1. Manufacturing of Large Electrical Machines

- History and significance of electric machinery

- State-of-the art of medium and high power machines

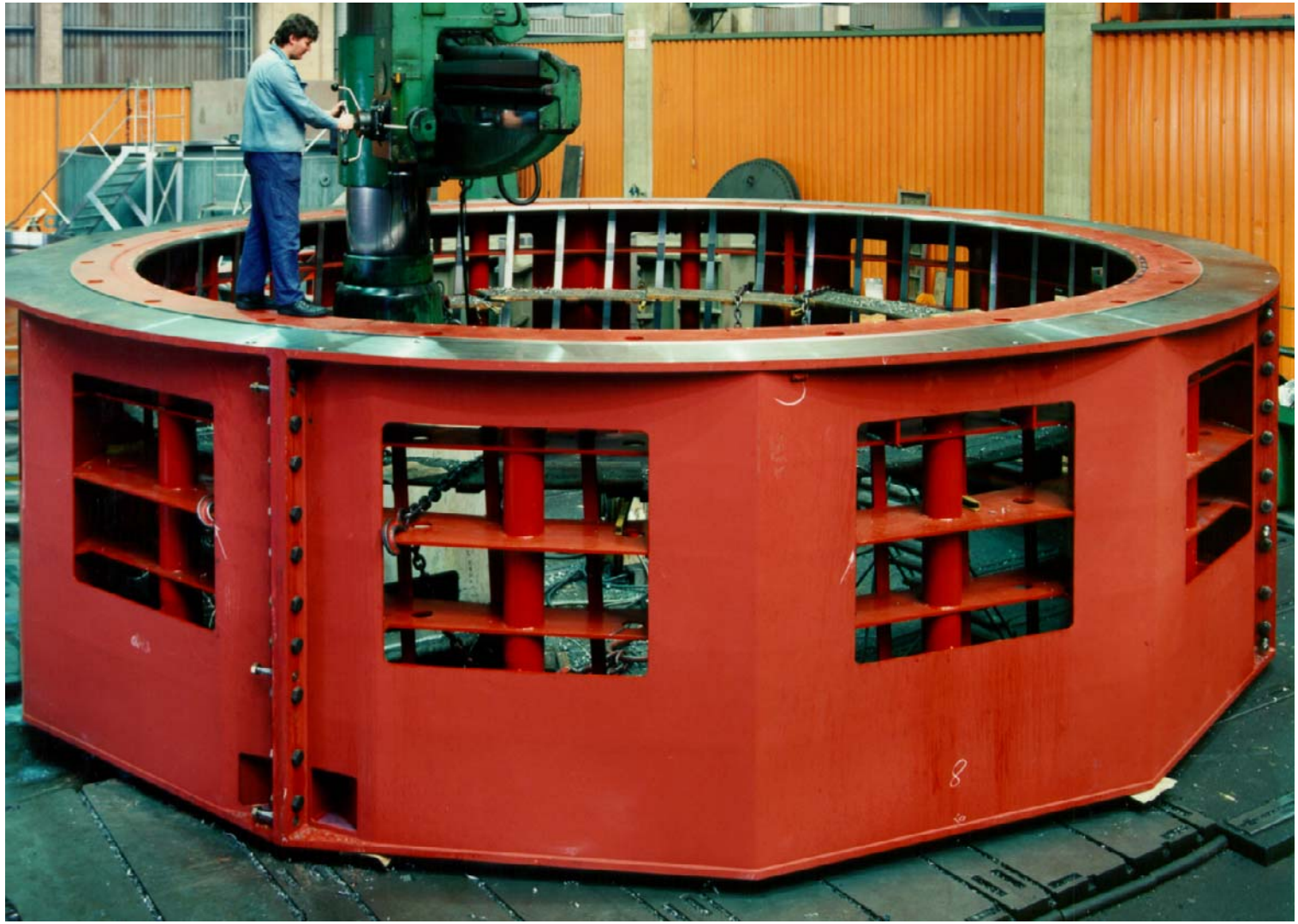
- Trends in large generators and high power drives

1. Manufacturing of Large Electrical Machines

Manufacturing of a big hydro generator

Manufacturing the stator of a hydro generator with vertical shaft

Welded stator housing of synchronous hydro generator



Source:

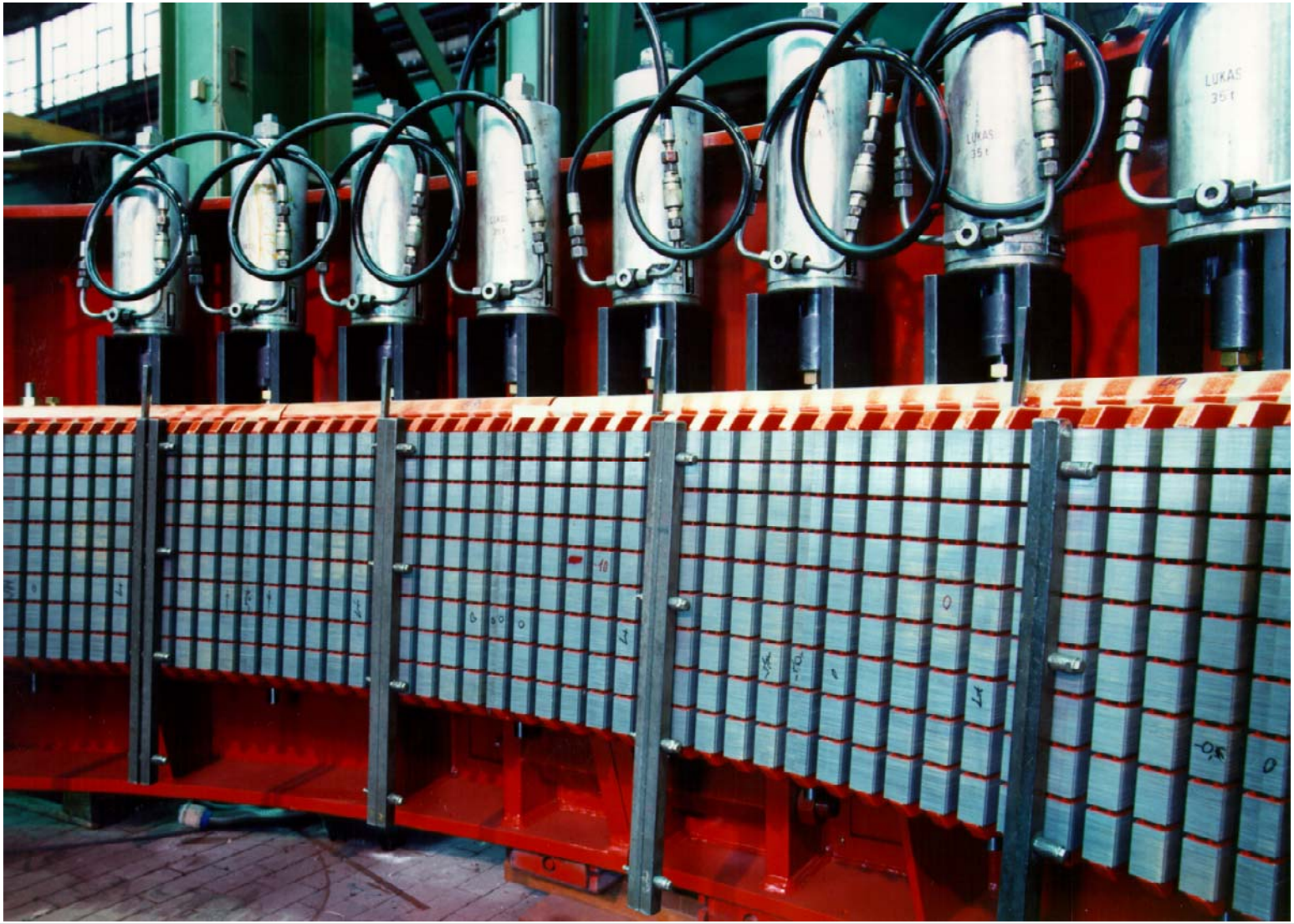
VATech Hydro, Austria

Stacking of stator iron sheets of synchronous hydro generator

Source:

VATech Hydro, Austria

Pressing of laminated stator iron core with hydraulic cylinders



Source:

VATech Hydro, Austria

Insulation of high voltage stator winding (one turn = stator bar) with insulation robot

Big generators:

Only one turn per coil. Coil is split into 2 halves = 2 bars.

Here visible: Insulating one bar for a 2-pole turbine generator with glass-fibre band with mica layer for high voltage insulation.

