Number 331

September | October 2014

nitrogen + syngas

www.nitrogenandsyngas.com

ANNA Conference, Tucson, Arizona

Demand for low density AN

Precious metal recovery

Autothermal reforming for methanol plants

Maximising uptime in ammonia plants with turbochargers

Andrea Gains-Germain, Director of New Product Development for Energy Recovery Inc., discusses how using a turbocharger in a CO_2 recovery system can help recover pressure energy from the system and increase plant uptime.

Over the past century, the practice of energy recycling has been built into industrial processes as a necessary step to minimise what would be otherwise wasted energy. Most are familiar with the concept of waste heat recovery, where heat that would have been dissipated and lost is returned to manufacturing and industrial processes. Waste heat recovery has helped industry optimise efficiencies and seize opportunities to become more profitable. But many industries, including ammonia producers, have yet to broadly apply energy recycling to another form of energy – pressure energy.

Much like heat, pressure is often wasted in industrial processes through let-down in valves or other devices. This is squandered energy that increases a plant's energy consumption and carbon footprint. For ammonia producers, the wasted pressure in the production of synthesis gas, or syngas, costs the industry millions and plagues plants with massive inefficiencies. As margins continue to tighten with ever-higher expectations of efficiency and emissions reduction, such waste can no longer be an option.

Ammonia producers have a huge opportunity to tap into pressure energy and reduce this waste, saving themselves expense and improving system reliability in the process. Plant owners can start by modifying their production of syngas. Most plants are currently configured so that significant pressure energy is wasted during the CO_2 removal process. This process is essential to purify the syngas needed for ammonia production. And this is where the greatest opportunity lies for leaps in operational and economic efficiency.

Historically, energy recovery devices haven't been widely adopted in ammonia production. The traditional hydraulic power recovery turbines, or reverse running pumps, represented the first major milestone in this field. But their efficiency and reliability have been unpredictable. Today, new technology, specifically designed for energy recovery in syngas processing, is available that dramatically simplifies and improves the CO_2 removal process. Further, this technology can boost overall uptime at a plant, leading to greater productivity and better economics for plant owner, operators and end-users.

Turbochargers

Energy Recovery first launched the *IsoBoost*™ energy recovery system to ramp up efficiency and profitability for midstream gas processors. With the technology proven in the demanding oil and gas industry, Energy Recovery has now adapted this technology for use in syngas purification, for ammonia, methanol and urea producers. This is the first turbocharger-based solution for energy recovery, and the only system to offer benefits beyond power recovery to deliver more uptime, more productivity, and more overall economic value to plants.

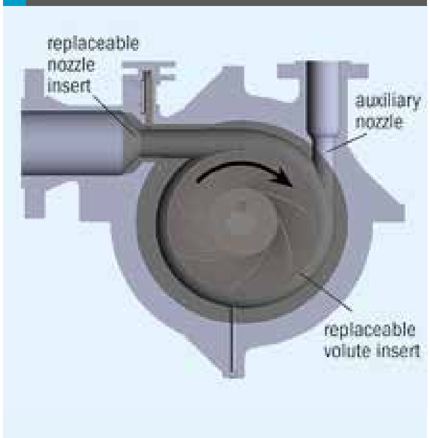
The *IsoBoost* system is capable of yielding high efficiencies with optimal operational flexibility and extremely high availability, making pressure recovery a process and economic asset. The system recovers energy in acid gas treatment processes at up to 80% efficiency by harnessing energy from pressure drops in one liquid process flow to boost the pressure in an adjacent flow.

Ammonia plant owners and operators have long supported efficiency as a means to reduce operating expenses and environmental impact, with good reason; syngas production, critical to the creation of essential products such as fertilisers, plastics and fuels, requires large amounts of energy. The CO_2 removal process in syngas purification is a significant contributor to overall ammonia plant energy consumption. No strangers to the concept of energy recovery, plant owners know that there are a variety of configurations and pumping schemes that can be optimised to yield overall plant benefit in terms of capital investment, operating and maintenance costs, and capacity. But they may not be aware that turbochargers can recover hydraulic energy within the CO_2 removal process while offering levels of reliability that can improve plant uptime and reduce overall plant maintenance.

