FLOWSERVE

ENERGY ADVANTAGE PROGRAM
DECARBONIZE BY DESIGN

True-turbine Design Enhances Energy Recovery and CO_2 Reduction

Improved hydraulic power recovery turbine efficiency advances energy transition in oil and gas applications

True-turbine design enhances flexibility and increases efficiency in hydrocracker processes

In the oil and gas industry, hydraulic power recovery turbines (HPRTs) capture energy in hydrocrackers that would otherwise be wasted to efficiently drive a charge pump, compressor or generator to power other equipment or operations.

The concept is not new. For decades, standard centrifugal pumps have been run in reverse to convert hydraulic energy in the flow of the hydrocracking process. However, less than half of installed HPRT equipment remains in operation.

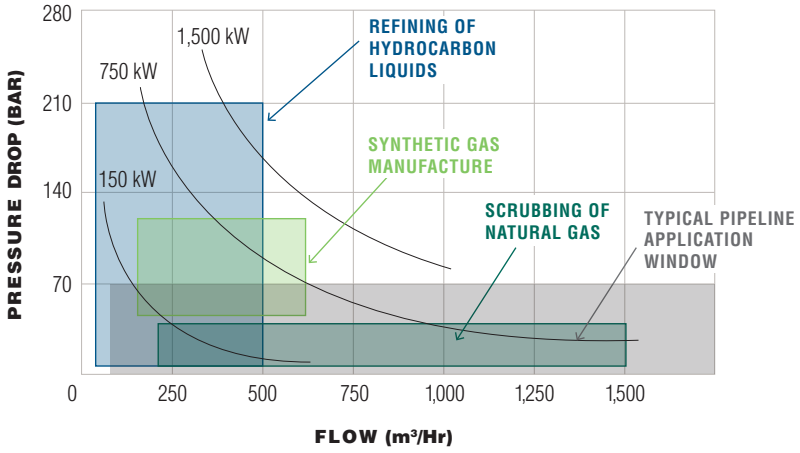
That's because standard hydraulic turbines have a narrow allowable operating range (AOR). They become unstable when the mix of liquids and gases varies from the pump's hydraulic design. This can happen any time the feedstock or other process conditions change. Since the HPRT is connected in many cases to the charge pump package, its instability or failure can shut down the hydrocracking process. So, refinery operators will bypass the highly sensitive HPRT, rather than risk the reliability of the hydrocracker, which is at the heart of oil and gas refining.

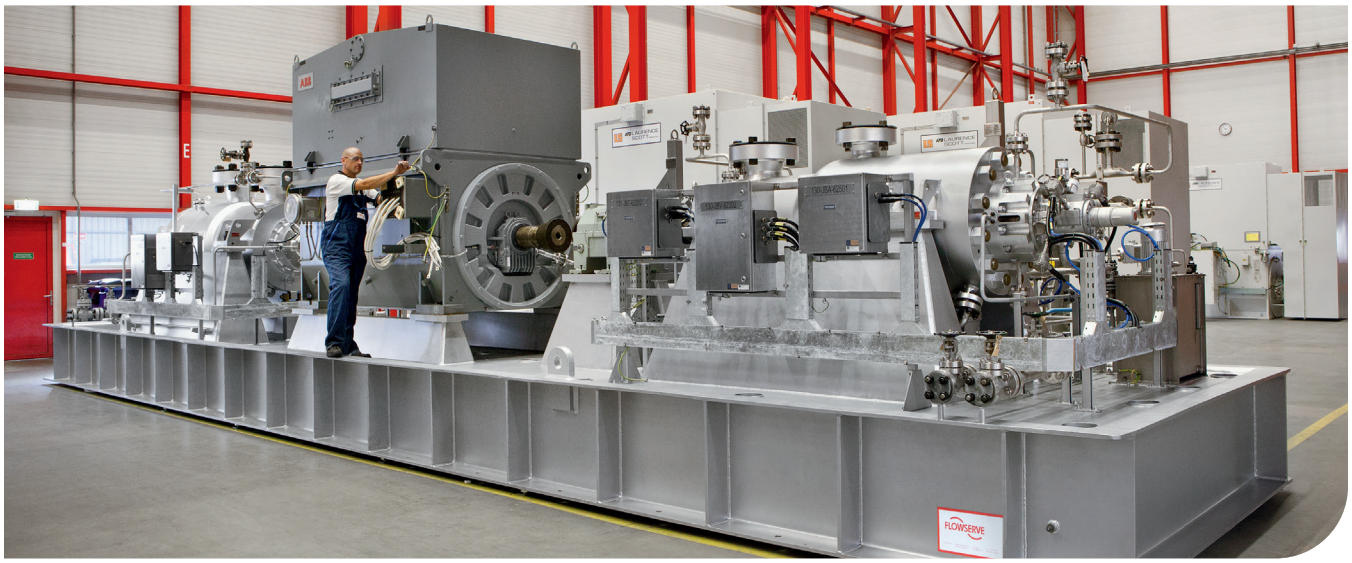
Flowserve enables refinery operators to avoid these issues and supports their corporate initiatives to optimize efficiency, minimize energy costs, and reduce carbon dioxide (CO_2) emissions. We convert reverse-running pumps into true turbines with superior energy recovery and stability. Our highly flexible turbine hydraulics can increase efficiency by as much as 7% compared to a conventional reverse-running pump.

