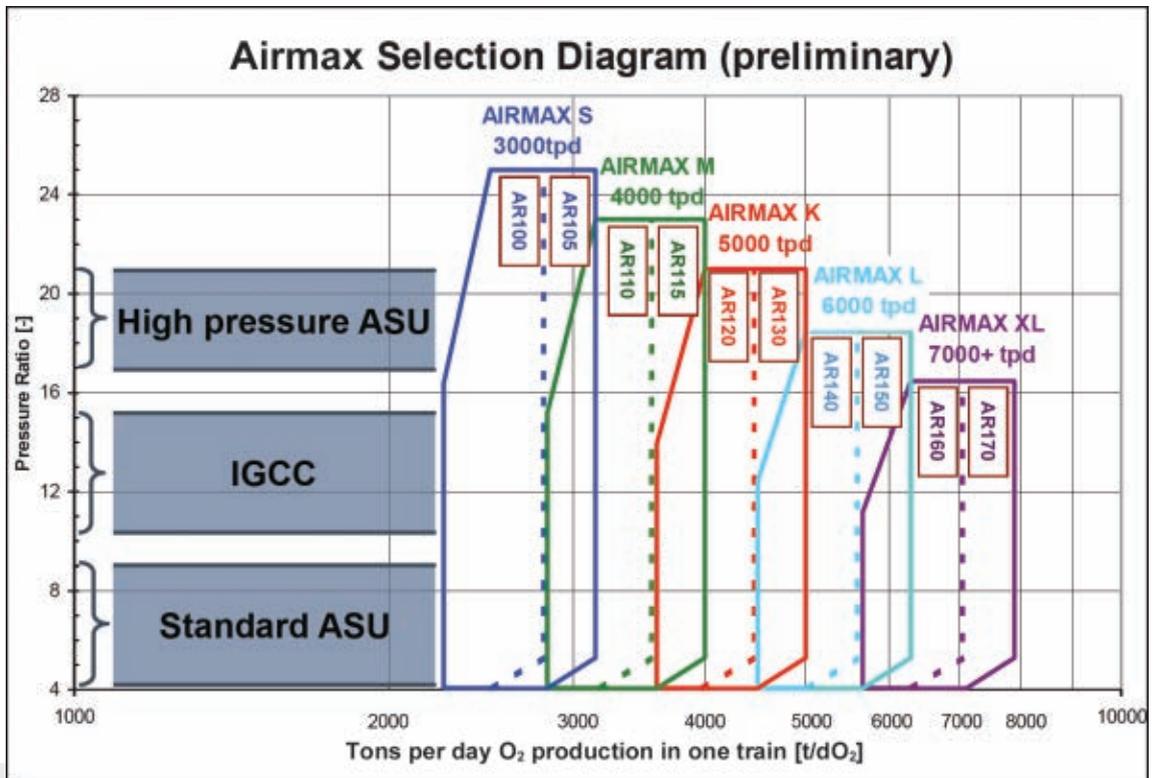


# Airmax Compressor Train Modularization

MAN reduces size, cost of ASU compressor train systems with new blading

BY ROBERTO CHELLINI



MAN's Airmax line can be used in a range of industrial applications.

The Max1 axial flow compressor blading was jointly developed by MAN Diesel & Turbo and MTU Aero Engines so as to combine the advanced design techniques used in the aero-engine field with the ruggedness needed for industrial machines.

MAN is a suppliers of compressors for Air Separation Units (ASUs), which are constantly growing bigger to cover the needs of larger gas-to-liquids, coal-to-chemicals, carbon capture and storage, and other projects (see *COMPRESSORtech*<sup>2</sup>, August-September 2010, p. 28).

ASUs up to 3307 to 3858 tpd (3000 to 3500 T/d) of oxygen can be served by conventional type radial or axial/

