Typical High Speed Application
Replacement of a Gearbox

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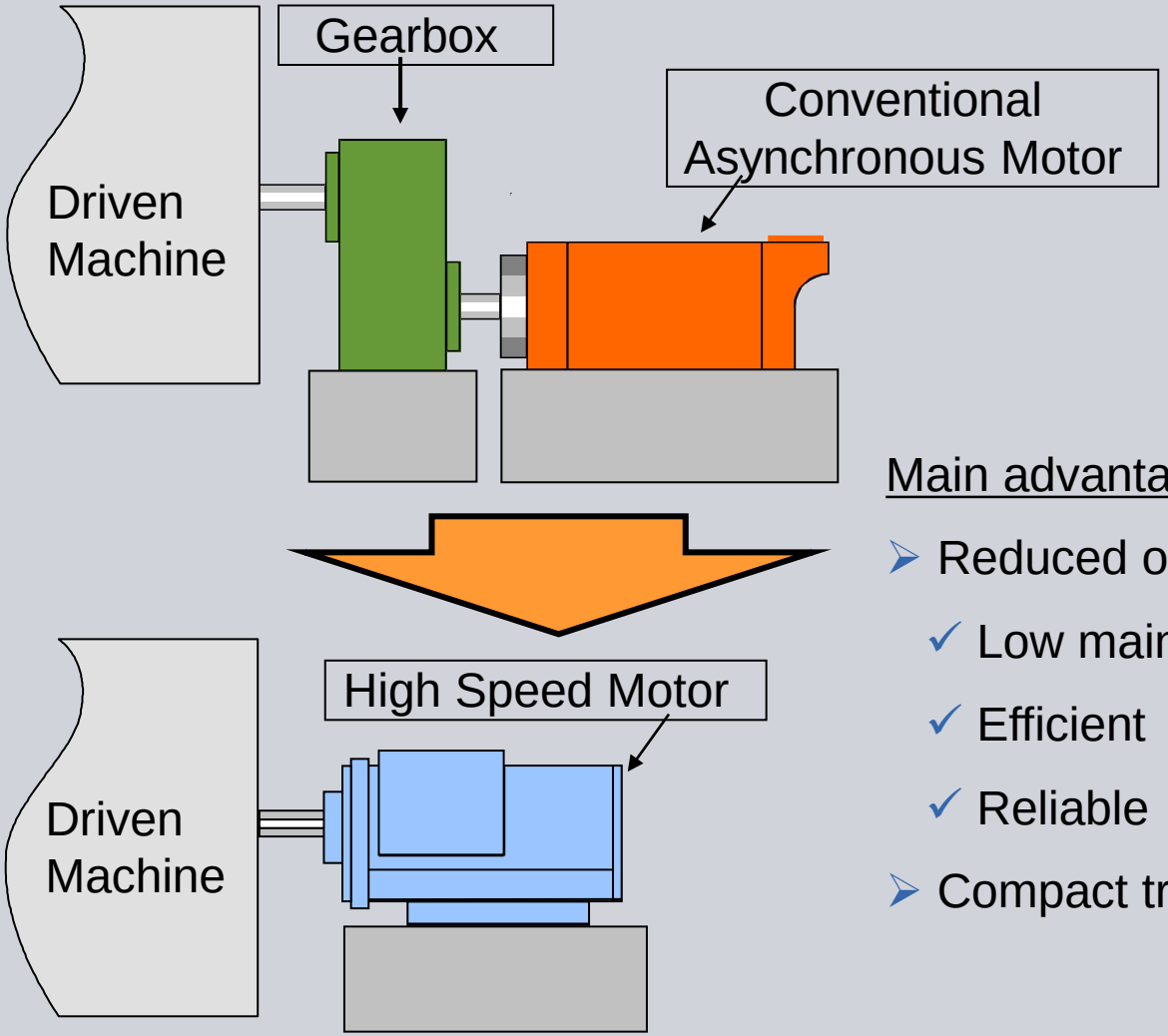


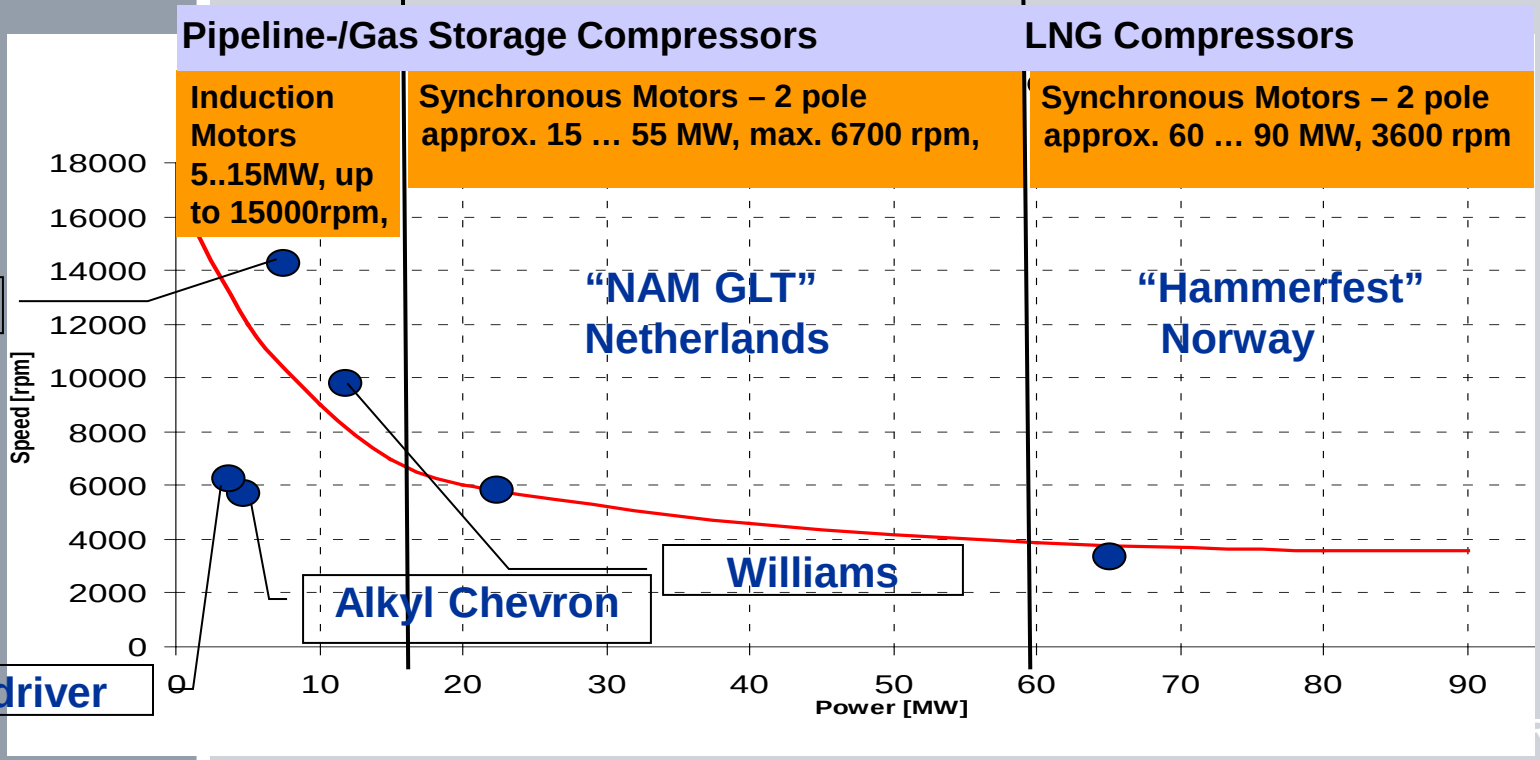
Main advantages:

