Low BTU fuel gas compressors driven after a 100 MW generator by a Frame 9E gas turbine at the Ilva steel mill in Taranto, Italy. Three similar units are installed in this steel mill.

INTEGRATING REFRIGERATING COMPRESSOR TRAINS FOR LARGE LNG PLANTS

Machinery Now Designed to Serve Unitary Plants of 8 Million T/Y and Above

By Roberto Chellini

LNG plant size has been growing considerably in the past 30 years which has lowered the production cost of LNG for the operator, helping make it more and more competitive in the marketplace. In the '80s, it was common practice to produce 2-3 million tons per steam per year. Present units produce 4-5 million tons per year, and engineering companies are now planning plants with unit capacities in the order of 7-8 million tons per year. It is believed that such sizes will allow savings up to 30% in the cost per ton of LNG plant capacity over the present plant size.

GE Energy Oil & Gas, a specialist in this sector, is manufacturing the equipment needed for the new offshore Qatargas II plant, an approx. 7.8 million t/y (tons per year) plant based on the Air Products refrigerating process AP-X in Qatar, Ras Laffan Industrial City.

In LNG plants, it is common practice to use industrial gas turbines to drive the refrigerating compressors. In parallel with the increase in size and absorbed power of the compressors, it has been necessary to identify the most suitable gas turbine for the required power output.

Up until now, GE Frame 6 and 7, originally designed to drive generators at constant speed, were also available for variable speed, mechanical drive applications, as required in LNG process plants.

Larger LNG units require more power. In order to be used in the Qatargas II train, GE Energy Oil & Gas has submitted its Frame 9E model (rated 126 MW) to a special qualification and testing program carried out by the Florence engineering team in synergy with the GE Energy team in Greenville, South Carolina, U.S.A., and Belfort, France, where this model is manufactured.

This machine was originally qualified for transients in the power generation mode between 95 and 105% of nominal speed (3000 rpm). FEA and CFD calculations were carried out to verify the possibility of operating the machine at different speeds for long periods of time, as it can be required for mechanical drive applications. Finally, the Frame 9E was qualified for steady operation within the 96 to 102% speed range.

GE Nuovo Pignone had already gained field experience with a hybrid mechanical drive/power generation application with Frame 9Es in a steel mill where a large fuel gas compressor train is driven on the same shaft as the electric generator. These gas turbines are fueled with low BTU gas from the mill and produce 100 MW of electric power while driving a 30 MW compressor. Their ISO rating is 126 MW, but in reality they deliver around 140 MW. In spite of the load and the type of fuel, which is not of the cleanest quality, their availability has been recorded in the 95 to 96% range. Because of this,

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Rotor of the MCL 1402 nitrogen compressor for the 7.8 million t/y Qatargas II LNG plant.

the customer has decided to move their major overhaul originally planned after the first 48,000 hours to 56,000 hours. The two turbines installed at the Ilva Taranto steel mill have operated on low BTU fuel gas since their installation in 1995, validating these machines for this type of fuel.

The Qatargas II units are equipped with a DLN combustion system to maintain NO_x emission below 25 ppm and can burn low BTU fuel with high nitrogen content. DLN experience comes from Frame 7 models with DLN systems in operation in other LNG plants where they are fueled with gas having very high nitrogen percentage. The Frame 9 machine is, in fact, a scale-up of the Frame 7 featuring the same combustors apart from their number — 10 on the Frame 7 versus 14 on the Frame 9E.

Compression power required by the various refrigerating cycles serving a 8 million t/y LNG plant is in the range of 300 MW. It is clear that the Frame 9E turbine becomes the optimum driver capable of delivering the required power, minimizing the number of units.

To overcome the start-up inertia of the turbine rotor coupled to the compressor rotor in its pressurized casing, it is necessary to dispose of a 45 MW starter-helper motor. An ASI Robicon, 4-pole motor was selected because of its compact size and drive technology. The ASI Robicon PWM (Pulse With Modulation) drive delivers a continuously approximate sinusoid of current which avoids pulsations on the turbine-compressor rotor couplings system, minimizing the torque ripple effect. The starter-helper motor has been placed between the turbine and the compressor for easier maintenance operations on the outboard compressor casing.

