RENK MAAG

Innovative Power Transmission

RENK-MAAG

Vacuum gearbox HET Gear®

Worth a mint in just a short time!

Vacuum gearbox HET Gear® – world's most efficient turbo gear

The RENK-MAAG HET Gear® (High Efficiency Turbo Gear) is based on the proven RENK-MAAG turbo gearbox. Solely the fact that the case-hardened rotors can rotate in an inner casing in a vacuum permits higher efficiency. The RENK-MAAG HET Gear® understands everything in the range of 15 to 120 MW!

The HET Gear® is impressive in new plants or as a retrofit

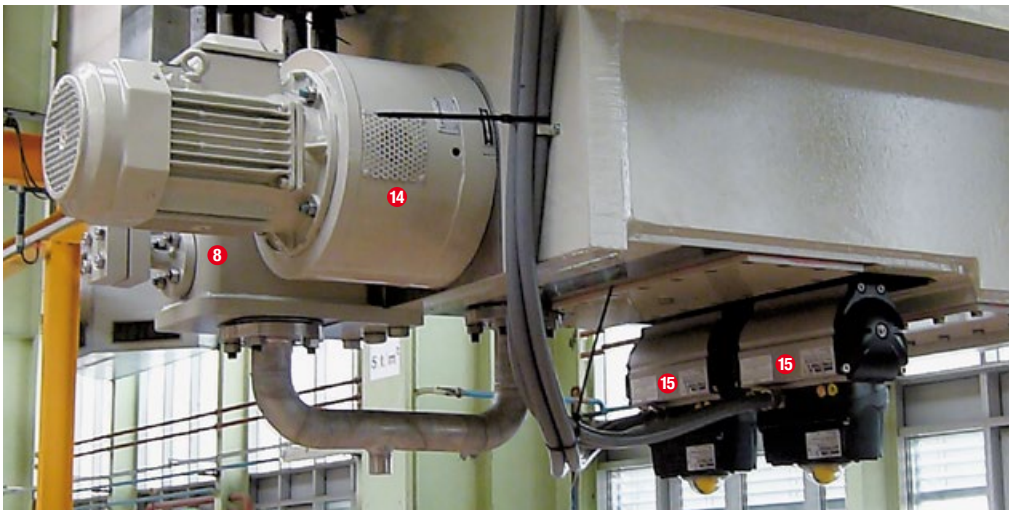
Applications

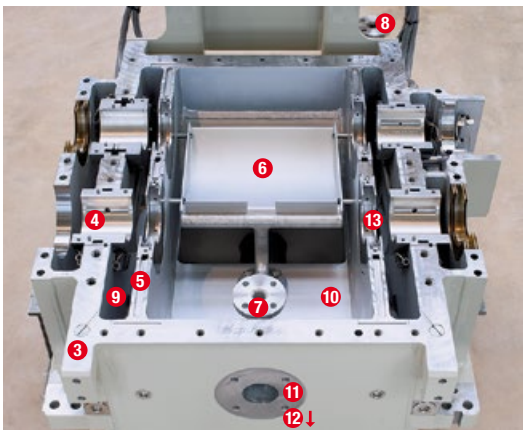
- Power generation
- Compressor drives
- Energy recovery, combined cycle technologies, cogeneration and others

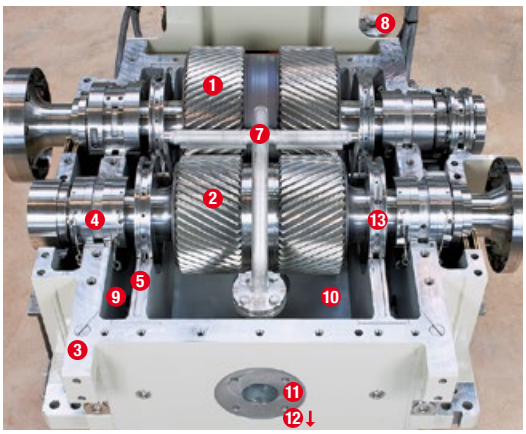
The turbo vacuum gearbox was developed specifically for use in energy recovery and to drive compressors. The primary goal: reducing the gearbox power loss (50% less power loss than with a standard gearbox at the same performance).

