A mega compressor in Houston

DRIVEN BY A 24,000 HP STEAM TURBINE, ELLIOTT'S 110M MACHINE WILL SUPPORT PROPYLENE PRODUCTION OF 544,000 MT/Y IN PETROLOGISTICS PLANT

In 2010, a propylene manufacturing facility will start up in Houston, TX, on the same site as a mothballed ethylene plant. Consuming 20,000 barrels of propane per day and producing 544,000 mt/y (1.2 billion pounds) of chemical- and polymer-grade propylene, the plant will be the largest of its kind in the world.

A landmark will be the supply of an Elliott 110M multi-stage centrifugal compressor for the new facility. Elliott, a wholly owned subsidiary of Ebara Corporation, is a supplier of centrifugal compressors and steam turbines used in the petrochemical, refining, oil and gas and process industries, as well as in power applications.

The 110M (Figure 1) is the largest frame size in Elliott's line of Edge compressors, and the PetroLogistics machine is said to be one of the largest compressors ever built. In addition to the 110M booster unit, Elliott will provide a 24,000 hp, 13-stage steam turbine driver, which will couple directly to the compressor, and a new lube oil system for the equipment train.

Elliott will also provide rerates and upgrades of existing equipment at the plant that used to produce ethylene. This includes work on four Dresser-Rand (Clark) compressors, and an overhaul of three Dresser-Rand (Turbodyne) steam turbines, as well as a technical review of two lube oil systems for existing equipment trains.

Figure 1: The Elliott 110M Compressor consists of a single casing that supports a rotor of nearly 24.5 ft length. The machine acts as booster compressor from the propylene reactor to the compressor trains at the Houston facility

Using a new process

Global demand for propylene (propene) has been increasing steadily for many years to support the rapidly expanding petrochemical industries and the production of polypropylene, acetone and isopropanol, among other products. While traditional methods of synthesizing the hydrocarbon involve ethylene steam cracking and Fluid Catalytic Cracking (FCC) processes at refineries, advancements in compression technology, as well as economic factors, have led to an increase in the application of Propane DeHydrogenation (PDH) for large-scale, cost-efficient propylene production. The PDH is a process dedicated to propylene production, wheras in traditional methods, such as FCC, propylene is one among a series of products obtained.

The high cost of propane feedstock has been a deterrent to the economic viability of PDH operations. However, as the price of crude oil has risen, the value of propylene and other associated products has increased as well.

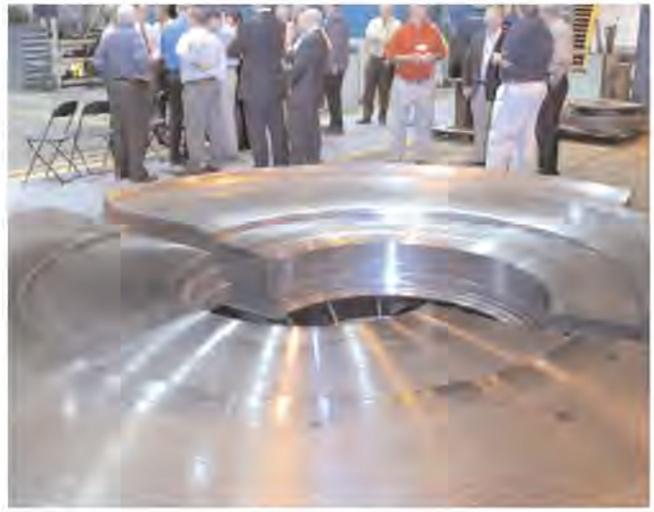
Larger propylene plants have replaced smaller facilities, while larger, more advanced compression systems have contributed significantly to more efficient production processes. Evidence of the move toward larger propane dehydrogenation production facilities can be seen in recent global projects.