- Reduced operating costs
  - ✓ Low maintenance
  - ✓ Efficient
  - ✓ Reliable
- Compact train design

The HS Modyn - Direct drives in the Megawatt class

The most reliable technology for offshore and onshore applications in the oil & gas industry

Turbomachine Classes and Related Motor Designs



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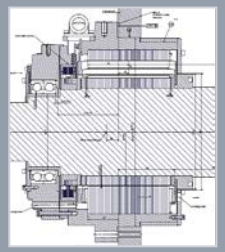
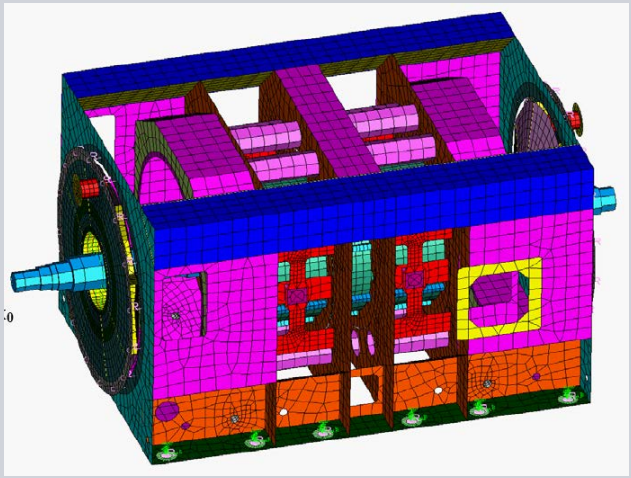
HS Modyn – New Main Motor Components Needed

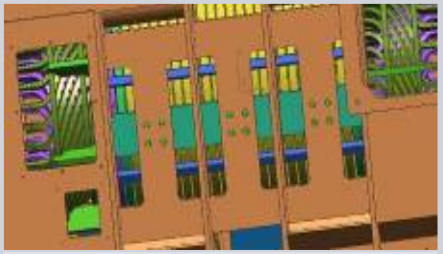


Active magnetic bearing

With flange design

Provided by e.g. S2M



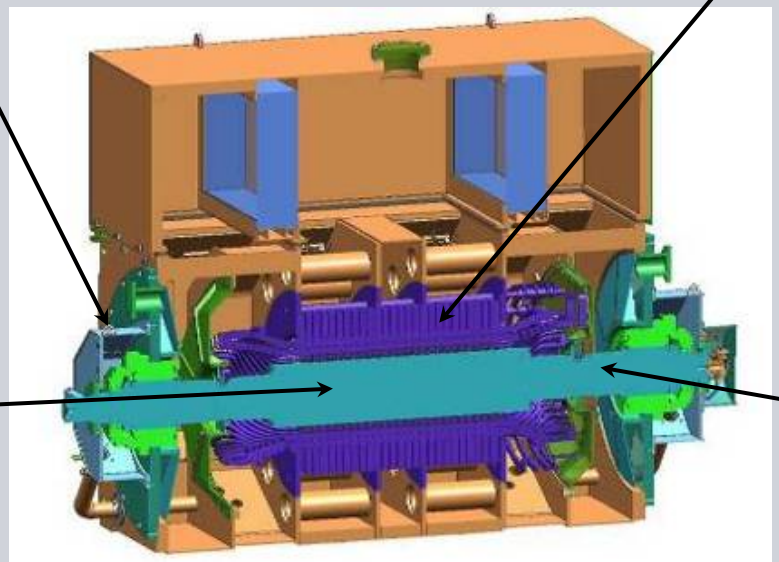


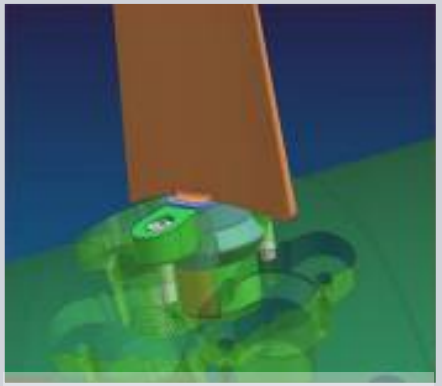
Stator design for VSDS (elastic)

New Frame & Housing Development

Asynchronous motor with solid shaft, copper caged

New Development & Unique / Patented Rotor Design





Self-cooled with shaft-mounted fan

New Development

HS Modyn - Rotor Design

- Minimum number of individual components in the rotor
- 100% connection between the copper and steel to form a solid body

