Integrally geared pipeline compressors for high pressure application

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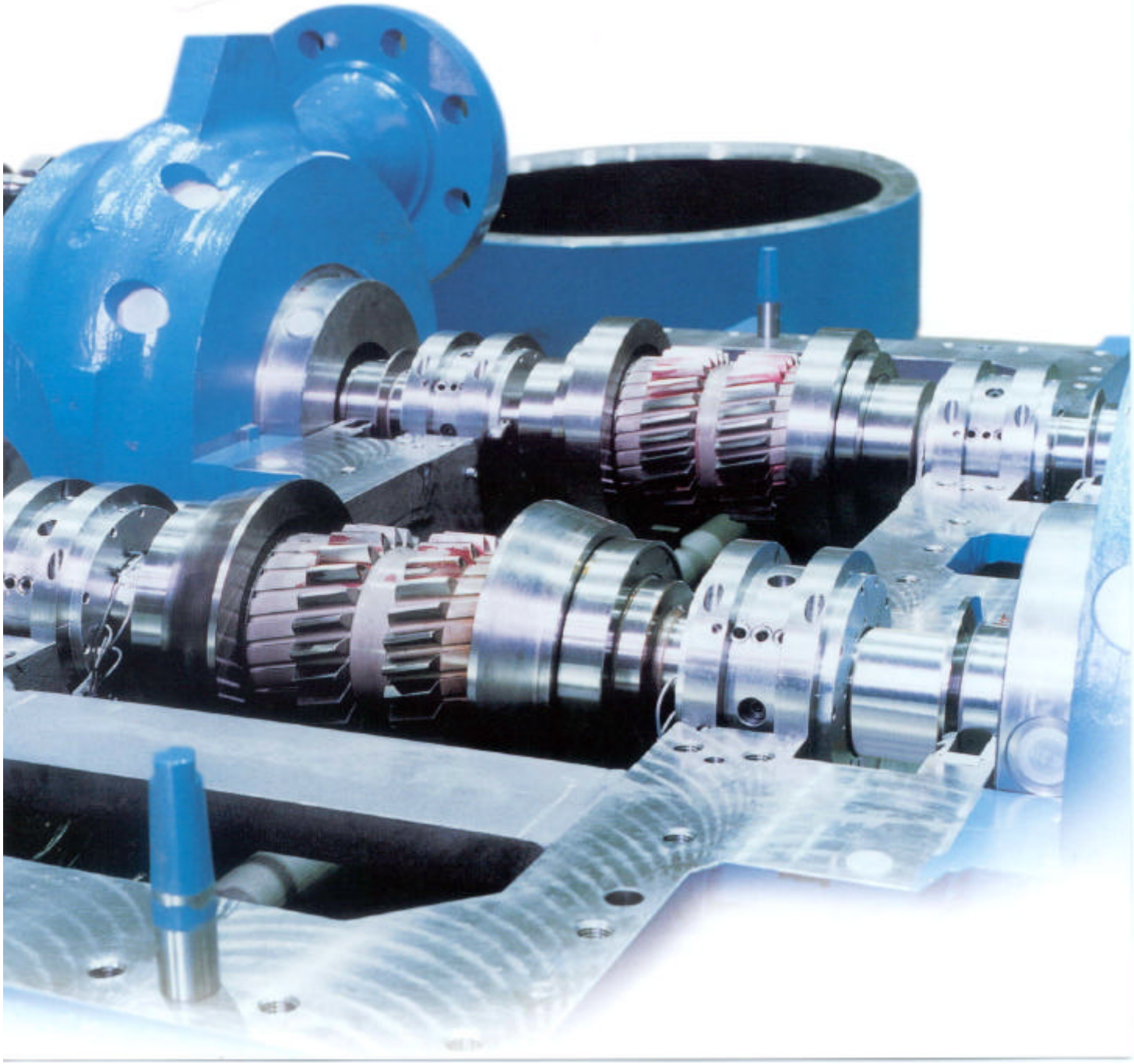
MAN TURBO



Integrally geared pipeline compressor for high pressure application; Delivery of high pressure CO_2 gas in a supply pipeline for enhanced oil recovery without any booster station

First integrally geared compressor for high pressure application

In 1995 MAN GHH BORSIG received an order for a 200 bar discharge CO_2 compressor for Russia. This compressor was successfully tested and delivered as the first integrally geared compressor with 10 stages for high pressure application. (please refer to our brouchure: World premiere; First 10-stage integrally-geared compressor).