At present, the largest propylene manufacturing facility is the Saudi Polyolefins Company plant in Al Jubail, Saudi Arabia. The facility, which went online in 2004, uses a PDH process to produce approximately 450,000 metric tons of propylene annually, representing roughly 5% of the world's total production. The next largest facility went online in 2003 and is operated by BASF Sonatrach PropanChem S.A, in Tarragona, Spain. The plant uses the UOP Oleflex process to produce 350,000 metric tons per year (mt/y).

Meanwhile, the largest propylene facility is now being developed in Houston, and is expected to begin production in 2010. PL Propylene LLC (PetroLogistics), with headquarters in Houston, recently acquired the Houston Olefins Plant formerly operated by ExxonMobil Oil Corporation.

The plant, which fronts the Houston Ship Channel, will consume approximately 20,000 barrels of propane per day, and produce 544,000 mt/y (1.2 billion pounds) of chemical- and polymer-grade propylene. Like the Saudi facility, the PetroLogistics plant will use the Lummus Technology Catofin process for propane dehydrogenation.

According to PetroLogistics, the new plant will meet the growing need for propylene by supplementing the product that currently is produced through ethylene cracking and FCC processes by North American refineries. Additionally,



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because the Houston facility has existing connections to pipelines already providing propylene and ethylene to the area refineries, PetroLogistics expects to begin production and deliver product to customers customers without some of the typically high capital costs involved in starting up a greenfield facility. "Our customers will be the major petrochemical companies throughout the shipping channel," says Bernard Sandner, Vice President of Manufacturing at PetroLogistics.

The Houston Olefins Plant first went into operation in 1965 as part of Sinclair Oil, and produced ethylene until the facility was mothballed by ExxonMobil in 2004. S & B Engineers and Constructors, Ltd., of Houston, has been selected by PetroLogistics to serve as the principal EPC contractor on the new project. "The location and general infrastructure of the plant are suited for the project, though a major transformation will be required to convert it from ethylene to PDH production," adds Sandner. The new plant will be the first propane dehydrogenation plant in the U.S. when it goes online.

Benefits of single casing

Ethylene and propylene production trains are generally similar. They typically feature a steam turbine driver, with two, three or four compressors (each consisting of one or two compression sections), with cooling external to the compressors between each section.

The main difference between the two is the composition of the gas streams. Also, the suction pressure is generally lower for propylene production than for ethylene production.

The biggest challenge in this project, at least in terms of sheer size and scope, is the design and manufacture of the 110M compressor. While the PDH process does not demand extremely high-pressure compression systems, it does require the ability to handle large volumetric flows.

The new 110M compressor is a booster compressor since the customer's supply pressure for the production gas is much lower for the propylene plant than it was for the original ethylene plant. Thus the gas must be boosted to a high enough pressure that can then be handled by the rerated low-pressure compressor. The new compressor and turbine will be located on a new deck adjacent to the existing compressor structures.

In ethylene production, the reactor operates at approximately 25 psi. However, in this PDH application, the reactor is only at 6 psi, well below atmospheric pressure, but with a flow of 310,000 cfm. The larger volumetric flow requires a booster compressor to take the gas from the reactor into product gas service. Elliott's Edge compression technology provides a single-case design at these flows, rather than having two compressor bodies separated by interstage cooling in an interchanger.

The compressor for the PetroLogistics plant is a six-stage, horizontally-split design with water injected between the impellers to atomize and cool the process gas. Single casings require less capital investment than multiple casings. Sandner of PetroLogistics says, "Only Elliott brought the compression solution we needed to be able to go to a single casing rather than two units."

Without EDGE technology, we would have had to offer a two-compressor case solution, says Art Titus, Vice President of Engineered Products at Elliott. "A two-body solution would have been more costly not only in capital expenditure, but also in installation and maintenance costs. We were able to offer a single body, six-stage compressor for the booster service at considerable savings to the project."