HS Modyn Manufacturing Process
Assembly of Cu-winding for HIP-process

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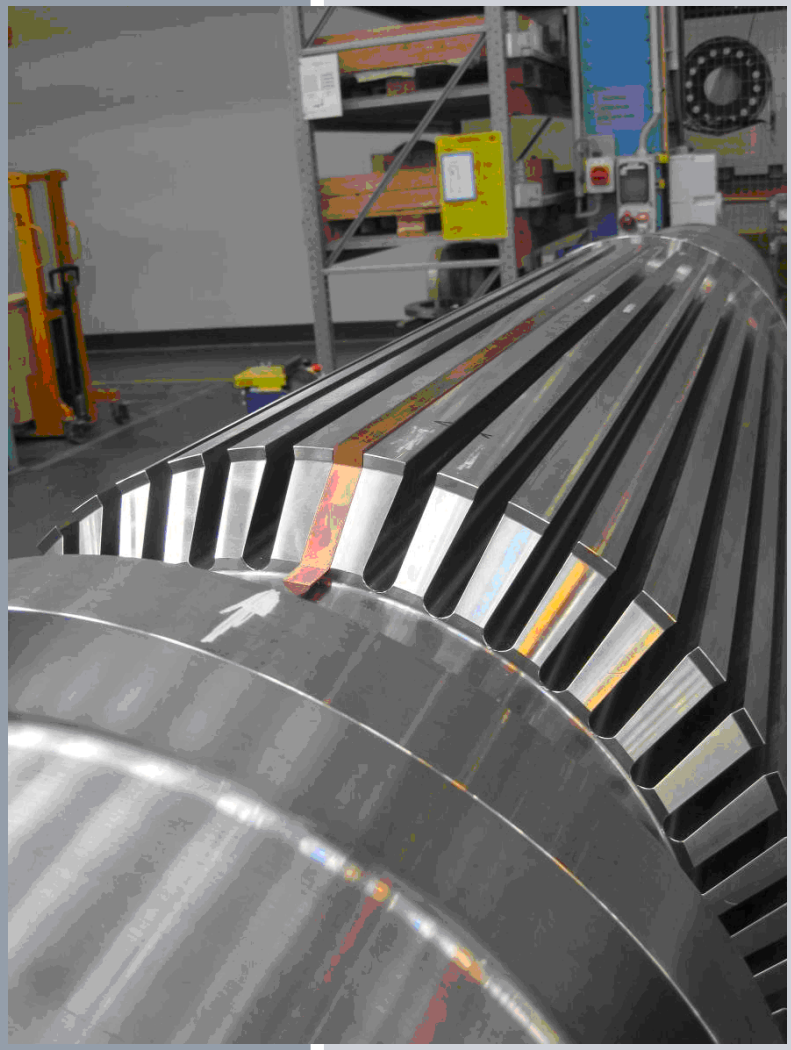

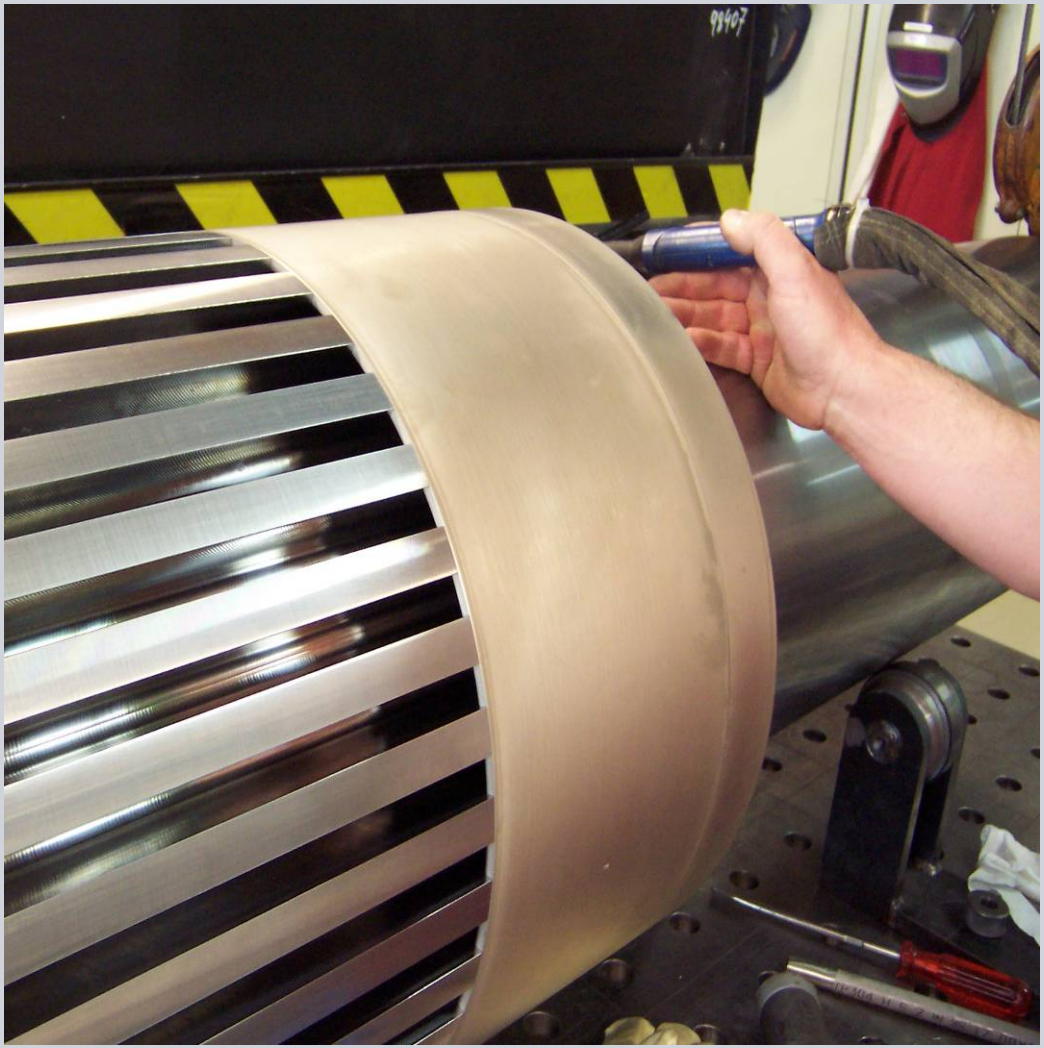

HS Modyn Manufacturing Process
Assembly of encapsulation for HIP-process

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HS Modyn Manufacturing Process
HIP-process (rotors in HIP-oven)