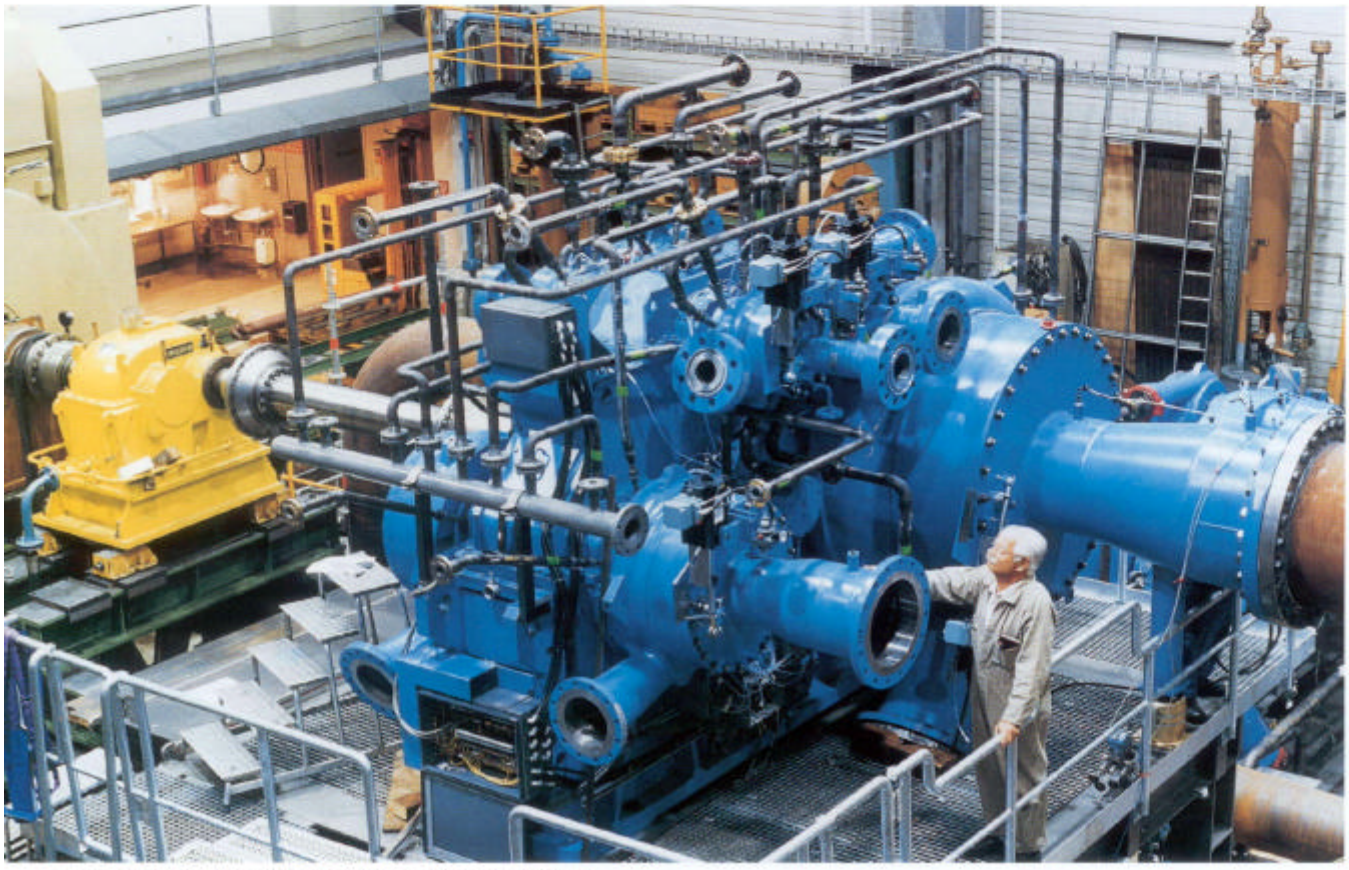
Integrally geared pipeline compressor

With above experience, MAN GHH BORSIG quoted in the end of 1997 the integrally geared design for a pipeline application, also for carbon dioxide, as the gas to be transported. This quote was in competition to beam type compressors with 2 or 3 casings and about 14 - 17 impellers, traditionally used as pipeline compressors.

Compressor Duty

Requested was a compressor to feed CO_2 in the front end station of a coal gasification plant in North Dakota/ USA. The pipeline routes from North Dakota over the canadian boarder to Saskatchewan oil fields, where the CO_2 is injected into oil wells for enhanced oil recovery. The total length of this 14 inch pipeline is 205 miles. There are no booster stations foreseen in between or at destination. The CO_2 gas is injected into the oil well directly out of the pipeline, what requires a quite high pressure at start.

