IMPROVING PERFORMANCE

Sergio Di Vincenzo, Boldrocchi, Italy, explains how customised fan systems can improve reformer performance.

Around the time that this article is published, two particular fertilizer plant projects in Indonesia will be commissioned. One is a new ammonia plant built in Central Sulawesi; the other project is the expansion of an integrated urea-ammonia plant in East Java. Indonesia is, of course, a key market for gas plants and derivatives due to its large reserves of natural gas. In addition, the Indonesian government has been encouraging fertilizer production and the construction or expansion of several plants as it aims to maximise the domestic use of its natural gas and strengthen the security of the nation's food supply.

The challenges of fan systems in the steam reforming process

In the two Indonesian projects discussed here, Boldrocchi supplied complex fan systems for the steam reforming process. These are essential components to achieve reformer performance targets. Steam reformers in fertilizer plants and hydrogen production units are equipped with a forced draft fan that supplies combustion air to the burners and an induced draft fan to extract exhaust flue gases from the reformer chamber, which is kept under slight negative pressure. Although two fans may seem like a simple order to some, they are highly engineered systems with a complex series of integrated components. From both an engineering and a job management point of view, areas of fertilizer plants requiring fans or blowers must be impeccably designed and produced in order to ensure reliable and long-lasting operation as they are critical items for overall production process. Some of these systems are so complex that they can nearly be considered small plants themselves.

Banggai Ammonia Project

The Banggai Ammonia Project for Panca Amara Utama (PAU) in Banggai Regency, Central Sulawesi, has seen a new ammonia plant built with a capacity of 1900 metric tpd. Erection was completed in the second half of 2017 and the project will be commissioned around publication date. The natural gas will be supplied from the Senoro – Toili Block. The plant will feature a leading ammonia technology, including the latest in energy-efficient technology, making it among the first in Asia to use this advanced technology. This places Indonesia at the forefront of ammonia production advances globally.

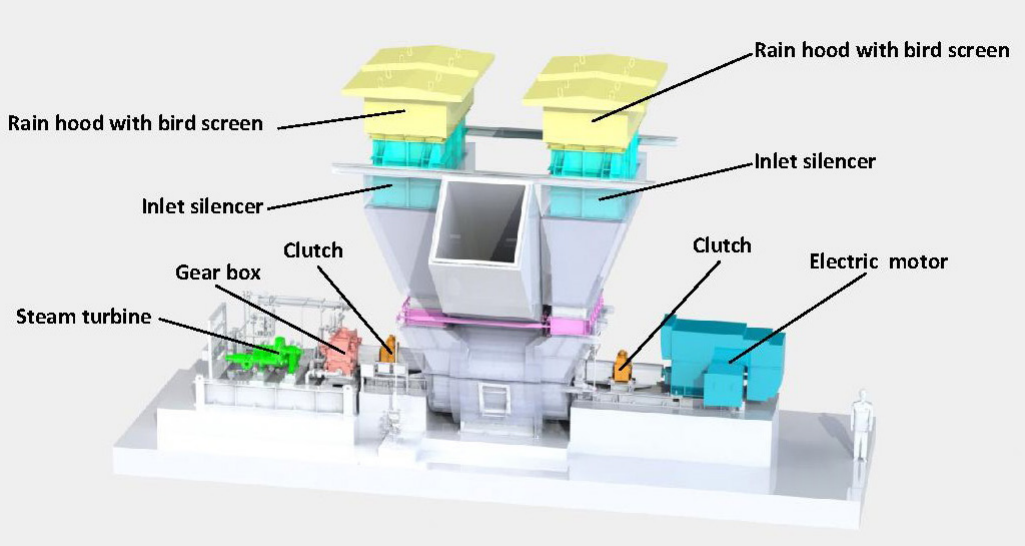

Figure 1. Schematics of the 'machinery train'.

Figure 2. A fan's rotor being assembled at Boldrocchi's Italian workshop.