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HS Modyn Manufacturing Process
Rotor after HIP-process

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HS Modyn Manufacturing Process
Rotor after final machining

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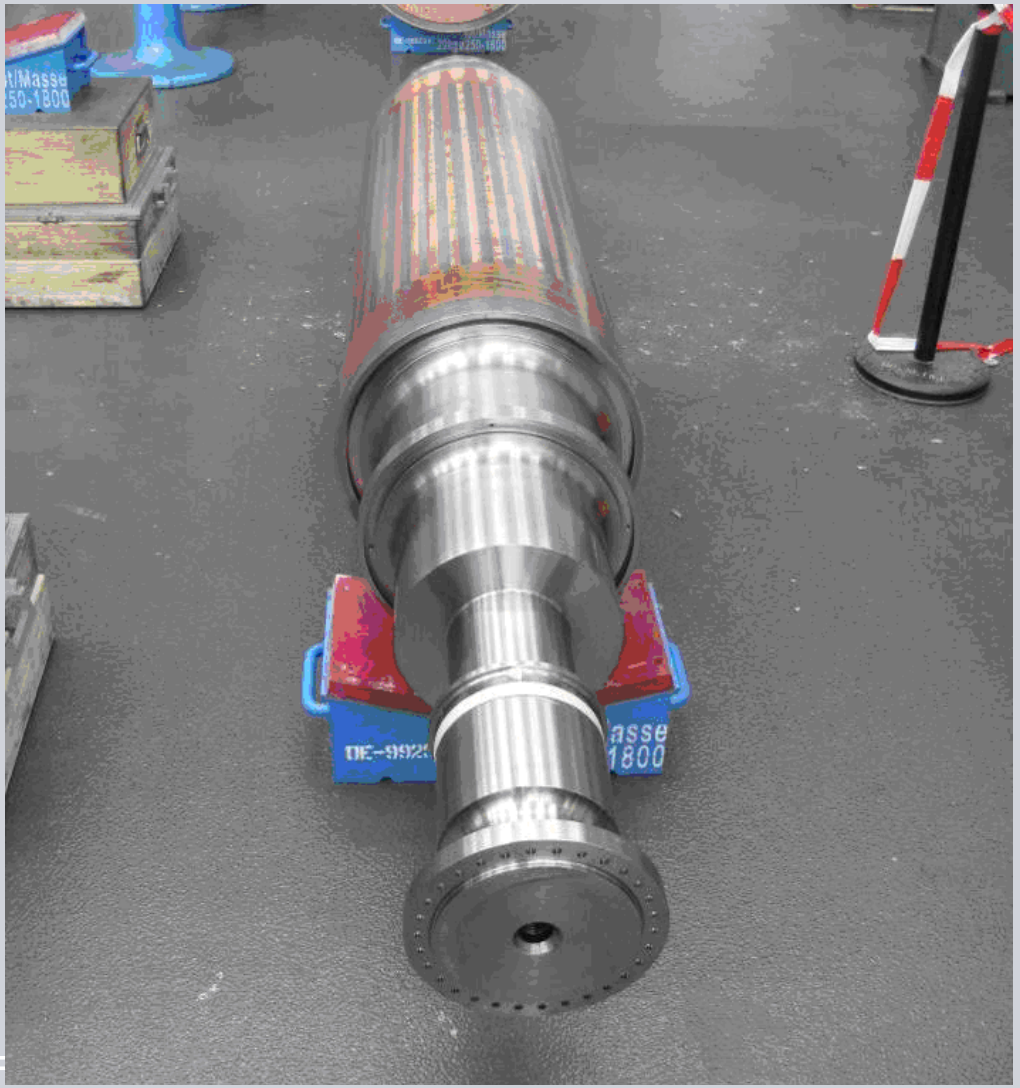
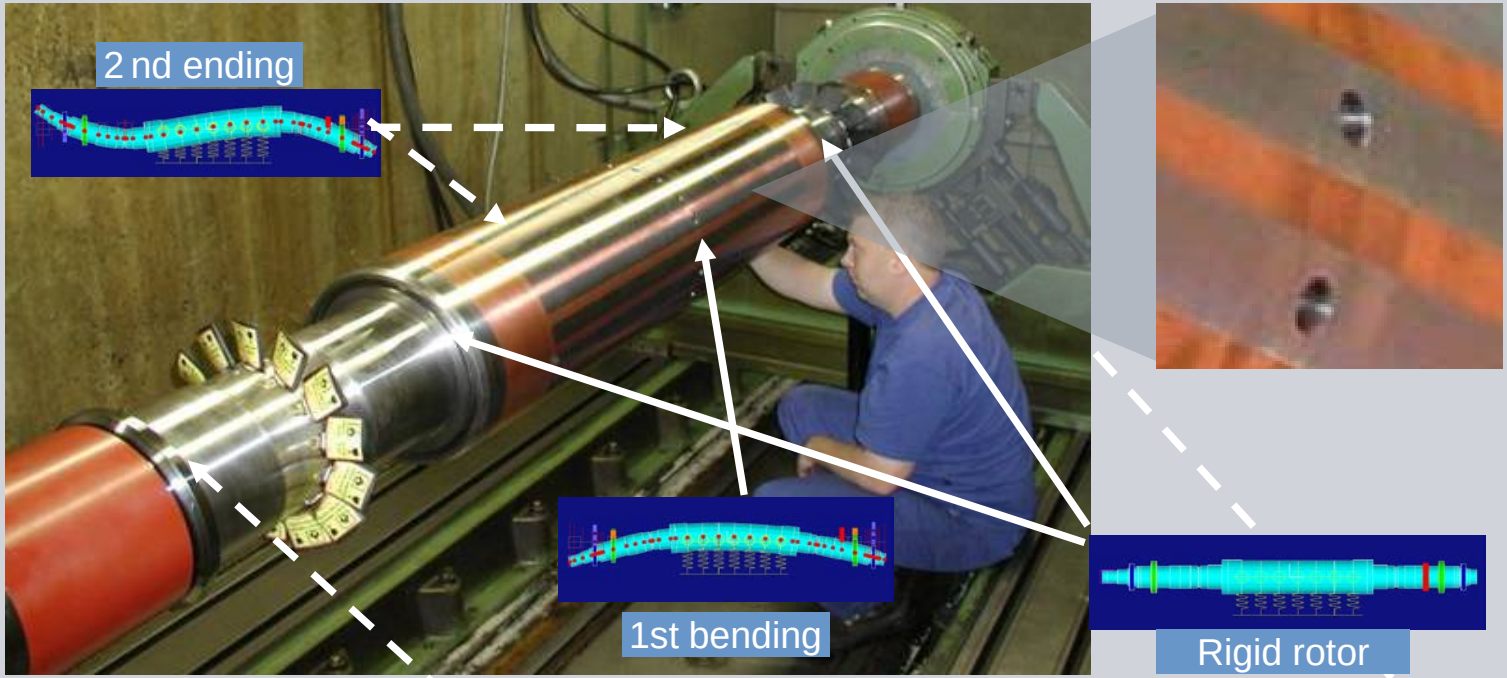