Technical Data (per compressor unit):		
Suction Pressure	1,1	bar
Discharge Pressure	187	bar
Power at Coupling	13,200	kW
Mass flow	123,000	kg/h
Pinion Speeds, No.1 pinion shaft	7,000	min^{-1}
No. 4 pinion shaft	26,000	min^{-1}



Compressor Unit during test run in MAN GHH BORSIG test bed

Enhanced Oil Recovery (EOR)

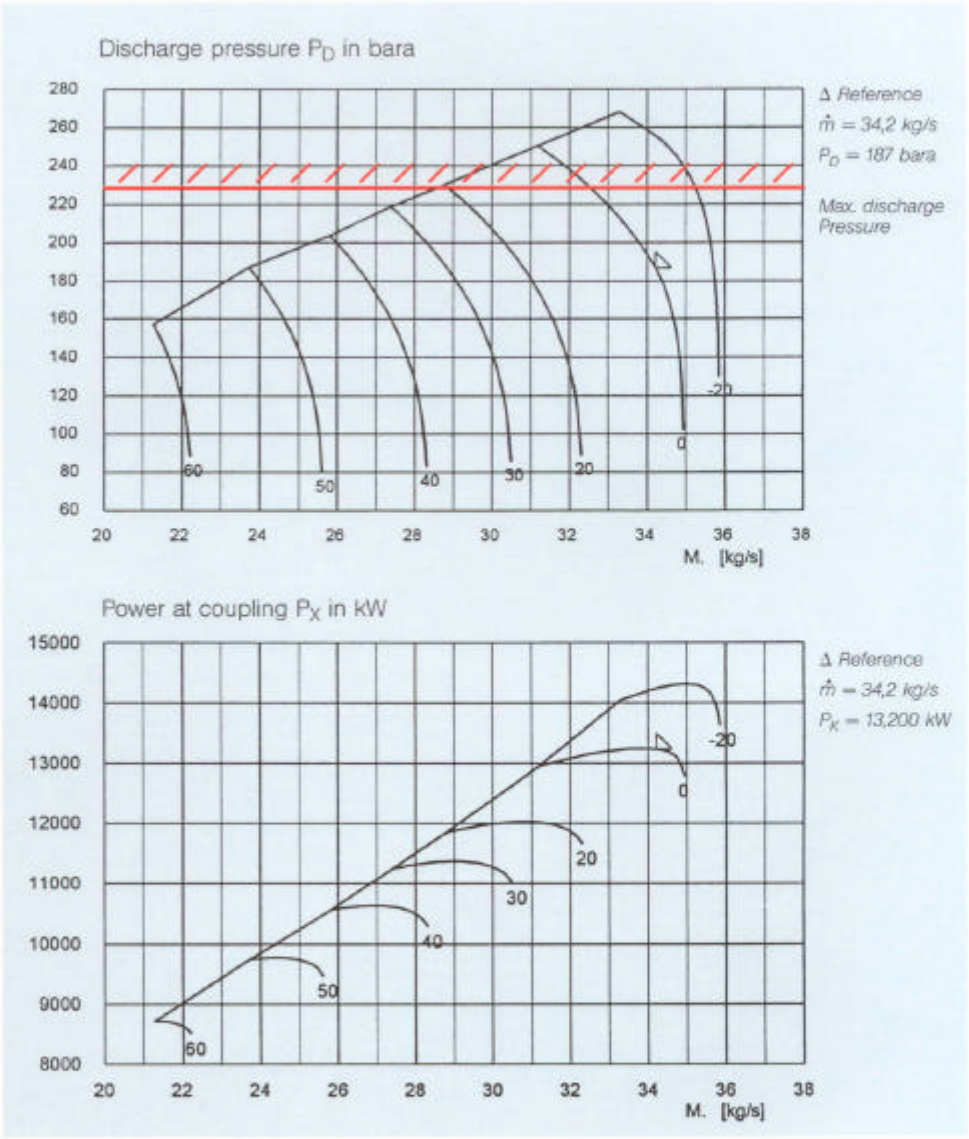
EOR is, simplified spoken, the mixing of crude oil and CO_2 down in the wellbore. Under certain pressure and time the crude oil swells and reduces viscosity, allowing a greater percentage of the hydrocarbons trapped in the well pore volume to be recovered. In reality, EOR is much more complex, but pays back and extends the economic life of an oil reservoir.