Boldrocchi was contracted by primary contractor PT Rekayasa Industri in November 2016 to engineer, manufacture and test the complex fan systems for the steam reforming process. This included:

- Fans.
- Silencer.
- Damper.
- Steam turbine system.
- Bearings.
- Gearbox.
- Electric motor.
- Lube oil unit.
- Machinery protection system.

Fan systems design

Boldrocchi designed both a forced draft fan system to provide combustion air to the burners rated 0.53 MW and an induced draft fan system for exhaust fumes rated 1.1 MW. Both fans have double inlets, allowing them to process the required elevated flowrate with high efficiency. Both fans are designed according to demanding API 673 requirements for special purpose units to ensure maximum reliability and are configured nearly identically. The only difference between the two, in terms of configuration, is the air intake, which is only present on the forced draft fan. This complete air intake system includes a customised inlet silencer to ensure targeted noise reduction.

Double regulation system

The systems for both the forced draft fan and the induced draft fan are regulated with a combination of fan speed regulation and damper control. Boldrocchi's team designed the system to reduce energy consumption at lower loads. Plant operators will be able to reduce fan speed and fine-tune the regulation of the process by controlling a damper. This double regulation allows the plant to save energy while ensuring critical speeds are never reached.

Fan drivers

As steam is generally available, a steam turbine acts as the main driver for the fans in most fertilizer plants. The main driver for the fans at the Banggai plant is a single-stage backpressure steam turbine designed according to API 611. It runs at approximately 4500 rpm with an API 677 designed external gear reducer connected to the fan shaft. An electric motor will be used as a backup driver at plant startup when steam may not be available, as well as in case of a turbine shutdown in order to safeguard the process and avoid any sudden plant shutdowns. To avoid both drivers working at the same time, two clutches – one on each fan shaft end – are used to engage and disengage the idle driver automatically.

Although Boldrocchi purchases the basic turbine from a subsupplier with the driver, the governor and the overspeed protection system, it engineers the rest of the turbine system. This is because tailoring the turbine to the customer's specific project requirements is essential for a high quality, reliable product. Therefore, the company's engineers design the instrumentation philosophy, the cabinets and the transmission couplings between the fans and the drivers. Even the couplings for this application are special. The coupling calculations for each combination are selected after a torsional analysis of the entire train via rotor dynamics analysis. The turbine, turbine control system and overspeed protection system were passed through functional tests at the vendor's test facilities before shipment.

Bearings and lube oil system

The bearings on the system are sleeve type with common forced oil lubrication for the complete 'train' (the machinery train that Boldrocchi supplies. See Figure 1). The oil is pressurised by a shaft-driven main oil pump. An auxiliary motor-driven standby pump is to be used as both a backup and a startup pump to ensure reliable backup. The lube oil system is designed according to API 614 and feeds the fan and turbine bearings with fresh oil cooled by a TEMA C water-cooled heat exchanger.

Monitoring the system

Boldrocchi designed a customised local instrumentation module that sends alarm and trip signals in case of oil pressure loss, temperature hikes or low levels. The lube oil system is fully integrated in the turbine skid with on-skid piping, enabling a reduction in the system's footprint and avoiding external pipe routing.

The company also supplied a complete machine monitoring solution using a GE Bently Nevada 3500 series system. It monitors the vibration, temperature and speed of the fan systems and communicates with the plant's main distributed control system (DCS)/emergency shutdown (ESD) system. Although in most cases the machine monitoring solution is in a simple cabinet inside the plant control room, the Banggai project presented a special case. It was requested that the entire machine monitoring system be installed outside the building in a classified area. This presented a more complex and heavy-duty design than usual, as in typical cases these cabinets are installed in an air-conditioned control room. The design for this cabinet needed to be explosion proof to prevent any risks of sparks. Indeed, the main issues were the pressurisation system and the cabinet design, which had to be robust, as well as gas tight. This monitoring system was engineered, assembled, FAT-tested and calibrated at Boldrocchi's factory, and then shipped as a whole unit.