HS Modyn – Rotor Balancing

The solid rotor design allows an optimized number and locations of balancing planes, i.e. freely selectable and more than 5 planes possible !



HS-Modyn – Shaft Fans

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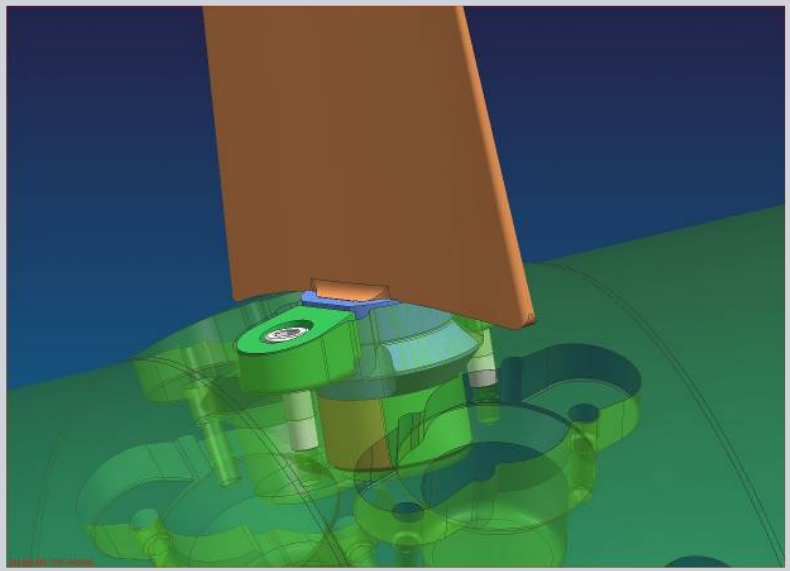


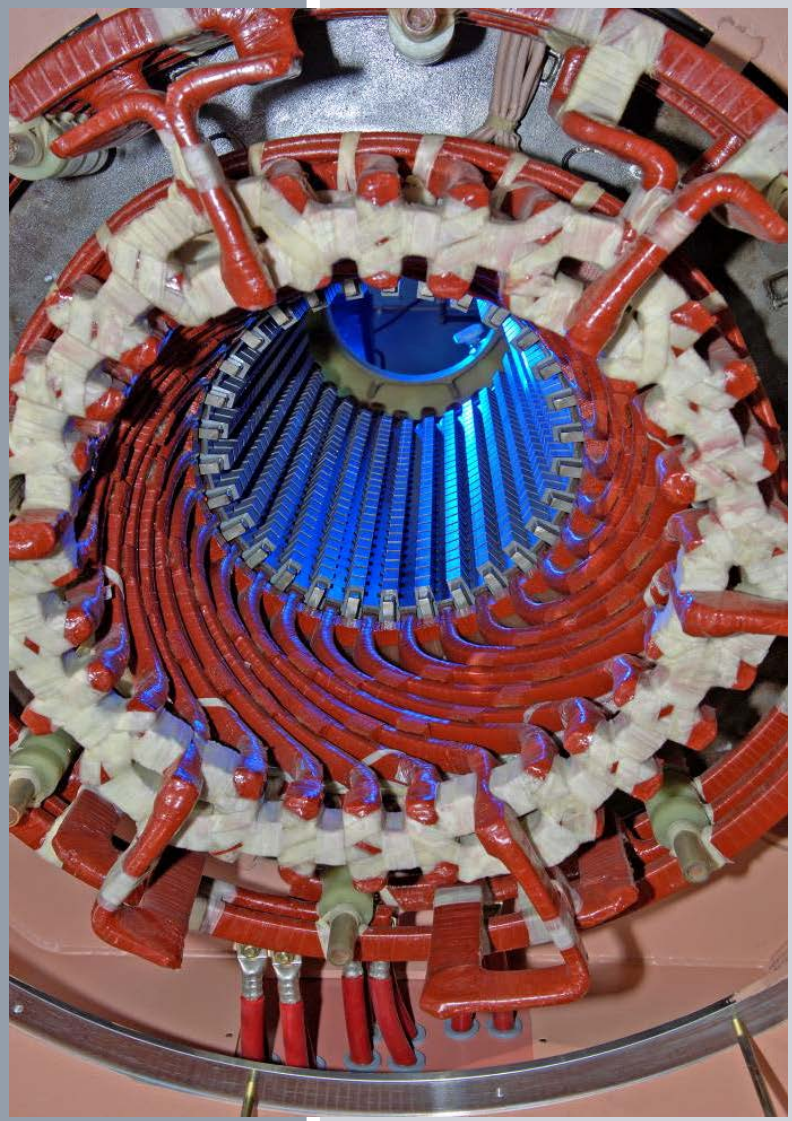
Development of a new Kevlar Fan Blades with

- extremely high strength, to control the high centrifugal forces

  $F = m*r*\omega^2$

- optimized shape for optimized air flow at circumferential speeds of up to **280 m/s or 1,000 km/h – 626 mph**.
- Small air gap between fan and air duct < 1mm
- optimum setting with bayonet type blade retention.

