

# 10-stage integrally-geared compressor for urea synthesis processes



MAN TURBO AG



## World première:

10-stage integrally geared compressor for use as a syngas compressor in a urea process

Pressure ratio:  
from 1 bar to 200 bar

In 1995, MAN TURBO AG received the order from Messrs Azot in Novomoskovsk (Russia) to build a gear-type compressor with 200 bar discharge pressure for fertilizer production as part of a factory with a daily urea output of 1,100 tons. Featuring five pinion shafts, the gear compressor is of a completely new conceptual design.

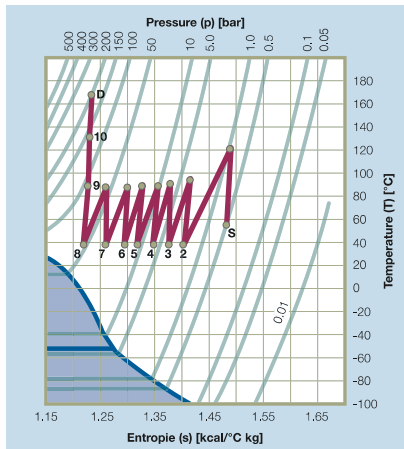
The gear compressor was successfully commissioned and the customer is very satisfied with the unit. Shaft vibrations and bearing temperatures are within the admissible limits.

### The urea synthesis process

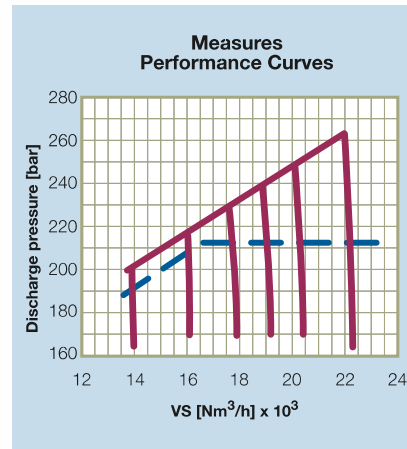
When used in urea synthesis processes, the compressor is required to raise the pressure of carbon dioxide (CO<sub>2</sub>) from 1 bar to 200 bar.

The feedstock for urea synthesis is carbon dioxide (CO<sub>2</sub>) and ammonia (NH<sub>3</sub>), which in advanced processes react at a pressure between 160 and 220 bar.

CO<sub>2</sub> compression is normally effected in two- or even three-casing centrifugal compressors of single-shaft design. When compared to multi-shaft machinery, these have major disadvantages. Therefore, a 10-stage integrally-gear compressor is used for this process at Novomoskovsk, replacing the reciprocating machines.



1 The 10-stage compression process shown in the T-s diagram



2 Performance map of the 10-stage integrally geared compressor

• Discharge pressure	>200 bar
• Intake pressure	1 bar
• Density in 10th stage	approx. 320 kg/m <sup>3</sup>
• Power rating	approx. 4.6 MW
• Intake volume flow	23,475 m <sup>3</sup> /h
• Drive speed	1,491 rpm
• Pinion speeds: No. 1 pinion shaft	11,000 rpm
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...	
...	
No. 5 pinion shaft	50,000 rpm

### Main merits over previous compressor concept

The gear type of compressor offers major advantages in comparison with conventional centrifugal single-shaft compressors.

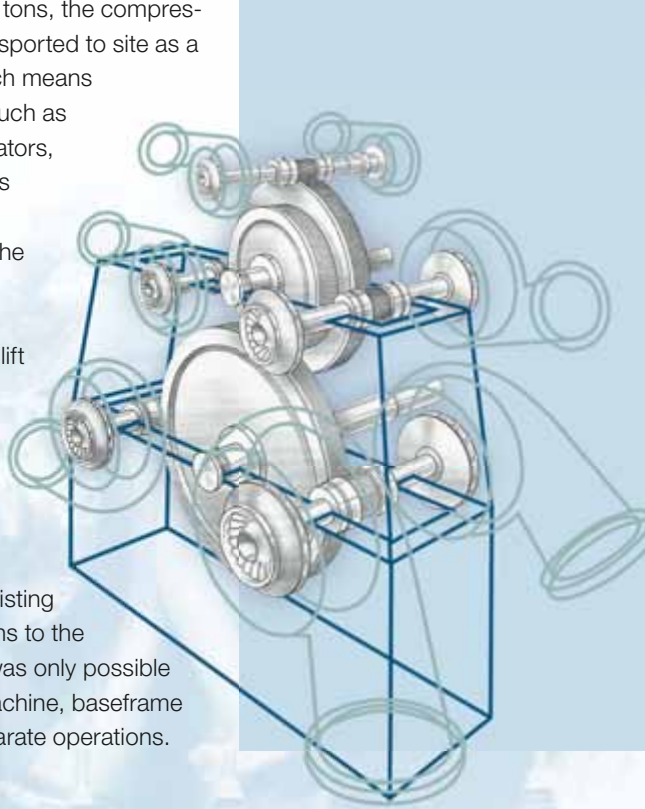
### These are:

- Peak efficiencies through optimized speed adjustment, axial-intake of each stage, and inter-cooling after each stage
- Tip speeds which owing to the machine design permit the number of stages to be reduced
- Operating regimes possible for flexible operation thanks to inlet guide vane control
- Reduced construction volumes, so that the machine house can be of a smaller size
- Much more lower capital outlay.

## Compressor unit “as-built”

Weighing some 90 tons, the compressor set can be transported to site as a Package Unit, which means that all ancillaries such as gas coolers, separators, oil console, process piping, valves, etc. are located inside the steel baseframe confines to provide a packaged single-lift unit.

A different approach was however chosen in this special case, where in view of existing transport restrictions to the customer's site it was only possible to transport the machine, baseframe and coolers in separate operations.



**3** Development of the integrally geared compressor 1995



**4** Bull gear with double modulus

The compressor of type RG 053/10 consists of 10 stages with radial impellers and their volutes. Sealing between the compressor stages and the gear case is by means of carbon rings. The necessary drive power is provided by an electric motor.

Some technical features of the compressor should be highlighted:

- The gear unit comprises two integrated bull gears with double modulus (patent granted).
- The impellers of stages No. 7 to 10 are made from titanium and will be made by precision casting (patent granted).
- The 4th and 5th pinion shafts rotate near the 3rd natural mode. For this, a completely new process for high-speed balancing has been developed.
- Specific components have also been developed in the shaft seals for rotor-dynamic stabilization of the pinion shafts, in particular in the high-pressure stages.



**5** Compressor in the field during Class I test



**6** Compressor with complete cooling system in the assembling bay at our Berlin works

**MAN TURBO AG**

Steinbrinkstrasse 1  
46145 Oberhausen / Germany  
Phone +49. 208. 6 92-01  
Fax +49. 208. 6 92-20 19  
[www.manturbo.com](http://www.manturbo.com)

**MAN TURBO AG**

Egellsstrasse 21  
13507 Berlin / Germany  
Phone +49. 30. 440 402-0  
Fax +49. 30. 440 402-2000

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**MAN TURBO AG Schweiz**

Hardstrasse 319  
8005 Zurich / Switzerland  
Phone +41. 44. 278-22 11  
Fax +41. 44. 278-29 89

**MAN TURBO S.r.l. De Pretto**

Via Daniele Manin 16/18  
36015 Schio (VI) / Italy  
Phone +39. 0445. 6 91-5 11  
Fax +39. 0445. 5 11-1 38

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