RENK-MAAG makes the same guarantees for a HET Gear® as for a standard turbo gearbox because:

- the design of the HET Gear® is based on the proven RENK-MAAG gearbox technology;
- all gearbox components are manufactured in the same manner as the standard gearboxes and must meet the same quality standards;
- all additionally needed elements such as built-on pump and vacuum safety valves are checked for reliability before use;
- the availability of the HET Gear® is equal to or greater than that of the standard turbo gearbox.

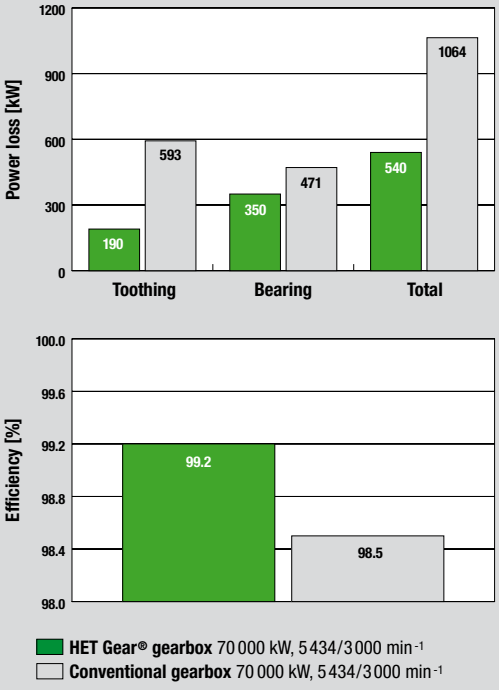


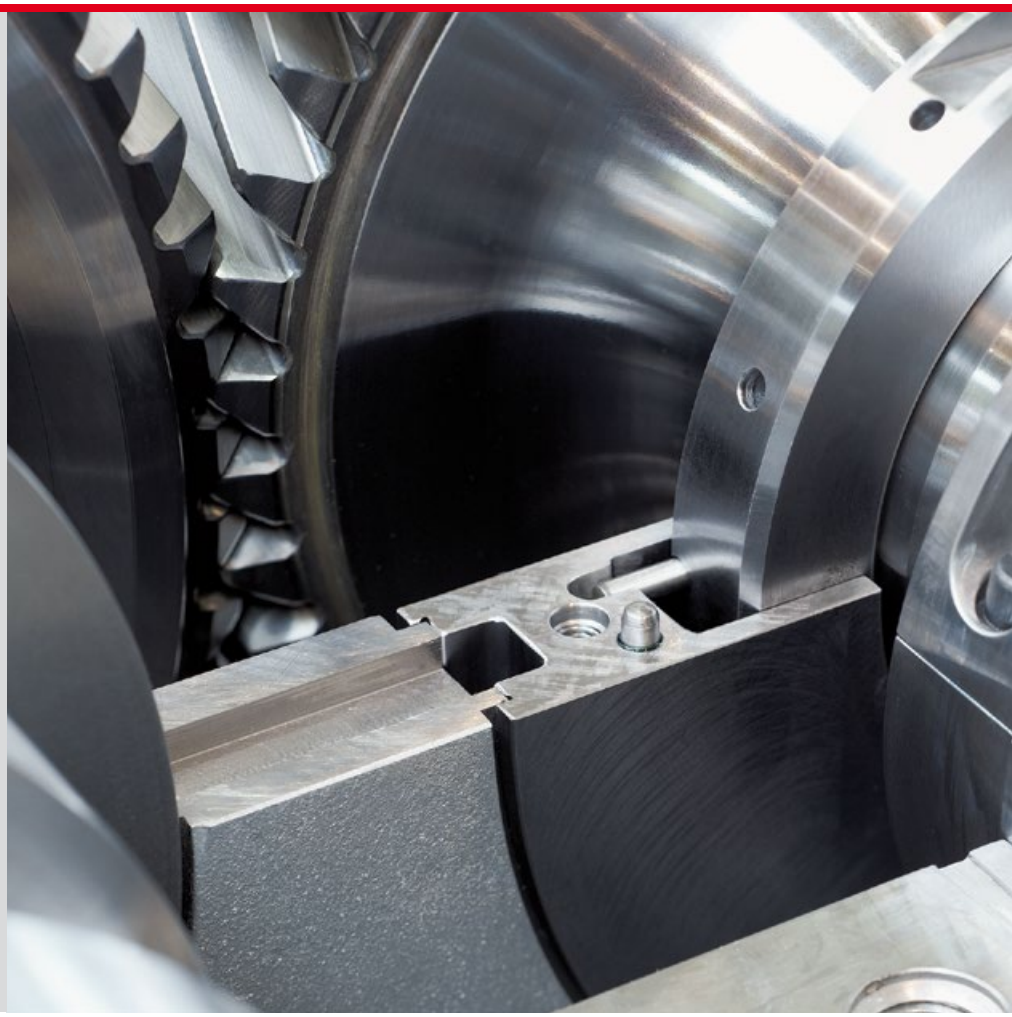




1 Wheel
2 Pinion
3 Gearbox casing