HS-Modyn – Stator Design



- The motor terminal voltage is defined by the converter output voltages ranging between 3 … 13 kV
- The high motor frequency leads to a twisted Roebel-bar winding with two conductors per slot
- The winding voltage is adapted to performance requirements and can be star or delta connected
- This design is standard at converter feed machines with higher speed

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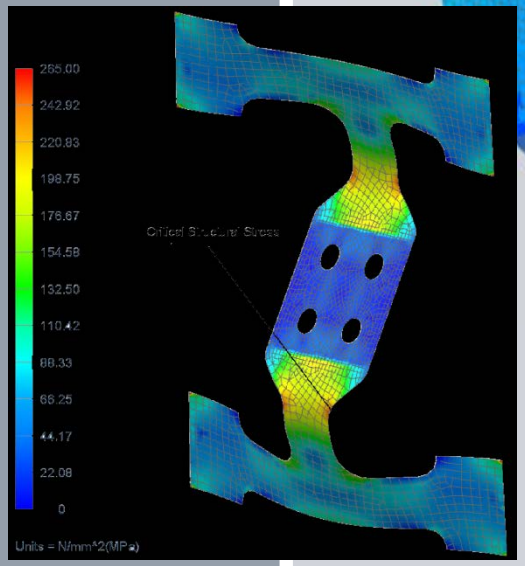
HS Modyn – Structural Analysis

Eigenmode at 163.4Hz

Damper Springs



- Eigenmode with high Isolation Element Involvement
- Not critical for Response to Magnetic Excitation

The stator is decoupled from the housing to ensure a low level of vibration and noise !

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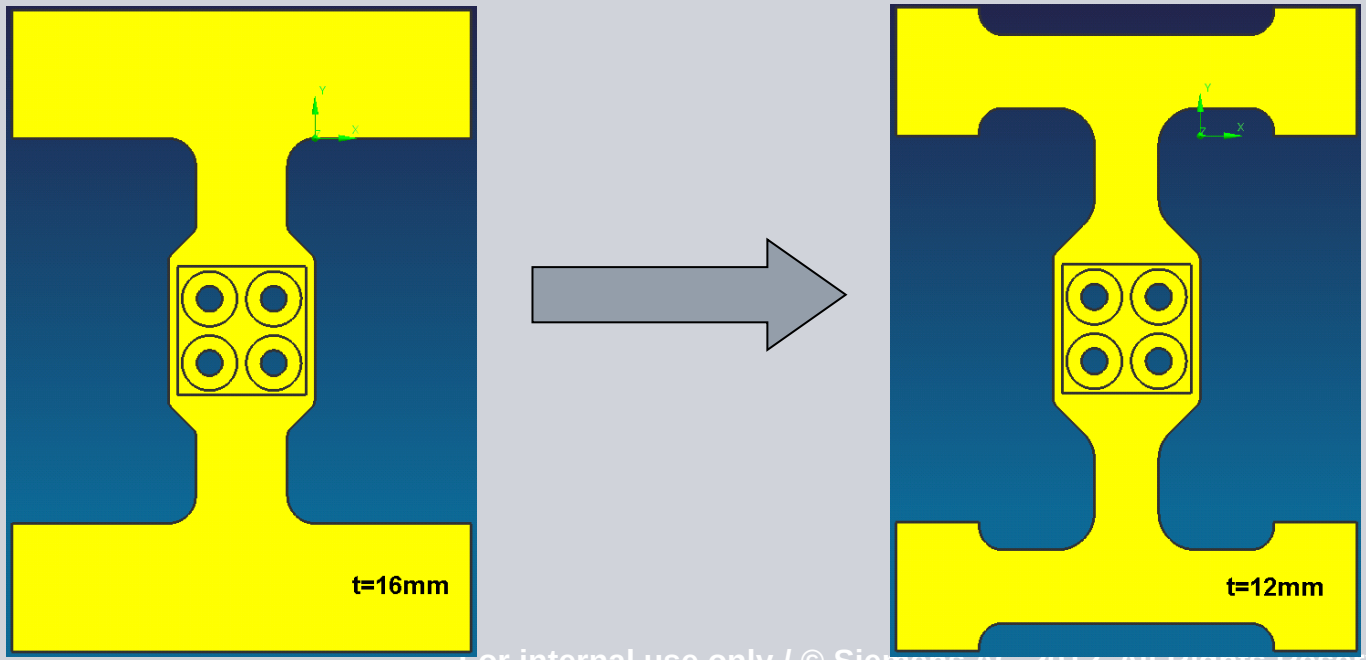
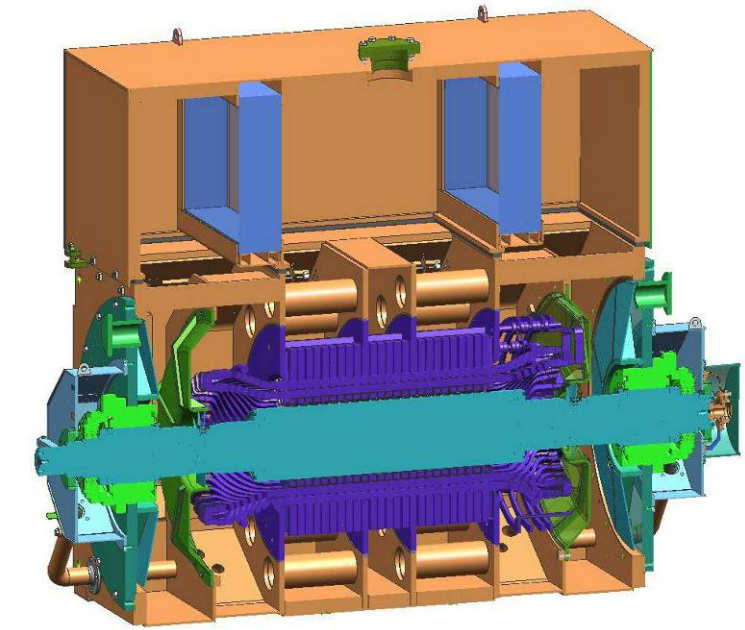
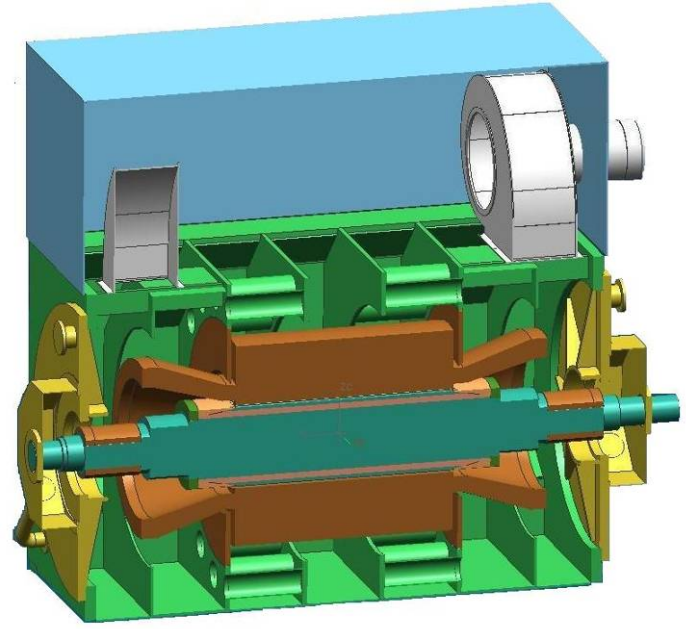
HS Modyn – Damper Spring Optimization