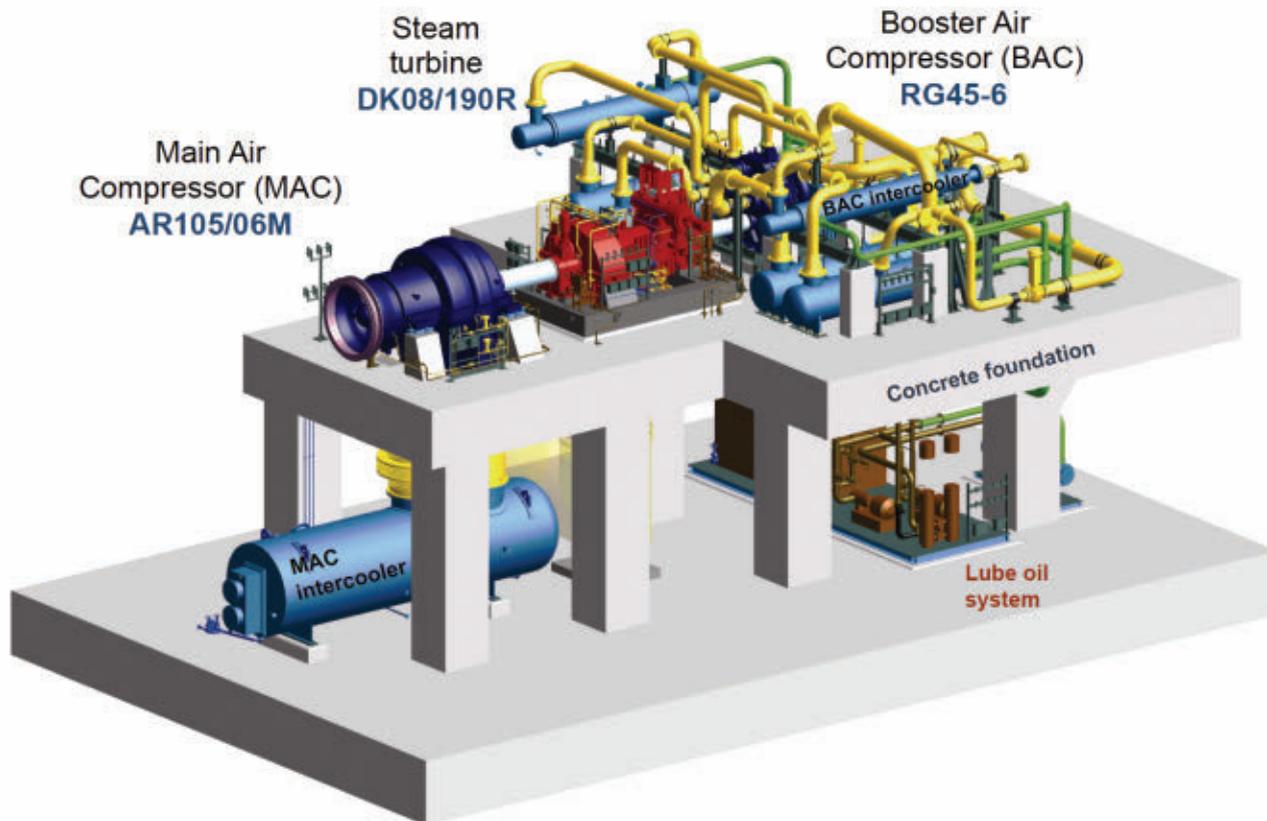
radial compressors used in the first compressor stage, the "main air compressor" (MAC), with flows of approximately 23 MMcfh (650,000 m<sup>3</sup>/hr). For bigger sizes, conventional compressors become so large that problems arise, mainly regarding cost-effectiveness and transportation.

The Airmax train contains an axial/radial MAC with Max1 blading (AR-Max1), which features higher rotating speeds (and higher blade tip speeds). With its reduced size it can handle flows up to 53 MMcfh (1.5 million m<sup>3</sup>/hr) or higher to serve plants with oxygen production rates up to 7716 tpd (7000 T/d), or 8818 tpd (8000 T/d) should the market require it.

The great majority of ASU is designed to work with compressed air at final pressures between 650 and 940 psi (45 and 65 bar). These plants feature a MAC that delivers the air to the booster (in-line or integrally geared compressor) at around 94 psi (6.5 bar). For high pressure ASUs the MAC has to deliver the air at 200 to 300 psi (14 to 21 bar), which MAN can deliver.

The Airmax air compressor train has been scaled to cover ASU plants in the range from 2756 to 8818 tpd (2500 to 8000 T/d) of oxygen.

In the lower range, the use of an Airmax train overlaps the conventional design, but already in this region it



■ The Airmax S standard compressor train was developed for air separation units.

becomes cost effective and also improves the overall plant efficiency.

In fact, its higher rotating speed not only is leading to a smaller and lighter MAC (at unchanged MAC power compared to a conventional unit) but also benefits the steam turbine driver, which rotates at a higher speed and therefore becomes smaller in size and gains approximately one point in efficiency.

To reach the discharge pressure of 94 psi (6.5 bar) the AR-Max1 needs only six axial stages followed by one radial stage placed back-to-back at the end of the same rotor, but after the air is run through an intercooler. This compares with the conventional AR design with eight axial stages and two radial stages.

The reliability of MAN axial flow compressors has been demonstrated by the 1000 units built so far and in operation for many years.

Smaller overall dimensions, reduced bearing span, a very stiff solid rotor, very robust wide chord blades and a

standardization of the whole train make the AR-Max1 and Airmax trains even more reliable than their predecessors.