Typical market envelope

As energy costs escalate, some widely used refining processes are ideal for energy recovery. These include:

- Refining of hydrocarbon liquids by hydrotreating or hydrocracking (blue; this technical article covers this area of use)
- Scrubbing of natural gas containing unacceptable quantities of impurities like carbon dioxide (light green)
- Synthetic ammonia manufacturing (dark green)
- Some pipeline applications due to their geographical footprint (gray)





Flowserve 10-stage HSO hydrocracking charge pump with a 12-stage HDO-TT power recovery unit that operates at 2,980 rpm

Instability by design: Running standard pumps in reverse

Many refinery operators change crude oil feedstock frequently in response to economic and marketplace trends and to meet business objectives. Often, the liquid and gas content of the feedstock does not match the AOR of the centrifugal pumps running in reverse and connected to the charge pump.

Instead of recovering energy efficiently, these reverse-running pumps become unstable, especially when gas volume expands beyond the range for which they were originally designed to handle. That's when refinery operators typically suspend HPRT operations; the risk to the charge pump, and therefore their entire hydrocracker unit, becomes too great.

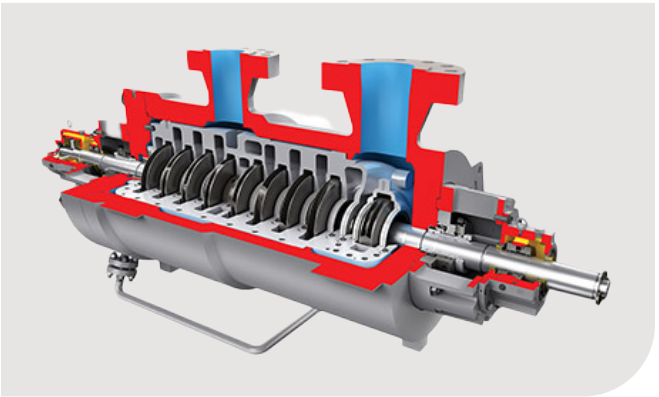
More issues can occur with standard centrifugal pumps running in reverse when there's a change in:

- Unit feedstock such as higher throughput, tougher feed, additional feeds or a different crude slate
- Product slate containing more or less naphtha, kerosene, diesel or fuel oil
- Product specifications that reduce sulfur content or improve diesel properties
- On-stream efficiency that can be impacted by cycle length, unit downtime or corrosion
- Operational efficiency that reduces utilities, improves the refinery's Solomon Energy Intensity Index® (EII) and hydrogen limitations