- Connection of Stator Core and Housing by Isolation Elements in order to Decouple Magnetic Excitation from Housing and Bearing Vibration
- Adaption of Isolation Element Stiffness to Stator Inertia
- Ensuring rigidness of Isolation Element during a Short Circuit Event



HS Modyn - Ventilation and Cooling





- Self-ventilated with shaft-mounted fans
- Force-ventilated with fans mounted on the motor
- Customized versions

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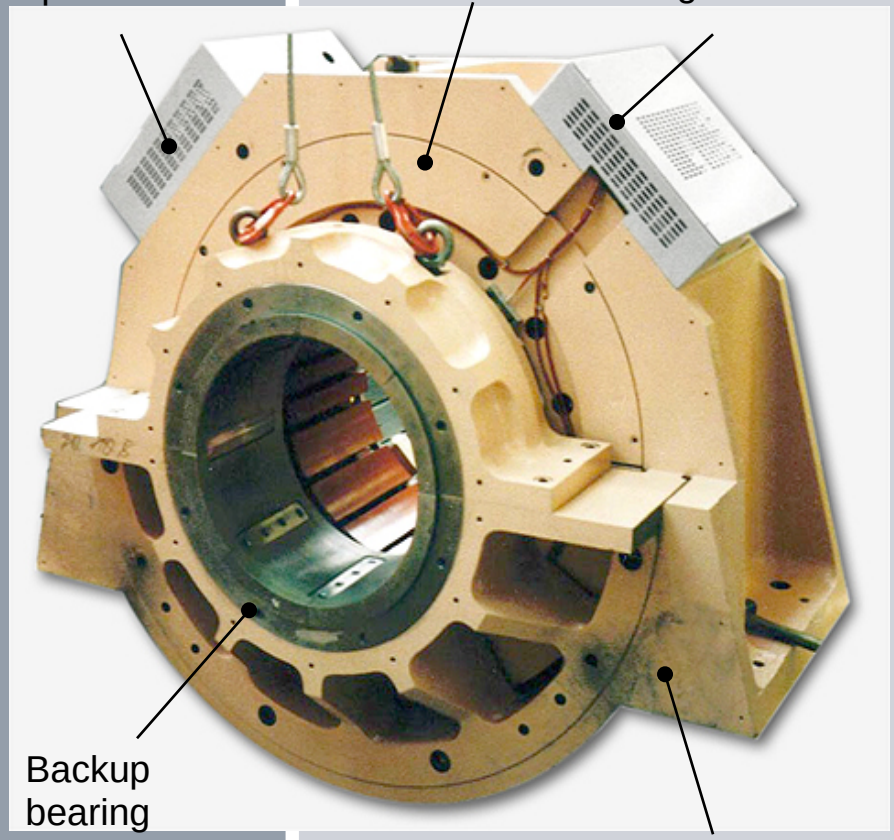
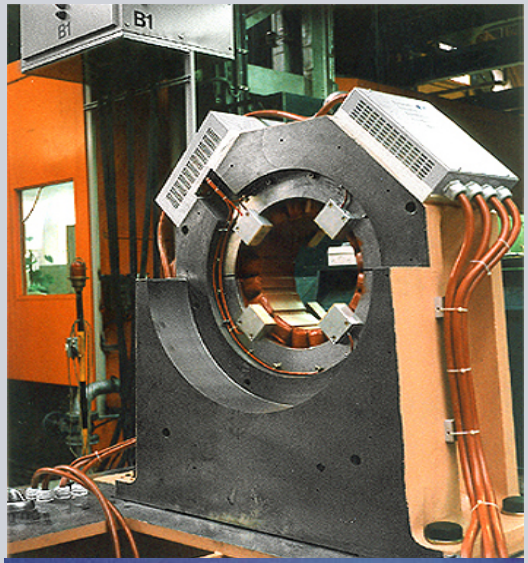
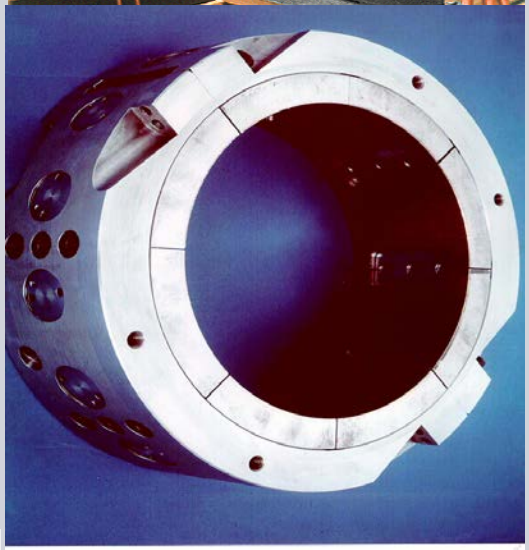
Active Magnetic Bearing (AMBs)



