineers use advanced analytical tools and techniques to systematically uncover the root cause(s) of the poor performance. Hydraulic and mechanical sources are investigated and corrective action plans are developed.

Upon client approval, Flowserve engineers work with plant personnel to implement corrective measures which address the root cause of the poor performance. Once improved performance is confirmed, the next troublesome asset is addressed and so on, until all are restored to expected performance. Customers report a 15% to 20% reduction in life cycle costs per pump.

Cooling Water System Assessments

Refinery cooling water systems are complex pipe circuits with very long piping runs. Performance and energy improvements can be obtained by a full water piping assessment, optimizing pressure losses. Flowserve engineers use advanced hydraulic modeling tools and life cycle costing methodologies to evaluate the system 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 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
- Insufficient cooling water
- Elevated energy consumption

The Assessment Process

The life cycle of a well-engineered process 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. Safely maximizing unit throughput 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 system performance.

1. Evaluate symptoms of deficient equipment or underperforming 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.

Firefighting System Assessments

A fire event is not the time to test the true capability of a plant's fire protection system. Over time, the condition of system piping can degrade and pump performance may diminish. Biological fouling, sedimentary build-up and corrosion can impact the system's distribution pressure with catastrophic results.

Refineries and petrochemical plants must continuously assess and maintain the operability of their fire water systems to ensure they perform as designed. Typically, however, the actual flow and pressure of the system are not tested, despite the criticality of these parameters to the system's ability to extinguish fires.

Flowserve has proven itself an indispensable resource for evaluating the actual performance of fire water systems and alerting customers to the hidden risks.

Utilizing the company's proprietary IPS wireless technology, Technical Services engineers gather real-time flow and pressure data under various system demands, including multiple fires. This scenario-based testing assesses the piping distribution and headers for head loss, appraises pump performance and evaluates the configuration of the system. The result is a comprehensive analysis that informs decision making regarding expenditures to restore and maintain the effective performance of this critical safety system.

Flowserve ID's System Deficiencies Despite NFPA Compliance

The Challenge: A U.S. oil refinery producing 75 000 bpd needed to address concerns expressed by its insurance underwriters regarding the plant's fire water distribution system. The concerns arose after a fire revealed insufficient flow and pressure in the system, despite its compliance with NFPA regulatory codes. Without interrupting operations, the refinery needed to establish the hydraulic capability of the system and determine upgrades to improve its function.

The Assessment: Technical Services engineers performed a thorough hydraulic study of the plant's fire water distribution system. Using hand-held GPS units, they mapped the entire system, including hydrant locations and piping runs. NFPA-approved Pollard diffusers with omni-directional wireless transmitters were used to log actual flow and pressure from more than 40 hydrants and pumps. Wireless sensors recorded pump vibration and bearing temperature data.

Flowserve created a hydraulic model with more than 1800 data points representing pumps, pipe segments and junctions. The accuracy of the model was validated using field data collected during the hydraulic study.

The Solution: Without disrupting operations, Flowserve engineers determined severe pressure drops and low residual pressure were negatively impacting the performance of the system. Using the validated model to determine the upgrades necessary to keep the plant safe, Flowserve recommended the refinery:

- Replace its existing six fire water pumps with three high-capacity vertical units
- Increase the diameter of the header

Knowledgeable People With Powerful Tools

In addition to their pump expertise, Flowserve engineers have extensive experience with refinery and petrochemical systems and processes. These credentials are supported by 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 refinery or petrochemical plant system requires the collection of a large amount of historical information and actual current performance data.

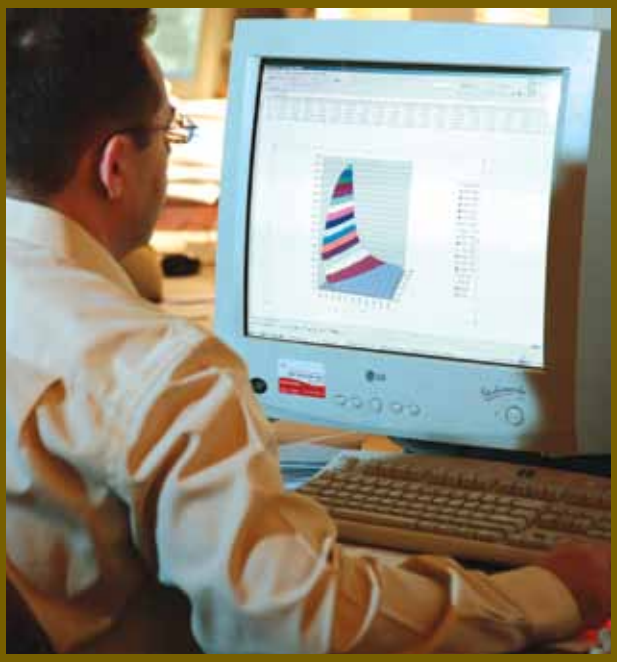
Experienced Flowserve engineers perform extensive on-site audits to define pump reliability issues and maintenance history, operating issues, and possible system and component design weaknesses. This is accomplished in part by interviewing plant staff and collecting historical data like maintenance files,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