IsoBoost can be inserted into the process that removes CO_2 from syngas in ammonia plants; harnessing the pressure energy and directly recycling it back into the system as hydraulic energy, producing far greater efficiencies, and power cost savings than competitive technologies. Its simplified design offers a compact footprint, rapid installation and, most importantly, lifetime reliability with con-

Fig 1: **Energy Recovery liquid-phase turbocharger**

Fig 2: **Turbine side view**



sistently high efficiency across a wide range of operating conditions. In one gas processing plant in Texas, a client realised that because of the *IsoBoost* energy recovery system, the overall plant uptime was increased. As *IsoBoost* controlled the amount of pressure and energy load, relieving ancillary equipment from heavy duty pumping, the plant owners and operators could rely on the technology to keep the plant running smoothly. This results in maximum uptime for a plant and makes this technology the next major milestone in energy recovery for ammonia production.

In CO_2 removal processes, the concept of energy recovery is simple; capture the pressure energy from the rich solvent exiting the absorber and transfer it to the lean solvent exiting the regenerator. While the execution of this energy transfer can be done using conventional rotating equipment, there are inefficiencies and maintenance issues that can arise. In a typical configuration, a long train of a recovery turbine, or reverse running pump, is coupled via a shaft and clutch to a high pressure pump and electric motor. The high-pressure pump is typically fixed speed. The connection of the recovery turbine to this pump then constrains the speed of the turbine. When off-design flow conditions occur, the turbine is unable to adjust to operate at the speed dictated by the flow. The speed mismatch can cause vortices and flow separation inside the turbine. This turbulent flow results in serious problems including vibration and impeller damage caused by flashing in the turbine due to the long residence time. To prevent this, flow must be bypassed or the recovery turbine disengaged from the pump, resulting in significant energy wasted and requiring extra attention from operators.

In CO_2 removal with a turbocharger, the energy transfer happens in a single, compact device. The rich solvent spins the turbine, which spins the pump, pulling in lean solvent and pumping it into the absorber. The custom turbine and pump are directly coupled inside a single casing. This eradicates the need for shaft seals and oil lubricated bearings that are common failure points in conventional high-pressure pumps. The single thrust bearing in the turbocharger is process lubricated by a small amount of filtered lean solvent from the pump discharge. The hydrodynamic radial bearings are also lubricated by this process fluid. The only maintenance required is a filter cartridge replacement in the on-skid filtration system at regular intervals. The simple design and low part count of the turbocharger results in a very high availability and can actually increase plant uptime by virtue of removing a high-pressure pump from the process.

Additionally, the back to back one stage impellers that form the compact rotating assembly in the turbocharger are not constrained by any coupling to a pump, motor, gear, or clutch. The single rotating assembly is free to operate at an optimal speed determined by the flow conditions; this speed flexibility removes the serious risks of vibration and misalignment caused by fixed-speed coupling of traditional rotating equipment in a long train to perform this same recovery function.

Efficiency

The turbocharger operational efficiency is high in a range of operating conditions. Because the turbocharger transfers hydraulic energy directly, the efficiency metric is calculated differently than with a typical recovery turbine. An energy recovery turbine is usually rated as having a certain efficiency based on the conversion of hydraulic power into mechanical shaft power. This shaft output is then mechanically transmitted to the feed pump which then converts that power back into hydraulic power in the amine stream. The efficiency of that feed pump is not included in the efficiency calculation. A better measure of efficiency is the ratio of the hydraulic energy returned to the lean solvent to the amount of hydraulic energy available in the rich solvent.

This ratio, the hydraulic transfer efficiency, or n_{te}, is defined as:

$$n_{te} = H_{out} / H_{in} \quad [1]$$

H_{out} = Hydraulic energy transferred to the lean solvent
H_{in} = Hydraulic energy available from the rich solvent

In the case of a recovery turbine or reverse running pump, n_{te} is calculated by:

$$n_{te} = (n_{ert})\ (n_{md})\ (n_p) \quad [2]$$

n_{ert} = recovery turbine efficiency
n_{md} = mechanical power transmission efficiency between recovery turbine and feed pump
n_p = feed pump efficiency.