4 Radial bearing/tilting pad bearing
5 Vacuum casing
6 Oil pan
7 Spray bar
8 Oil level monitoring
9 Gearbox interior (normal pressure)
10 Vacuum interior (rough vacuum)
11 Oil inlet
12 Oil outlet
13 Floating ring
14 Vacuum pump
15 Butterfly valves

The design of the HET Gear® is patented by RENK-MAAG GmbH.





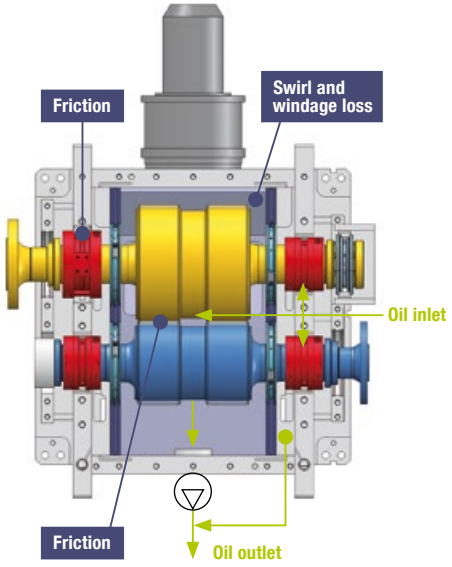
Approximately 55% of the total losses occur at the toothing, and 45% is caused in the slide bearings. The majority of the toothing losses, namely 80% or more, is caused by aerodynamic effects known as “windage” (air resistance losses), and only 20% or less are caused by friction in the toothing under load.