Designing the system

To design the system, the team performed rotor dynamics analysis on the complete train to predict critical speeds and provide a basis for solutions to reduce vibration risks. This involves significant engineering and it is crucial that it is done properly to ensure optimal performance and reliability. In particular for such complex machinery trains, all components were specifically designed to avoid train torsional frequencies in various operating conditions. Boldrocchi uses a set of software programs for rotor dynamics developed internally with the University of Milan. The Holzer calculation method is used for the torsional analysis calculation. This calculation elaborates the stiffness and moment inertia of the steam turbine, the clutches, the fan and the electric motor to determine torsional natural frequencies of the complete unit. The above calculation is then reused several times using various combinations of couplings' stiffness until a satisfactory combination is reached (allowing all operating speed ranges required by the process). The operation logistics of the entire system, including the combined regulation by speed variation and damper control, are then verified and set to avoid operation near critical speeds.

Testing

Boldrocchi performed successful functional tests of all the equipment at its in-house testing facility in Italy before shipping the solutions, and was careful to ensure proper settings and reliable operation. This testing is a crucial step on such highly engineered applications.

Figure 3. The Banggai Ammonia project was the first of two recent fan contracts in Indonesia to improve the reformer process.

Figure 4. A fan undergoing a functional test at Boldrocchi's workshop near Milan, Italy.

Integrated urea-ammonia plant expansion in East Java

East Java's urea fertilizer demand is currently nearly double the region's production capacity, so expanding this plant was a strategic move to avoid importing raw material for fertilizer. The plant's expansion will bring the facility's production to 2000 metric t of ammonia and 1725 metric t of urea per day and makes it slightly larger than the Banggai plant.

Boldrocchi was hired in August 2016 by engineering, procurement and construction (EPC) contractor Wuhuan Engineering Corp. to be the single point of responsibility (contracted to design, manufacture and install) for the complete machinery train up to the main process interface. Therefore, Boldrocchi carried out the technical coordination and engineering of all main components in the steam reforming system, including the mechanical, instrumentation, acoustic, electrical and piping.

The main fan packages in the scope of the project were:

- Flue gas induced draft fan.
- Combustion air forced draft fan.
- Blower for fluidising cooler.

The package on this project was very similar to the one on the Banggai project, although there were some differences. In

Figure 5. The Banggai Ammonia plant will feature a leading ammonia technology, placing it at the forefront of ammonia production advances globally.

Figure 6. The Banggai Ammonia plant from above.

this project, the rating was higher, the size was slightly larger and overspeed protection was not required for the steam turbine.

In this plant, the forced draft fan, pushing combustion air to the burners, is rated 0.66 MW and the induced draft fan for exhaust fumes extraction is rated 1.1 MW.

The control system was done similarly to the one done in the previous project, although this one was developed by Boldrocchi engineers in conjunction with the end-user. Again, this control system must be programmed to operate the fans properly in all operating conditions, including startup and shutdown, as well as emergency situations and must include a control scheme for a driver switchover in case the main driver is unavailable. Deciding how such a control system will function is more complicated when there is a double regulation system, as it must include protection for all components, including the turbine, motor and clutch system, as well as the overall unit. It must also be programmed with the desired actions to be taken automatically if one of the components fail.

As per usual, functional tests were performed in Boldrocchi's Italian workshops to verify that all components were working optimally before shipment. For this project, the company was also contracted to supervise site activities. A site specialist was at the plant in East Java to ensure all systems were properly erected.

Commissioning and startup are expected around publication date.

Conclusion

Fan systems in the steam reforming process are crucial yet complex components that can make or break the plant's achievement of targeted performance goals. They may be a relatively small part of the fertilizer process, but effective reforming goes a long way towards making the entire process hit objectives. Customised fan systems are the ideal solution to ensure the quality and reliability of a reformer. WF