Assume a CO_2 removal system uses a multistage feed pump rated at 74% efficiency at the operating point. The system also employs a multistage reverse running pump as a recovery turbine that displays an efficiency of 78% at the operating point. The two units are coupled by a double extended shaft motor. The data is summarised as:

$$n_{ert} = 78\% \text{ or } 0.78$$

$$n_{md} = 100\% \text{ or } 1.00 \text{ (no loss)}$$

$$n_p = 74\% \text{ or } 0.74$$

Substituting the above values into equation [1] yields an energy transfer efficiency, n_{te}, of 0.58 or 58%. That is, 58% of the hydraulic energy in the rich solvent is converted into hydraulic energy in the lean solvent. The rest of the energy is lost.

On the other hand, the energy transfer efficiency of a turbocharger is independent of the feed pump efficiency. Thus, the hydraulic transfer efficiency equation can be used to define the turbocharger efficiency – up to 80% for the Energy Recovery *IsoBoost* system.

Not only are hydraulic turbochargers

designed specifically for efficient energy recovery, they also incorporate unique and important features for maximum flexibility at current and future design points. As shown in Figure 2: Turbine side view, there are two nozzles associated with the turbocharger, the main and auxiliary nozzle. A flow control valve, the auxiliary valve, allows flow to enter the auxiliary nozzle as needed. The turbine thus has a variable flow coefficient and can operate in the region between the two flow curves as defined by the open or closed auxiliary valve. This is important for maintaining best efficiency for a range of flow conditions instead of a single point.

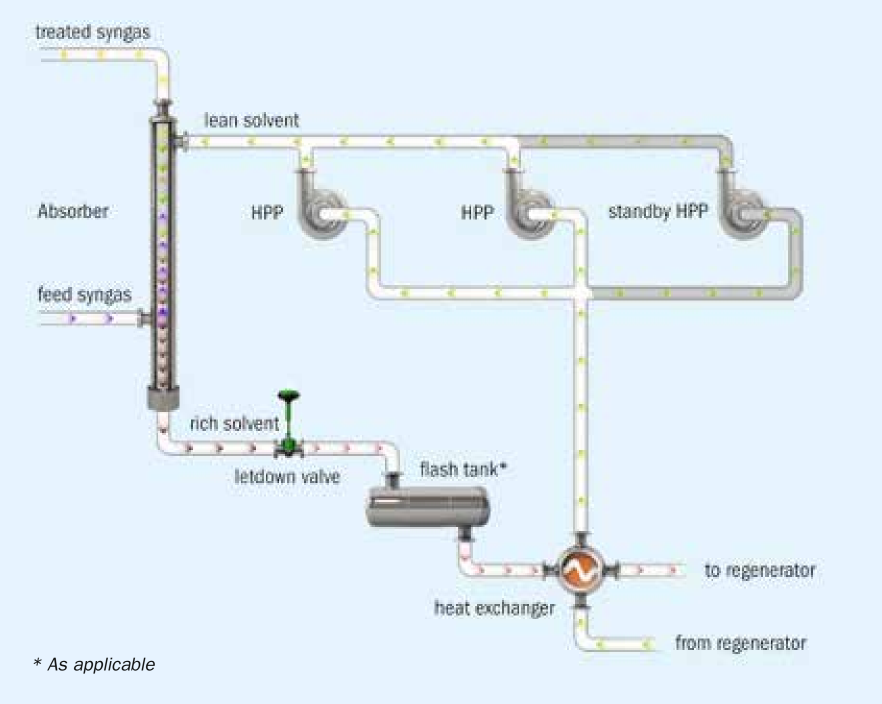
Should process conditions change permanently, the custom hydraulic components are designed to be easily changed out–insertable nozzles and replaceable volutes can be easily retrofitted if flow or pressure drop requirements change by a significant amount and because of the turbine casing's back pullout configuration, these internal components can be replaced in a matter of hours without disturbing the process piping connections.