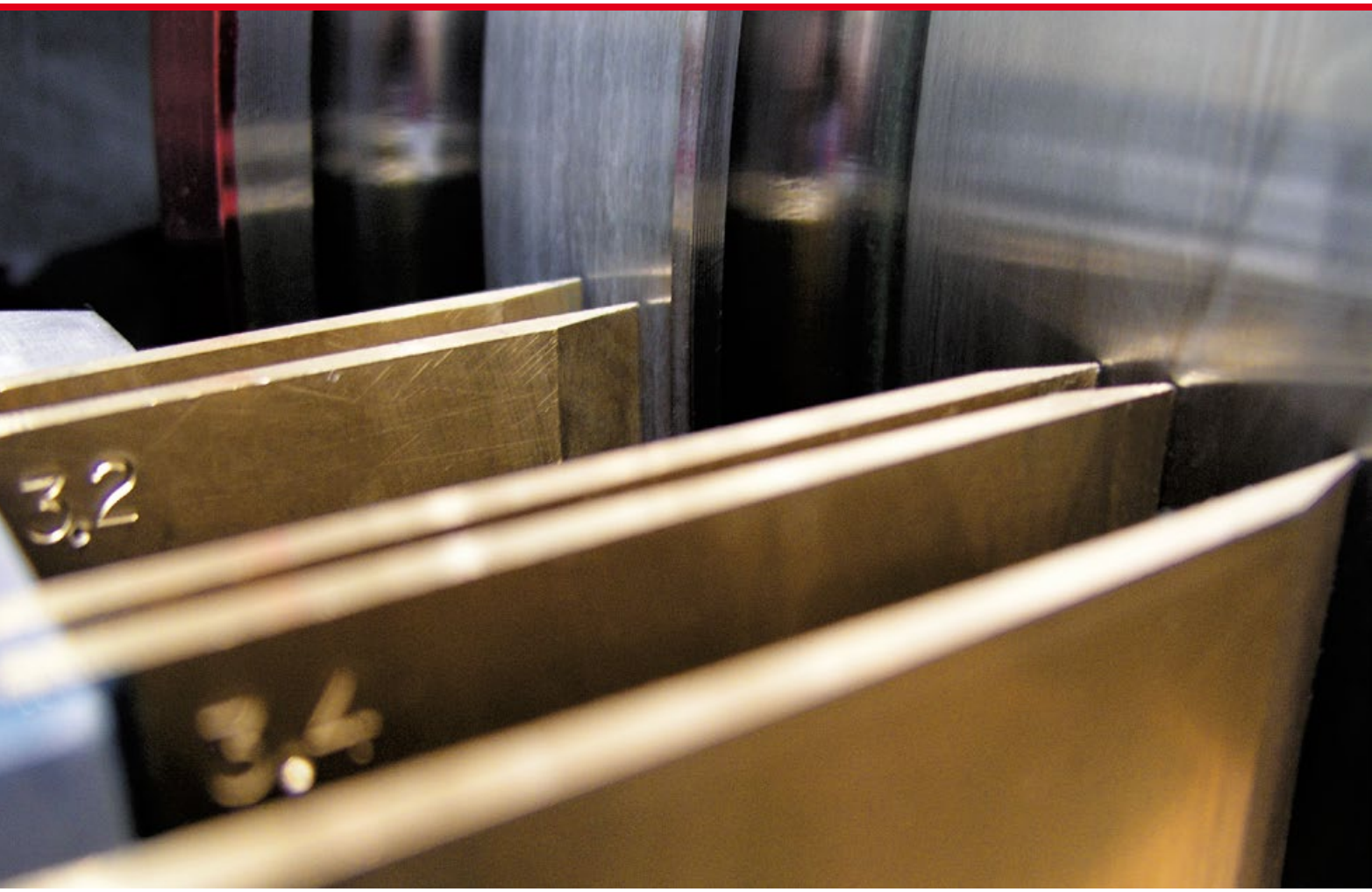
The requirements on the construction of a vacuum gearbox are both simple and logical at the same time: Remove as much as possible from the media causing the windage.

- On the one hand, since this medium is air, it must be removed from the space around the rotating parts of the gearbox.
- On the other hand, the oil flow to the toothing must be reduced to the minimum required (good lubrication and cooling remain guaranteed).

A HET Gear® can operate in two ways dependent upon requirements: either as a conventional turbo gearbox or as a HET Gear®, where a vacuum is generated in which the toothed wheels rotate, thereby significantly reducing windage losses.

On the HET Gear®, crushing and air flow losses are reduced to a minimum. Accordingly, the entire gearbox runs at a lower temperature and the amount of oil required drops. This results in smaller cooling and pumping systems and a reduction in size of the entire plant, saving train costs.



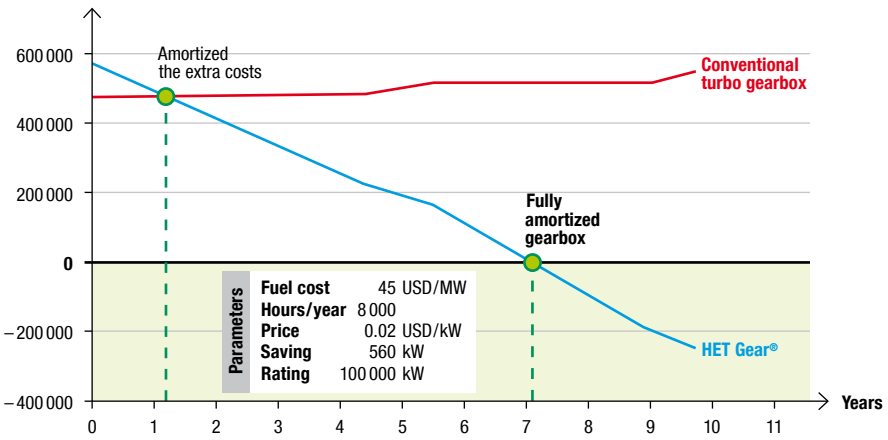


Benefits with HET Gear®

- Availability and reliability equal or higher than standard gearboxes.
- About 50% lower power loss than a conventional turbo gearbox!
- Switch-over between conventional and vacuum operation is always possible without any restriction to operation or production.
- Simple and safe control system.
- Redundant oil level detectors and vacuum release valves.
- Vacuum level 80 to 85% to reduce gear ventilation losses.
- Three pad bearings with 40% lower power loss compared to conventional bearings.
- Bearings are not affected by vacuum to ensure safe and dynamically stable operation also under partial load conditions.
- Combined oil and air pump.