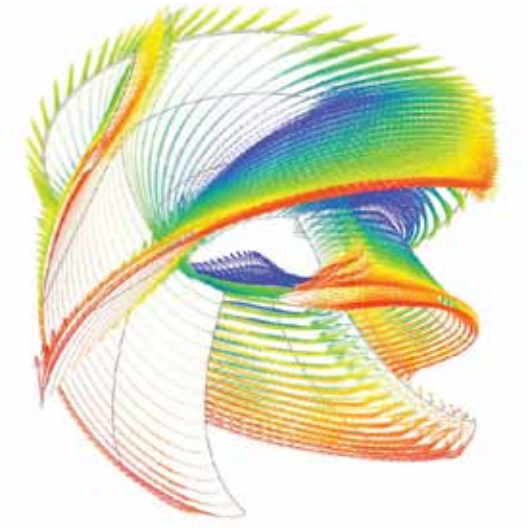
- A 48-channel, vibro-elastic data acquisition system to allow signature analysis, ODS, field model analysis, etc.
- Erosion and corrosion materials analyses with specialized overlay, surface-coating and hard-facing technologies
- Software to model steady state and transient pipe flow in complex pump systems
- Hydraulic design CFD analysis, flow visualization, energy optimization, erosion modeling, etc.
- Rotor dynamic analysis including all fluid force effects to calculate natural frequencies, forced responses, dynamic stresses, etc.
- Structural dynamic analysis to verify rotor-structure interactions and foundation-pump structure dynamics
- Acoustic analysis of pump systems to handle pressure pulsation problems
- Powerful elimination schemes (rather than truth tables) to diagnose the root cause for vibration-pulsation problems



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



Hydraulic Upgrade Tames Bad Actor

The Challenge: A major oil refiner faced serious reliability and operating issues with a critical refinery process pump after a drastic change in operating requirements. One of its severe duty ISO 13709/API 610 (BB2) pumps was exhibiting high vibration levels and consuming excessive energy. Mechanical failures and poor efficiency were leading to high operating and maintenance costs as well as lost production.

The Assessment: An inspection performed by Flowserve engineers uncovered excessive wear on wet end components due to recirculation. Further evaluation revealed the pump was operating at 39% of the best efficiency point (BEP) — far from its original design point — to meet the new capacity requirements.

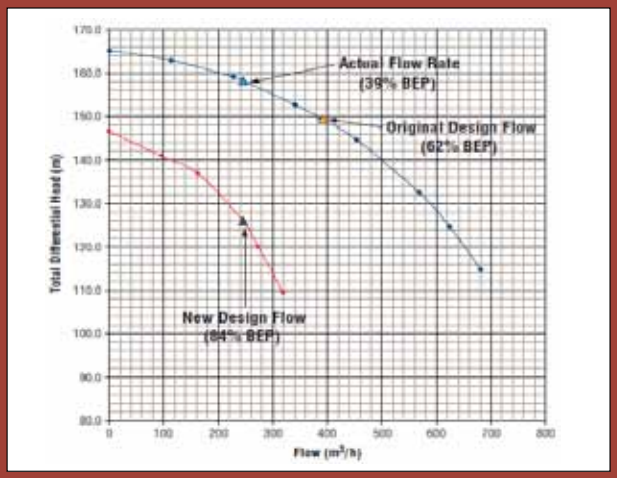
Flowserve engineers determined the extremely low flow rate required by the new operating parameters was inducing recirculation in the pump. This in turn elevated vibration levels and increased radial and axial thrust loads. These factors all contributed to premature bearing and mechanical seal failures and low pump availability.

The Solution: Flowserve engineers designed a smartly conceived upgrade to better fit the pump's hydraulics to the new system requirements.

Key upgrades included:

- Installing plate inserts into the volute to reduce capacity
- Converting to a high-efficiency impeller
- New wear rings

Costing about US$36 000, the upgrade improved the pump operating point to 84% of BEP. In addition, the adverse effects of recirculation were eliminated, with vibration levels reduced by 90%. The energy savings associated with the upgrade are estimated at US$9000 annually.



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