Order in April 1998; Codeword: DACOPIPE

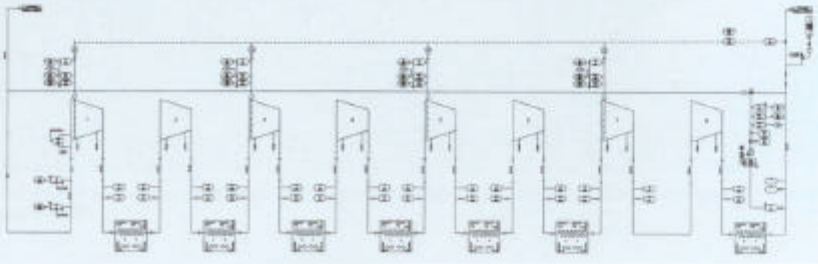
MAN GHH BORSIG received the order on two identical compressor units, type RG 080/08-L4, in April 1998 from Dakota Gasification Company, North Dakota/ USA. The compression with below parameters is effected with 8 radial impellers and 6 air cooled intercoolers up to a pressure of approx. 190 bar absolute. The order consisited of the compressor units including the multi shaft gear, the special developed multi chamber carbon ring shaft sealing, the synchron drive motors, the lube oil systems and the complete monitoring of both units with anti surge control, load sharing and intercooler control via MAN GHH BORSIG control system Turbolog. The air cooled intercoolers and aftercoolers together with the interconnecting piping was in the scope of the client.

All compressor material in contact with process gas is in compliance to NACE criteria due to the H_2S content in the process gas. The compressor volutes as well as the intercoolers and the interconnecting piping are of black material because of dry carbon dioxide with no measureable content of water.