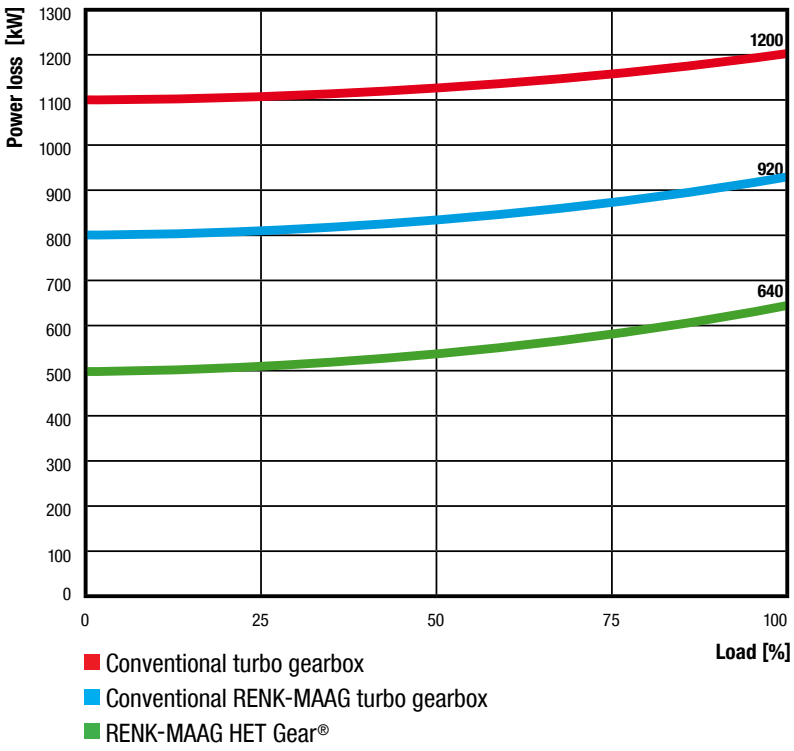
Significantly lower operating costs means investment costs can be amortized quickly!

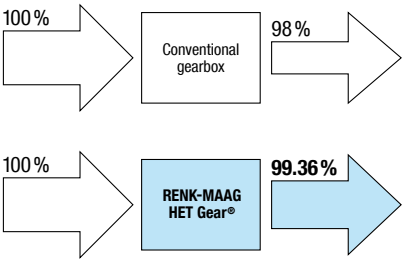
CAPEX vs. OPEX



After only 14 months, the higher investment costs of the HET Gear® have paid off compared to a conventional turbo gearbox. From this point on, the use of vacuum gearbox is highly profitable thanks to a 50% reduction in power loss. Six years later, the HET Gear® is not only self-supporting (including maintenance and operating costs) but even profitable!

HET Gear® – higher efficiency means more profit





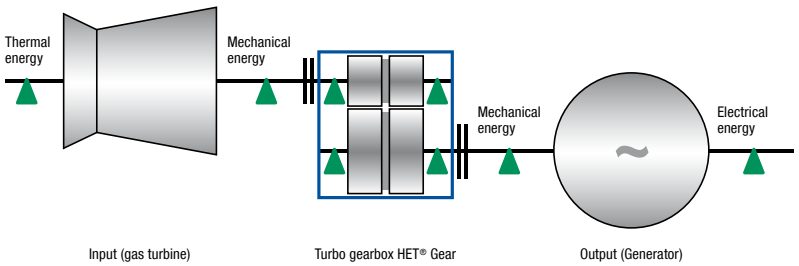
Example of a 100 MW Power Plant
Electricity revenue: USD 0.02/kWh
Operating hours: 8 000 h/year

Additional profit per year
560 kW x USD 0.02/kWh x 8 000 h

USD 89 600 generated

Further Example
Power: 14 127 kW at 8 434/12 285 rpm
Efficiency conventional: 98.45% (220 kW)
Efficiency HET Gear®: 99.22% (111 kW)
Nearly 50% power loss reduction

Train arrangement – compact solution, space and wight saving



The bigger the power and the higher the pitchline velocity (> 120 m/s) the bigger the benefits from HET Gear® technology!

