

# THE HYBRID AXIAL COMPRESSOR

MAN DIESEL & TURBO PARTNERS WITH MTU AERO ENGINES TO INCORPORATE GAS TURBINE TECHNOLOGY IN COMPRESSION EQUIPMENT FOR MEGA PLANTS

**M**AN Diesel & Turbo, Augsburg, Germany, and MTU Aero Engines, Munich, have completed preparations for the first test run of a new MAN axial compressor (Figure 1) at MTU's Munich test stand (Figure 2). This opens the way for the future deployment of a new generation of axial compressors that will help to make mega process plants economically viable.

With support from the German Federal Ministry of Economics and Technology, development teams from MAM Diesel & Turbo and MTU Aero Engines have worked together for three years to develop a new generation of axial compressors. This hybrid, which is based on industrial designs as well as compressor technology derived from stationary gas turbines and aircraft engines, targets mega processing plants worldwide. The hybrid compressor — with higher speed and fewer stage counts — will be used in future Air Separation Units (ASU) that are expected to have twice as much capacity as today's trains.

## Limits of scaling

ASUs represent a technically demanding and economically important application for turbocompressors. The engineering of air separation units is today increasingly influenced by the trends in the energy markets. Examples are synthesis gas-based processes for the production of high-quality fuels from gas (Gas To Liquids; GTL), coal (Coal To Liquids; CTL) or biomass (Biomass To Liquids; BTL), and processes for CO<sub>2</sub> capture and storage including Enhanced Oil Recovery (EOR).

ASU turbomachinery trains have a key role here as the air flow rates for downstream production of oxygen or nitrogen that can be achieved with current industrial compressor technology are barely sufficient for today's larger plants, says Kai Ziegler, Vice President Engineering Compressors, MAN Diesel & Turbo SE. In addition, the required discharge pressures are increasingly exceeding existing technological limits.

Some of the largest ASU machine trains ever built are currently being installed in the Pearl GTL plant in Qatar and the Escravos GTL plant in Nigeria.

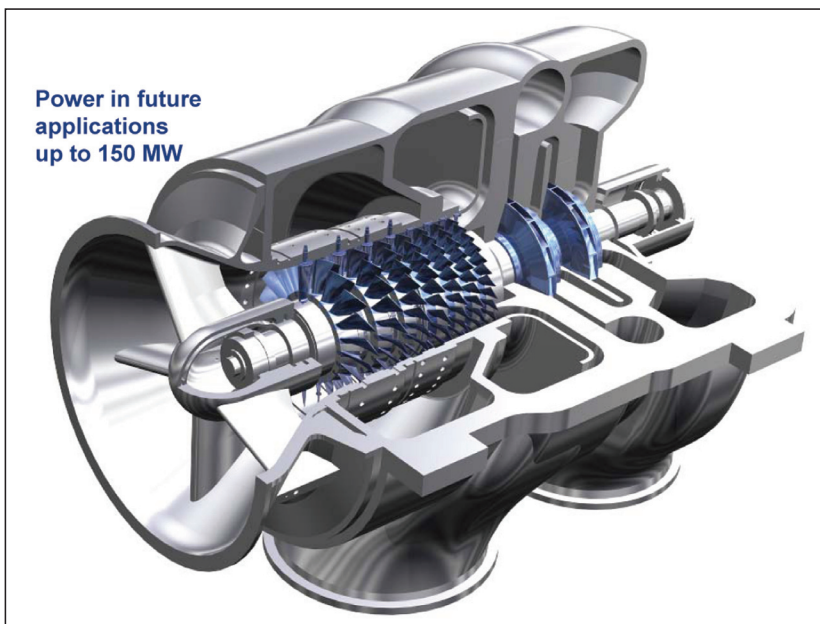


Figure 1: MAN Diesel & Turbo's new hybrid axial compressor

With an air intake flow of 700,000 m<sup>3</sup>/h, each individual air separation unit produces approximately 3,500 metric tons of oxygen per day. An ASU compressor train consists of a main and booster air compressor, both of which are powered by a shared 80 MW industrial steam turbine. The power requirement of the Main Air Compressor (MAC) is 55 MW, that of the booster air compressor is 25 MW. These machine trains have been developed and manufactured by MAN Diesel & Turbo.