While the Frame 7 has a 3600 rpm rotating speed, the Frame 9E is a 3000 rpm machine. In order to directly couple the compressor train, it was necessary to increase the size of the compressors not only because of larger capacity, but also to adapt them to the lower speed.

Compression of large flows of gas can be carried out, starting with an axial compressor on the low pressure side followed by a centrifugal compressor casing or using only centrifugals according to customer preferences.

Qatargas II plant selected an all-centrifugal solution with the use of unprecedented casing sizes.

The large capacity and the reduction of the rotating speed from 3600 (FR7) to 3000 rpm (FR9), imposed an increase of impeller diameters from a typical size of 1300-1400 mm to 1600-1800 mm. The Florence shop of GE Nuovo Pignone is equipped to machine compressor casings with internal diameters up to 12.4 ft. (3800 mm), while new 5-axis milling machines can produce 3-D shrouded impellers having diameters exceeding 6.5 ft. (2000 mm) from a single forging.

GE Nuovo Pignone has used this technology to produce over 300 impellers, with dimensions at the beginning up to 2.9 ft. (900 mm) diameter, then up to 5.11 ft. (1.5 m) in a second step, and now up to 6.5 ft. (2 m). This innovative production system eliminates any welding and consequent stress-relieving heat treatment. In addition, the gas channels feature exact dimensions (no distortion) and have a very smooth surface finishing.

A bearing span in the order of 16.4 ft. (5 m) requires a shaft of suitable diameter on the bearings and end seals. Dry gas seals with internal diameters of 1.14 ft. (350 mm) needed to be qualified.

In order to limit the weight to be lifted on-site for maintenance purposes, the upper half of the diaphragm bundle is no longer fixed to the upper half of the horizontally split casing, as is common for smaller size machines. The top part of the outer shell is first lifted (which weighs about 80 tons) and then the upper part of the diaphragm bundle, which is kept in position by special keys, is lifted separately to give access to the rotor.

The compressor models presently in the production stage for the 7.8 million t/y Qatargas II plant at Ras Laffan are propane cycle 3MCL 1403 + MCL 1402; mixed refrigerant cycle MCL 1805 + 2BCL 1006; and nitrogen cycle MCL 1402 + BCL 1003

A full load testing program will be carried out before delivery of each individual compression string, which is scheduled before May 2006. ■

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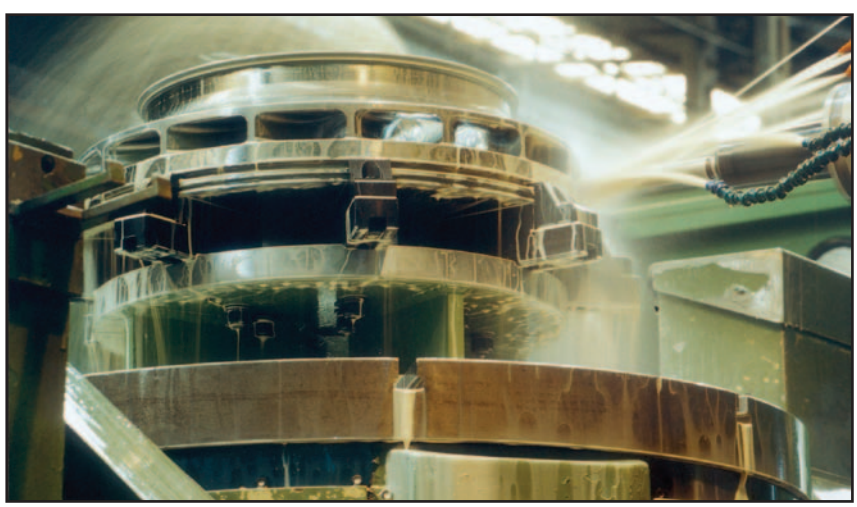

Shrouded impeller milled on a 5-axis machine from a single forging.