Rotordynamic analysis was conducted using a SR3 program while bearing stiffness and damping coefficients were computed using the ALP3T program. All rotordynamic requirements comply with API 617 7<sup>th</sup> edition specifications.

A testing program has ascertained that all components comply with the most severe safety standards. Blade stresses, also under surge conditions, are well below safety standards.

Tests have demonstrated that the Max1 blades could pass through a very high number of surges without any blade damage. Nevertheless, in practice surge has to be avoided not to damage other components of the compression system (intercoolers, air intake filter, piping, valves, etc.).

The booster compressor has been for years either a standard integrally geared booster or an in-line compressor of the barrel type. However, in order to reduce power consumption, the Air-

max train now comprises an integrally geared compressor as a standard booster that, thanks to a nearly isothermal compression, can lower energy consumption significantly.

MAN integrally geared boosters are available for ASU sizes up to 7716 tpd (7000 T/d) of oxygen or larger. This compressor line is built by MAN at its Berlin plant.

The Airmax S train (S for small) is the smallest standardized MAX1 train and covers the ASU plant size from 2756 to 3307 tpd (2500 to 3000 T/d) of oxygen. The size S is covered by an AR 100/06M (in the lower range) or an AR 105/06M MAC.

The AR 105/06M in its standard design point features six axial stages followed, after the intercooler, by one radial stage featuring a 3-D shrouded type impeller, to deliver the air at a pressure ratio of 6.7.

The compressor has a capacity of 19.8 MMcfh (560,000 m<sup>3</sup>/hr) and absorbs 51,200 hp (38.2 MW) supplied

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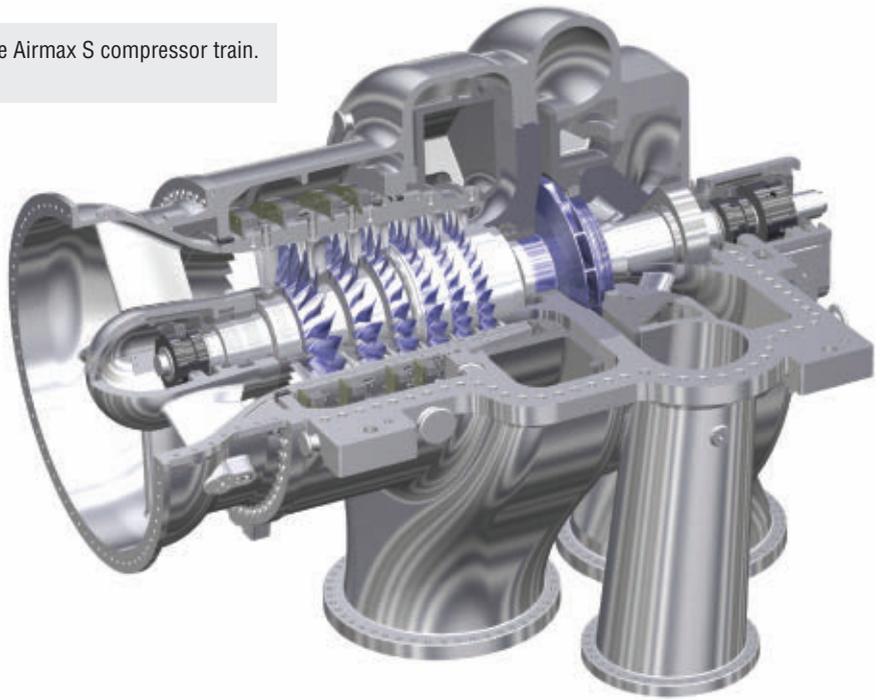
■ MAN's AR105/06M is used in the Airmax S compressor train.

by a DK080/190R steam turbine which is directly coupled, at 4754 rpm, on the exhaust side of its shaft, while on the high pressure shaft end the steam turbine shaft is connected to a pinion shaft of the integrally geared booster compressor.

Capacity control is achieved by four rows of variable guide vanes of the MAC and variable inlet guide vanes of the booster compressor.

MAN is building four units at Oberhausen, Germany, for shipment to China by sea. To reach the installation site in the "coal triangle" near Inner Mongolia, it is necessary to go through toll gates that require a package size lower than 14.7 ft. (4.5 m) in width and 14.4 ft. (4.4 m) in height.

In spite of the large capacity of such plants, all the MAN machinery of the Airmax S compressor train can reach this package size fully assembled with savings in trans-



portation and final erection costs.

The Airmax line of compressor systems comprises five different sizes up to the Airmax XL designed for production of 7716 or 8818 tpd (7000 or 8000 T/d) of oxygen.

MAN implemented the Airmax project to serve the needs of jumbo plants. The products also have demonstrated their applicability to plants that one time were considered large but now have become "standard." CT2

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