MAN Diesel & Turbo SE is a leading provider of large-bore diesel engines and turbomachinery for marine and stationary applications. It designs two-stroke and four-stroke engines that are manufactured both by the company and by its licensees. The engines have power outputs ranging from 450 kW to 87 MW. MAN Diesel & Turbo also designs and manufactures gas turbines of up to 50 MW, steam turbines of up to 150 MW and compressors with volume flows of up to 1.5 million m<sup>3</sup>/h and pressures of up to 1,000 bar.

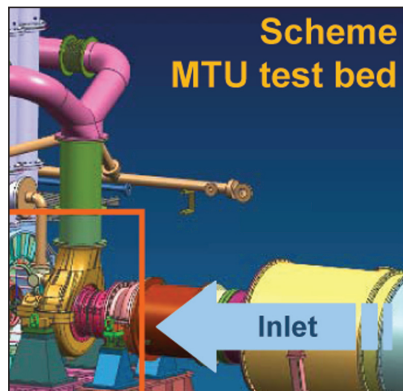
Meanwhile, in the Pearl GTL in Qatar, eight of these compressor trains will process 130 million m<sup>3</sup> of air per day

after commissioning in order to ensure the daily oxygen requirement of 28,000 tonnes for the GTL process. The necessary power input of 640 MW roughly corresponds to the average electricity requirements of a city of 700,000 inhabitants, including industrial, commercial and retail consumption.

Based on economies of scale, the medium-term planning for future GTL- and CTL-plants envisages oxygen requirements of 50,000 metric tons or more per day. These oxygen requirements will be met by compressor trains with corresponding air separation columns of 5,000 metric tons of oxygen per day in the next step, rising to 7,000 metric tons per day in a few years time.

In Carbon Capture and Storage (CCS), similar or even larger compressor trains are expected, driving supplier efforts toward larger ASUs that can deliver the required volume flows and pressure ratios. This primarily affects the MAC, which is today configured as a combined axial-centrifugal compressor.

The MAC of an ASU machine train must meet a wide range of operating requirements. Firstly, operation is influenced by the process requirements, plant



**Figure 2: Testing in December, 2010**

startup and overload operation. Secondly, consideration must be given to changes in intake temperature, air humidity and intake pressure in order to maintain process conditions. “Ultimately, the customer wants to be able to operate the equipment without interruption and extended outage intervals, which makes it important to allow some leeway for possible fouling of the compressor,” says Ziegler.

There are however limits to simple upscaling of the MAC. These include not only the rotordynamical feasibility of long rotors (at high pressures), but also the entire supply chain, starting

with raw part procurement through production, assembly and transport to handling at the plant and therefore mark the technological limits of conventional industrial axial compressors.

### **Leveraging gas turbines**

Compressors of stationary gas turbines and aircraft engines have significantly higher power densities compared to conventional industrial axial compressors, i.e., greater stage pressure ratios, higher speeds and fewer stages, says Ziegler. “However, gas turbine compressors are not suitable for industrial use for many reasons, e.g., they do not have the necessary operating range, the efficiency levels are too low and they do not have the necessary robustness and flexibility in terms of flow rates or pressure ratios. In addition, gas turbine compressors have a limited speed range of normally 95% - 105%, which does not meet the required API standards.”

To solve this problem, the R&D department at MAN Diesel & Turbo has taken a new approach. Without relinquishing the benefits of current industrial compressors, e.g. robustness, efficiency and operating range, the advantages of gas turbine compressor technology have also been implemented with a new type of blading — a hybrid based on proven

industrial design and gas turbine design.

Three years ago, MAN Diesel & Turbo entered into an agreement with aircraft engine specialist MTU Aero Engines, for the joint realization of this hybrid concept. The development of an industrial axial compressor in collaboration with a development partner from the aero engine sector is a novel approach, observers say.

During the concept phase, all variables had been investigated in order to ensure optimal compressor design. Comprehensive matrix studies had also been carried out in all areas of the design taking into account all aspects, e.g., aerodynamics, mechanics, rotor dynamics, production, costs and so on, in order to ascertain the overall optimum for the new hybrid generation. The prototype of this hybrid axial compressor, called MAX1 is ready for testing at MTU’s test stands in Munich.

MAX1’s speed is about 1/3 higher than its predecessors. This results not only in a reduction of stage count (around 1/3 fewer) and weight and cost savings in the axial compressor, but also in a rise in power density in the steam turbine drive, says Ziegler. Following the conclusion of the first test programs at the MTU test stands towards the end of this year the new hybrid compressor will be released for sale. **TI**