The units are shipped in July



Measured performance map of integrally geared CO_2 compressor



Schematical arrangement of compressor stages and intercooler

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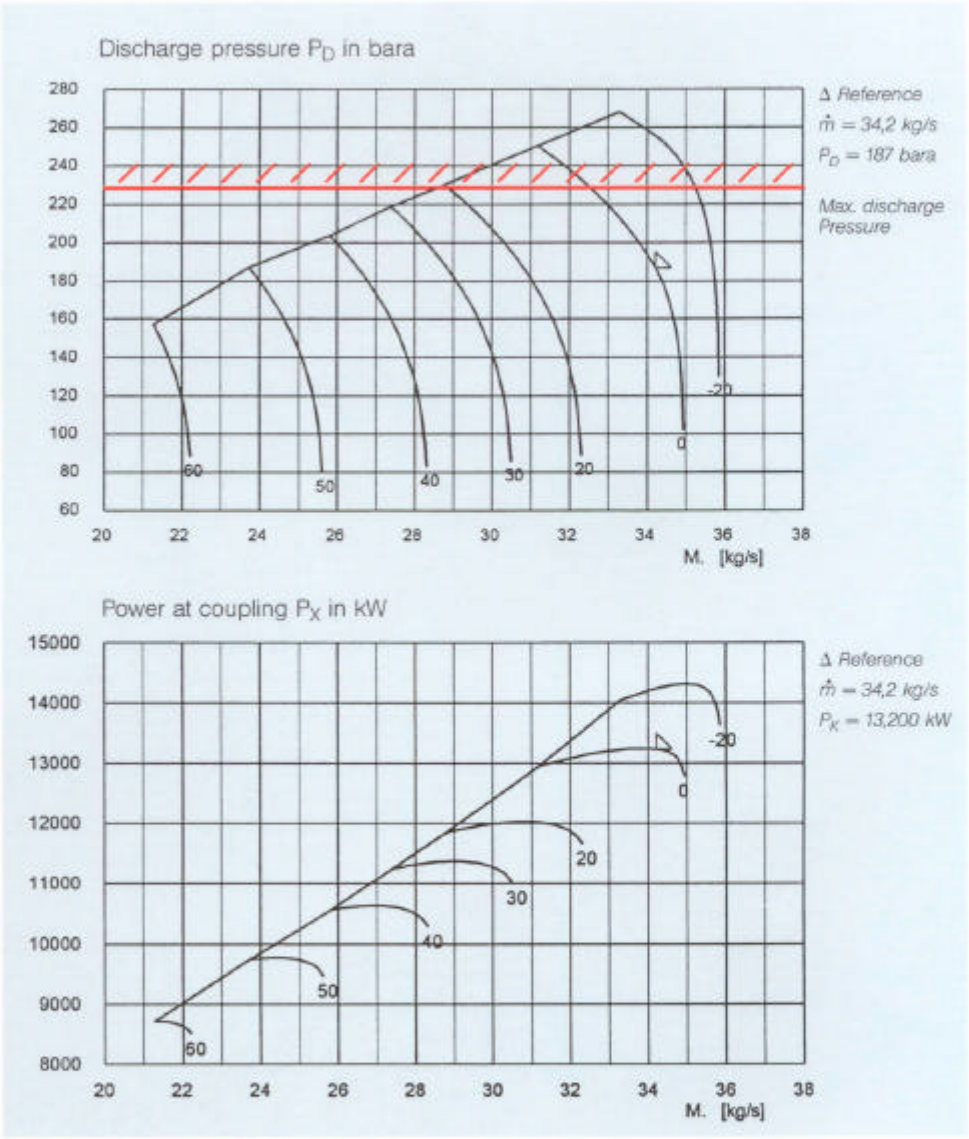

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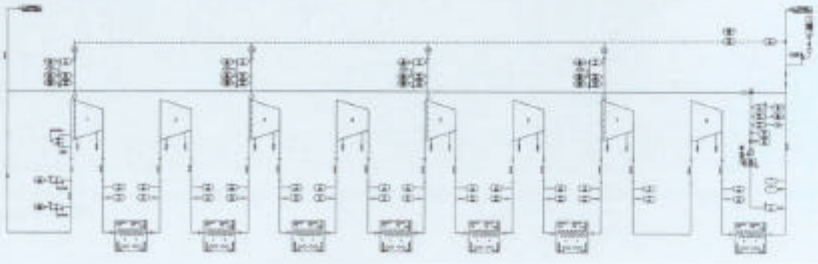