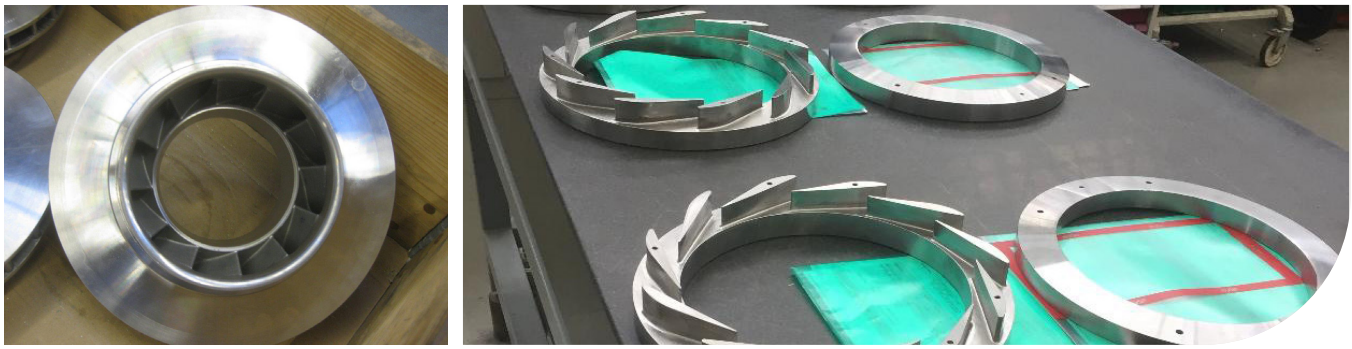
A better BB5 solution: A true-turbine design

To overcome these issues, Flowserve specialists have redesigned the inner volutes of the BB5 barrel pump to have true-turbine hydraulics. No longer simply a pump running in reverse, the HDO-TT offers greater efficiency and performance. A correctly designed and installed turbine connected to the charge pump package can recover the equivalent of 50% or more of the power consumed by the charge pump.

The HDO-TT is ideal for medium- and high-pressure oil and gas applications and can be tailored to your hydrocracker process conditions and fully comply with API 610.



The Flowserve HDO multistage split volute barrel BB5 pump is available with true-turbine hydraulics designed to exactly match process conditions when used as a hydraulic energy recovery turbine in hydrocracker processes.



To match a true turbine to process conditions, Flowserve modifies the runners (left) and uses diffuser nozzle rings (right). The modifications require the nozzles to be machined into the existing inner volute.

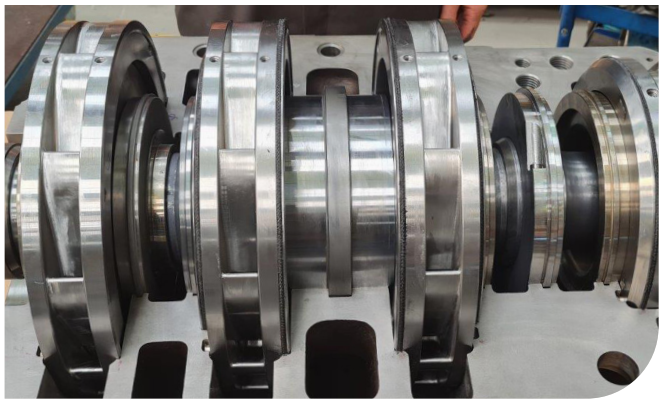
Custom engineered to match process conditions

Our engineers and service specialists understand how to analyze the behavior of the total mass flow of liquids and gases in each hydrocracker system. We conduct computational fluid dynamics (CFD) analysis to determine how feedstocks from various regions and changed process conditions can impact the behavior in each stage of the turbine.

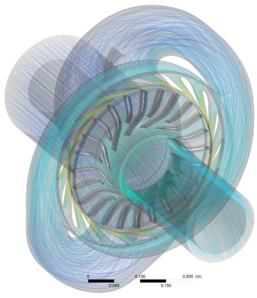
That's the critical step because the gas content can increase or decrease depending on the feedstock. Too much gas content can cause instability. While more stable than reverse-running pumps, true-turbine designs still have operating limits. Typically, they can operate no more than 80 to 120% out of their design window; go beyond that and the HPRT becomes unstable.

Simply put, the physics and behavior of a pump are different when running in reverse. So Flowserve offers the HDO BB5 pump with true-turbine options.

Impellers and volute diffusers are replaced with runners. We custom engineer the runners in each stage based on the CFD analysis results. We also design runners with more vanes and modify the width of the nozzles to match the hydraulic conditions in each stage.



Flowserve designs the runners and nozzles on HDO-TT rotor assemblies (like the one shown above) to match a CFD analysis of conditions stage by stage. (See CFD images below.) This is what we mean by a true-turbine design.



Greater flexibility to handle various feedstock

This comprehensive approach even enables refinery operators to change the hydraulics when new feedstock is scheduled for processing; when other hydrocracker conditions change, our true-turbine concept provides refinery operators with greater flexibility. It also significantly shrinks the time needed to update the runners and nozzles inside HDO pumps from Flowserve as well as equipment supplied by other manufacturers.