Another benefit of the solution is that its compact form makes for reduced space requirements; it is even light enough to be scaffolded instead of ground-mounted with a poured foundation. The customizable design also allows flexibility in system configuration as it can be optimised for maximum benefit to the customer in terms of opex, capex, and process needs. In one midstream gas processing plant, the customer wanted to increase processing capacity without increasing energy consumption due to emissions regulations on their existing pumping scheme. The installation of the energy recovery solution allowed them to add this pumping capacity with only a fraction of the emissions and operating cost they would have incurred with the addition of a high-pressure pump. The energy recovery solution and a small, low-head boost pump provide the additional capacity and level control.

In the second configuration, the customer's goal was to take an old high pressure pump in a 3-2 configuration, off-line. As multiple pumps serve a portion of the flow into the absorber, it is possible to fully replace one of these pumps with an energy recovery solution.

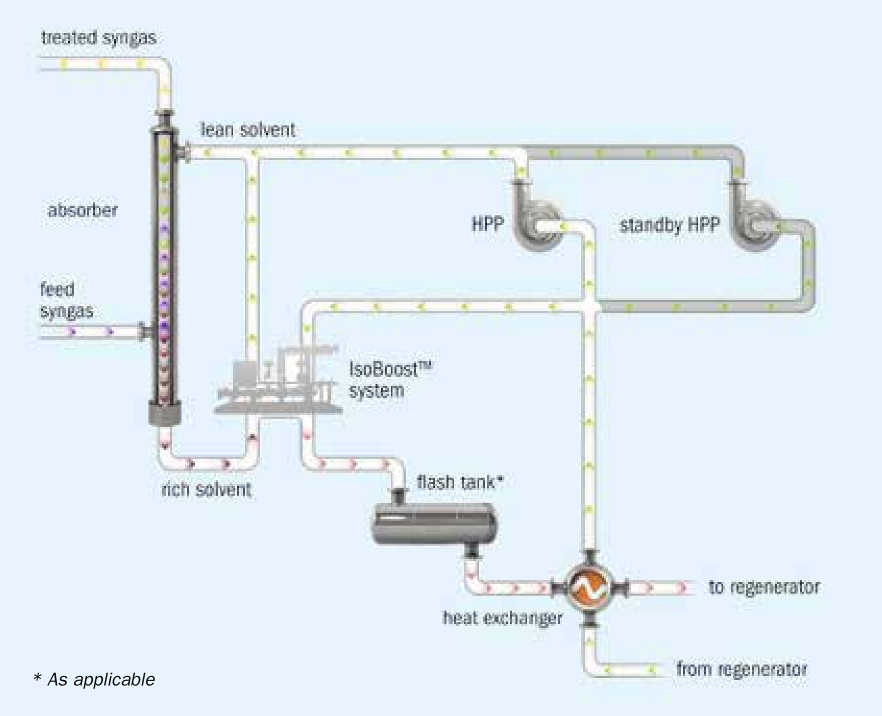
Regardless of the configuration, turbocharger technology for energy recovery offers the performance, reliability, and efficiency that are increasingly demanded by the ammonia industry today. Leveraging the proven turbocharger technology from Energy Recovery that revolutionised midstream oil and gas production, ammonia producers can reap the benefits from tapping into the often overlooked opportunity of recycling pressure energy. This new technology asks ammonia producers to rethink what energy recovery devices can do for them. Well beyond reducing carbon footprint, this solution has the potential to create serious impacts on uptime, efficiency and profitability. With a simple addition to a plant, ammonia production can now become more profitable and better for the planet.

Fig 3: **Simplified process flow before energy recovery** (3/2 configuration)



* As applicable

Fig 4: **Simplified process flow with energy recovery** (3/2 configuration)



* As applicable


Boost uptime
in ammonia plants
energy recovery
IsoBoost
IsoBoost™ is the only system designed and proven to increase plant uptime, reduce power consumption and lower overall operating costs.
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Increase profitability
Reduce overall plant maintenance
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