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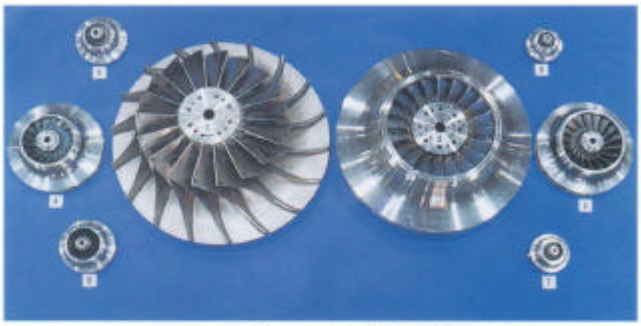
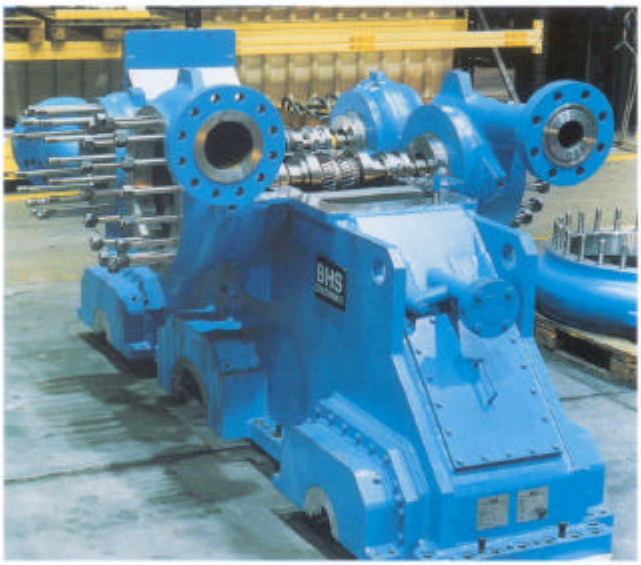


Impeller arrangement from 840 mm (1. stage) to 145 mm (8. stage)



New gear concept with two horizontal splits ensures excellent maintainability

1999 and are to be commissioned in early year 2000. The compressors are successfully performance tested in the MAN GHH BORSIG workshop in Berlin with original carbon dioxide gas. The final performance and accepance test is agreed to take place with original air cooled interstage and aftercoolers at site in North Dakota. As visible in the performance maps, the turndown flexibility of this compressor is much better that of beam type compressors for compareable applications.

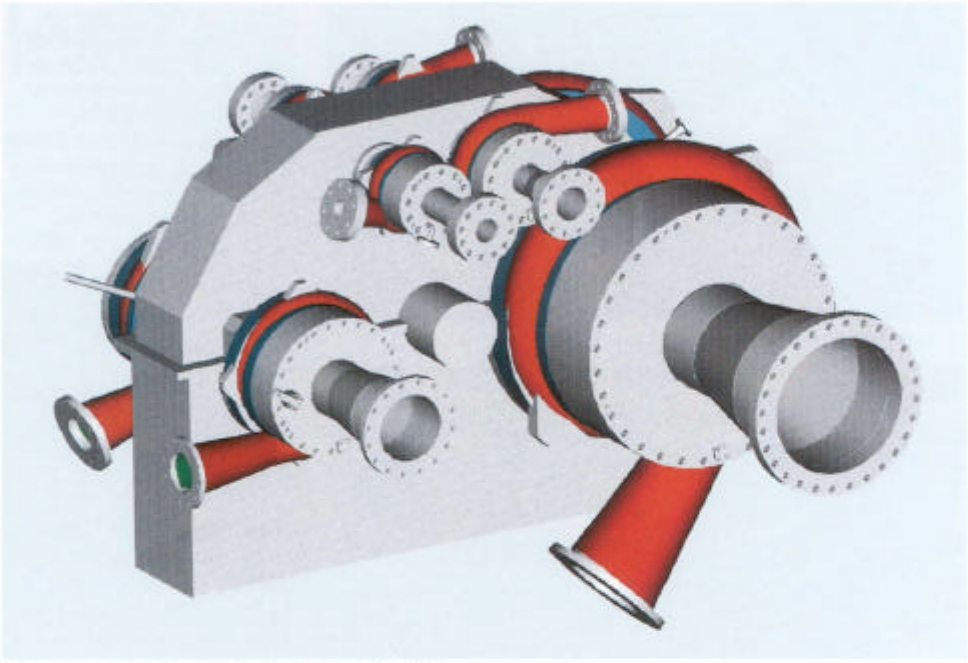
Main merits over previous compressor concepts