▲ = Bearing

Summary

RENK-MAAG has developed and built up its experience in the technology of vacuum gearboxes in the range of 15 MW–120 MW since 1996.

- Lower contact temperature (teeth) = more safety against fretting and pitting.
- Lower oil and casing temperature due to the vacuum.
- More efficient plant = higher production rate.
- More profit in power generation.
- Lower energy costs (less electricity or fuel).

Product portfolio

RENK-MAAG provides new products, services, inspections, repairs and spare parts (incl. complete gearboxes) for all types of MAAG/RENK-MAAG gearboxes.

Turbo Gearboxes

Parallel Shaft Gearbox

Developed for applications in generator, compressor and pump drive markets.

Applications/Industries
- Oil and gas
- Power generation
- Petrochemical industry
- Steel production
- Paper industry
- Energy recovery systems
- Testbeds

Features
- Since 1915 over 11 000 gearboxes supplied
- Partnership with various companies for tailor made gearbox designs
- Power range up to 180 000 kW
- Gear ratio single stage: $i \leq 10$ double stage: $i \leq 50$
- Speeds up to 63 000 rpm

HET Gear® (Vacuum Gearbox)

For highest efficiency where it is needed – world's most efficient turbo gear.

Applications/Industries
- Power generation
- Compressor drives
- Energy recovery
- Combined Cycle Power Plant (CCPP)
- Combined Heat and Power (CHP) plants

Features
- Highest efficiency
- Up to 99.3 % at 90 MW
- Power range 15 MW to 120 000 kW
- Viable at pitchline velocity > 120 m/s

Integral Gearbox MULTICOM®

The heart of a multi-tiered gearbox compressor and/or expander.

Applications/Industries
- Gas compression trains used in petroleum, chemical and gas industries
- Air separation
- Oil and gas
- Power recovery (in combination with RENK-MAAG Synchronous Clutch Coupling)

Features
- 1 to 10 stages
- Radial Compressors
- Up to 63 000 rpm
- First 10 stage integrally geared compressor gearbox ever built
- Toothing (e.g. Hirth) or polygon
- Up to 50 MW

High-Speed Epicyclic Gear

A simple, efficient principle when space is at a premium – plant cost (CAPEX) can be reduced.

Applications/Industries
- Power generation
- Compressor drive
- Pump drives
- Marine applications
- Paper industrie
- Hydroelectric

Features
- Over 1000 gearboxes installed in more than 55 years
- Ongoing GT-Generator drive program with more than 70 units running
- Partnership with various companies for tailor made gearbox design
- Power range up to 45 000 kW
- Gear ratio single stage: $1.6 \leq i \leq 13$ double stage: $12 \leq i \leq 45$
- Speeds up to 36 000 rpm

Special Gears [1] e.g. clutch gearboxes

Recovered energy in modern power recovery processes is automatically and directly fed back to the train.

Applications/Industries
- Between expander and blower as an increasing gear "BPRT" [2] for steel works
- Between steam turbine and fan as a reduction gear "SHRT" [3] for steel works

Features
- Integrated RENK-MAAG Synchronous Clutch Coupling type MS
- Over 125 BPRTs installed
- Power range 1000 to 100 000 kW
- Gear ratio single stage: $i \leq 8$
- Speeds up to ≤ 10 000 rpm

All RENK-MAAG gearboxes are according to DIN/ISO, AGMA or API (other norms or special design upon request).
Ask also for RENK-MAAG gear couplings (such as automatically synchronizing, engaging on demand or completely disengageable).

[1] RENK-MAAG develops and manufactures special gears for an enormously wide range of applications. The clear strength lies in the close technical cooperation with customers. A detailed specification and required gearbox design for optimum solutions are discussed and developed in person with the customer.

[2] BPRT = Blast Furnace Power Recovery Turbine

[3] SHRT = Sintering Heat Recovery Turbine

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Our manufacturing and other operational activities are implemented in accordance with our internal quality assurance system and in strict compliance with ISO 9001:2008, ISO 14001:2004 and OHSAS 18001:2007.

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