Main bearing pedestal

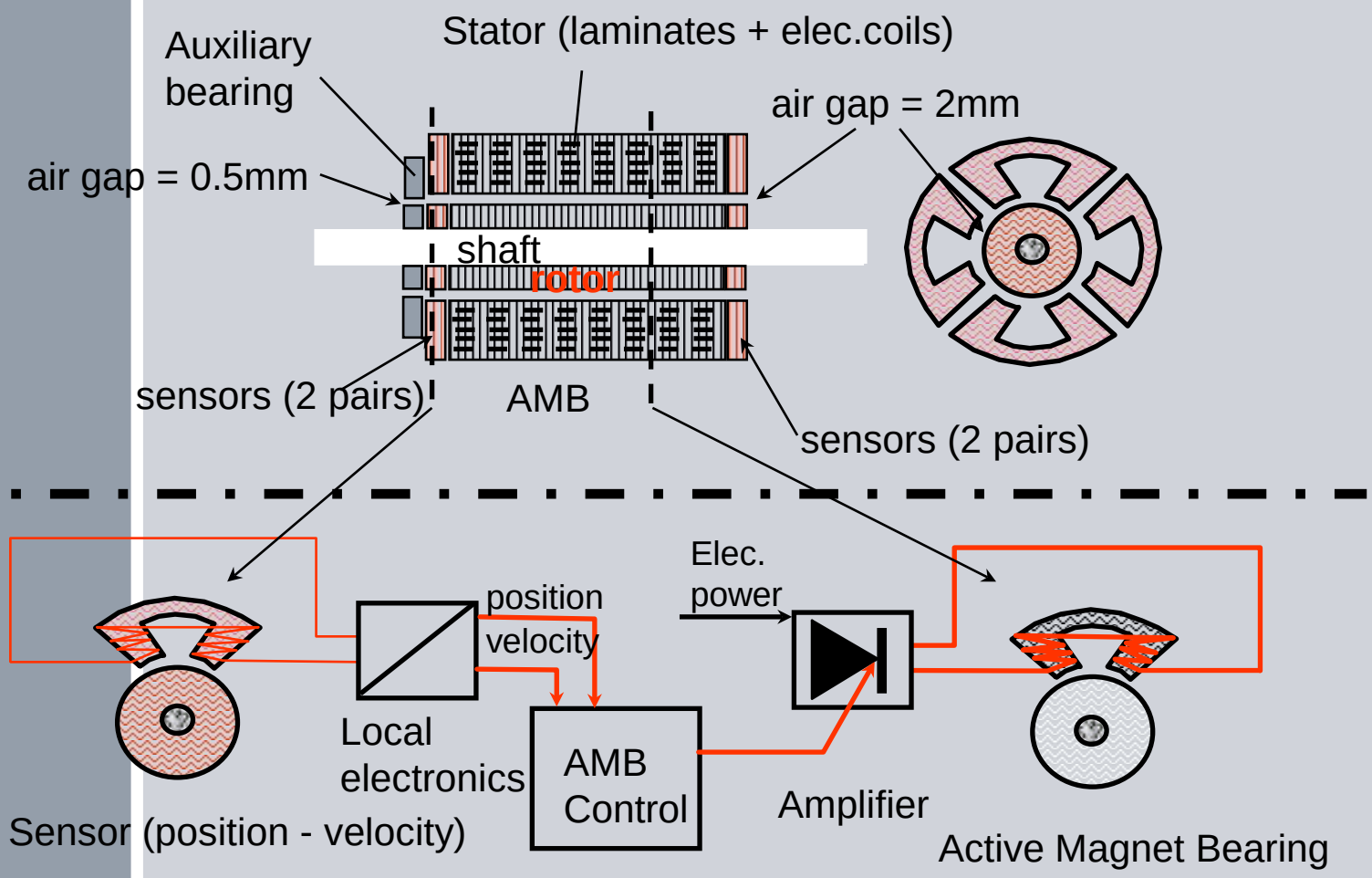


Exciter bearing pedestal



Back up bearing stator shell

Active Magnetic Bearing (AMBs)



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Comparison AMB vs Sleeve

	Sleeve Bearings	Active Magnetic Bearings
Speed	Up to around 8000 – 9000 rpm (circumferential speed up tp around 90 m/s / 325 km/h / 201 mph possible)	**Can be used for any Speed** **Typical from 6000 rpm and up** **Depends on application / speed range e.g. 1st critical**
Service	Higher - Environmental restrictions - Oil quality - Limited life time on the bearing shells	Nearly no service needed
Emergency	Small Issue and well known - Oil rings or other coast down measures - In case of damage just change bearing shells	More complex - UPS for coast down or active breaking - Back up bearings have limited drop capabilities (5-20) - Change of back up bearings quite complex
Price	Known	High Investment - from 180,000 € to 250,000 €
Needed Space	Known - Oil cooling system - inflexible piping - flange coupling possible	- Control cubicle need
Losses	High - around 0,1% to 0,2% of rated motor power	Small < 0,1% of rated motor power
Pros		**Bearing stiffness adjustable**