Some customers stock multiple sets of rotor assemblies to match different feedstocks, which can change frequently at some refineries. Cartridge-style inner case sub-assemblies — which include the rotor, runners, nozzles, seals and bearing assemblies — are dynamically balanced and stocked on-site. This cartridge-style construction reduces the downtime needed for hydraulic change-outs when operating conditions change by allowing quick replacement of the entire sub-assembly. Change-outs can take 40% less time compared to how long it takes to remove and replace a whole standard centrifugal pump installed to run in reverse.

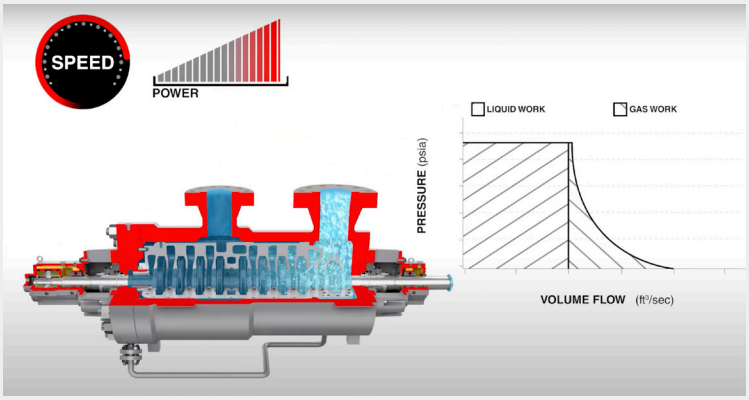
Flowserve has experienced engineering and service teams available globally to support on-site rotor change-outs within your regularly scheduled plant shutdowns. In addition, Flowserve teams support site acceptance testing (SAT) and validation of turbine performance.

Comprehensive support to help you drive efficiency

After completion of a CFD analysis with actual operating conditions, Flowserve sizes the runners and nozzles for each stage of a pump to recover maximum energy in a hydrocracking process.

Properly calculating HPRT unit efficiency and power recovery

The unit efficiency and power recovered by an HPRT is highly dependent of the presence of evolved gas in the fluid. If you are not factoring in the presence of evolved gas, your calculations are probably wrong.
Watch this video to learn why.



Return on your investment in 12 months or less

In many cases, the investments refinery operators make in updating reverse-running pumps can be paid back in less than one year in addition to providing heightened flexibility, efficiency, CO_2 reduction, and stability in their hydrocracking processes. However, that's achieved only when turbine hydraulics and components are correctly designed and implemented to match each refiner's unique feedstock and process conditions.

Leverage decades of turbine expertise

By partnering with Flowserve, refinery operators can leverage our successful experience in oil and gas turbine applications around the world.

For more than 35 years, we have provided oil and gas customers with energy recovery solutions engineered for their unique hydrocracking process conditions.

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Accelerate your energy transition plan

Optimizing equipment and unit efficiency is an increasingly important consideration toward the achievement of sustainability goals. The Energy Advantage Program from Flowserve offers a suite of solutions focused on enabling significant efficiency, reliability and carbon reduction improvements from the optimization of HPRTs and hydrocracker units.

The Energy Advantage Program can quickly enable your company to start achieving operational cost objectives and accelerate progress toward realizing your decarbonization goals. Partner with Flowserve to implement the program and then monitor the savings on an ongoing basis to ensure that your company continues to meet energy efficiency targets.

Flowserve specialists share our unparalleled experience in implementing solutions to optimize pump efficiency around your process needs.

Contact us today to see how we can support you at EnergyAdvantage@Flowserve.com

Our commitment to energy transition

At Flowserve, our approach to energy transition begins and ends with our purpose: to make the world better for everyone. We understand that when we enable our customers to tackle climate change and address increasing energy demands through our innovative flow control solutions, we can make the world better — now and for generations to come.

Our approach is threefold. We are diversifying, decarbonizing and digitizing to support the global energy sector's transformation toward low-carbon sources.

DIVERSIFICATION

Our innovative portfolio of flow control solutions and services will support energy systems around the world to diversify the energy mix and adopt cleaner sources of energy.

DECARBONIZATION

We will support the reduction of energy-related CO_2 emissions across the mix of energy sources through our innovative portfolio of flow control solutions and services.

DIGITIZATION

We will enable improvements in efficiency, productivity, sustainability and safety of energy systems around the world through our digital solutions and services.

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