The gear type compressor offers major advantages in comparison to conventional centrifugal beam type compressors. These are:

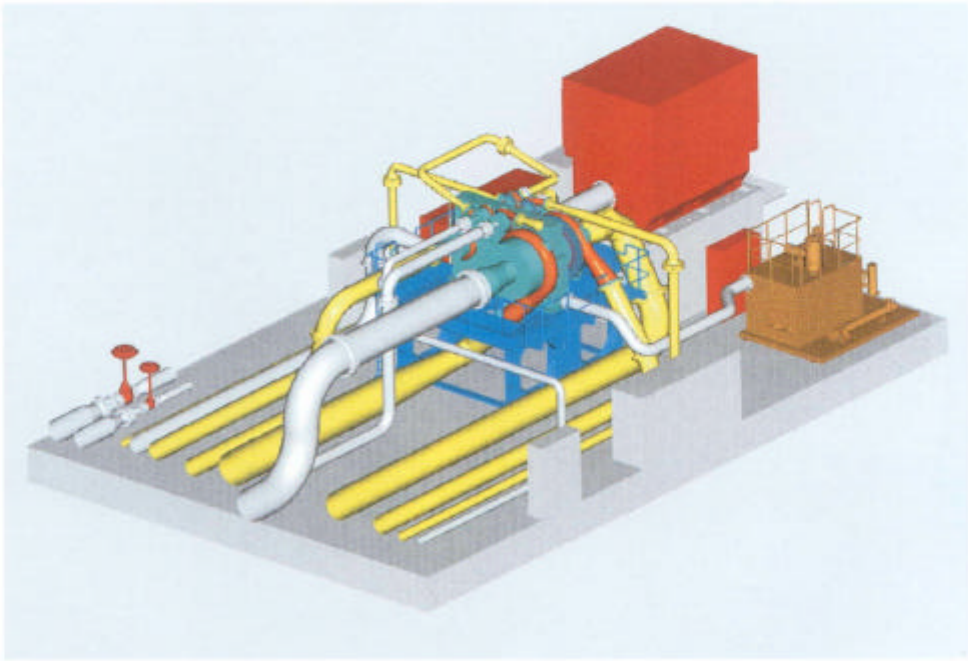
- Peak efficiences through optimized speed adjustment, axial intake of each stage, and intercooling after each stage
- Tip speeds, which owing to the machine design, permit the number of stages to be reduced
- Higher operation flexibility, by inlet guide vane control
- Reduced construction volumes, so that machine house can become smaller
- Much lower investment cost

Outview

MAN GHH BORSIG is able to offer a sound solution with the new developed integrally geared compressor design. This design is not only limited to carbon dioxide application, much higher compression ratios than with standard beam type compressors can be achieved for nearly all other gases too, by improving the efficiency and reducing investment cost at the same time. MAN GHH BORSIG is leading the trend to deliver more an more process gas compressors as integrally geared units. Due to experiences with all kind of direct drivers, like gasturbines, steamturbines, expansion turbines and electric motors, MAN GHH BORSIG is able to serve all processes with this advanced design.



3-D computer model showing arrangement of volutes



3-D computer model showing compressor, drive motor and lube oil system with interconnecting pipe arrangement to remote intercooler

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