The machine has a rotor length of around 24.5 ft. The assembled casing will weigh more than 500,000 lbs. Elliott has manufactured 110M frames previously, but this is the first of these units to incorporate Edge technology. The company recently manufactured and shipped a 103M unit (one frame size below the 110M) that also used Edge technology, which helped in designing the PetroLogistics machine.

The Edge compressor design uses larger main shaft diameters and bearing sizes, which enhance rotor dynamics and allow longer rotors and higher operating speeds. Improved inlet vane configurations reduce inlet losses and higher efficiency staging also allow higher pressure ratios before interstage cooling is required. Scaling techniques are employed to optimize impeller selection from the lowest through the highest flow frame sizes. These design features allowed a single 6-impeller arrangement.

The compressor will be manufactured and tested at the Elliott facility in Jeannette, PA. In addition to the typical challenges associated with a major engineered-to-order machine, such as the procurement of raw materials and monitoring standard quality procedures, the sheer size of the 110M compressor creates an array of manufacturing challenges.

Because the impellers, shaft and casing are all larger than other units, some of the methodology needed to be addressed. For example, large frame rotors normally are assembled vertically. The extreme length of the 110M rotor required establishing a larger vertical assembly area. In addition, the shop crane capacity had to be upgraded to accommodate the weight of the unit. Elliott has experience testing

GE Frame 7 gas turbine packages, so moving the sizeable 110M to the test area for perfomance testing will not be an issue, say Elliot engineers.

Rerating for propylene

Some of the existing equipment at the PetroLogistics plant that will be used includes four Clark compressors, which were originally installed in the late 1960s, and three Turbodyne steam turbines. The compressors had been rerated for ethylene service in 1998, but out of service since 2004.

A significant aspect of the project is rerating for use in the PDH process application. The process began in April 2008, when the four compressors and three steam turbines were disassembled on-site and shipped to the Elliott service facility in Houston.

The first equipment string — the charge gas train in an ethylene production process — consists of two compressors with a steam turbine driver operating at roughly 26,000 hp. The first compression unit serves as a low-stage compressor at approximately 42,000 cfm. The second unit operates at approximately 8,500 cfm, with a discharge pressure of 580 psi. As the product gas train in a PDH process, the suction pressure is raised from 24 psia to 41 psi. Because the density of the gas is also increased, fewer stages are required. Polytropic head in the re-applied units is 45% of that required in the ethylene charge gas plant. On a volumetric basis, none of the original internals on the compressors were able to be used.

The second equipment train, the traditional propylene refrigeration train in an ethylene production plant, consists of one compressor and steam turbine. This unit is roughly the same size as the low-stage compressor in the charge gas train and employed five stages to compress 30,000 cfm of pure propylene at 23 psi to a discharge pressure of 271 psi. There were three sidestream connections. As the heat pump train in propylene service, inlet volume flow is almost exactly the same, but suction pressure is significantly increased and polytropic head is reduced by 2/3. Only two stages are required.

The third string is the ethylene refrigeration train, which also consists of one compressor and a steam turbine driver. This compressor is always smaller than any of the other services, designed to take ethylene from atmospheric pressure of 15.7 psi to a discharge pressure of 306 psi. The string operated at approximately 5,000 hp and 5,200 cfm of ethylene. As the mixed refrigerant train in the PDH process, the pressure ranges are the same, while the gas has a greater density. Seven compression stages are used in both processes. Inlet volume flow is slightly higher in the re-application, which means existing staging cannot be retained.

While the compressors will undergo complete rerate and replacement of all internals, the associated steam turbines require only minor refurbishment. Engineering for the compressor rerates has already begun, and manufacturing of the components will be conducted in phases over a 21-month time period. Each of the rerated units will be assembled and hydro-tested in Houston prior to being shipped to the Jeannette facility for ASME PTC10 Type II mechanical testing. The equipment will be shipped to the PetroLogistics facility by late 2009, where production of propylene is expected to begin during the summer of 2010.

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