Source:

VATech Hydro, Austria

Insulation of high voltage stator winding (one turn = stator bar) with insulation robot

Source:

VATech Hydro, Austria

Resin impregnated coils are heated in the oven to dry and harden the insulation

Source:

VATech Hydro, Austria

High voltage form wound stator coil with several turns N_c for two-layer winding

Winding overhang

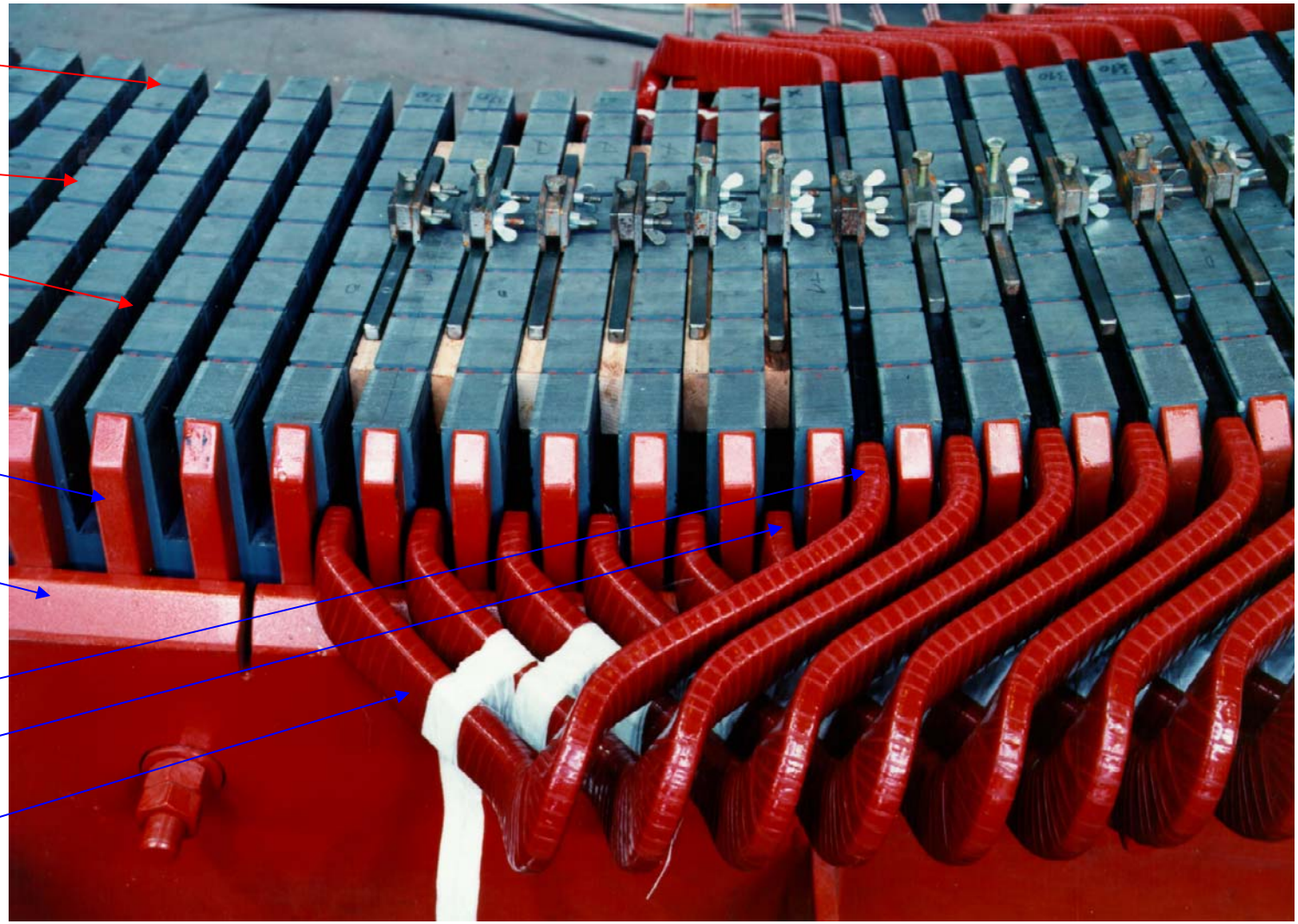
coil side, inserted in slot

coil terminals

Source:

VATech Hydro, Austria

Inserting of impregnated form wound coils in the stator slots of a synchronous hydro generator with high pole count



Source:

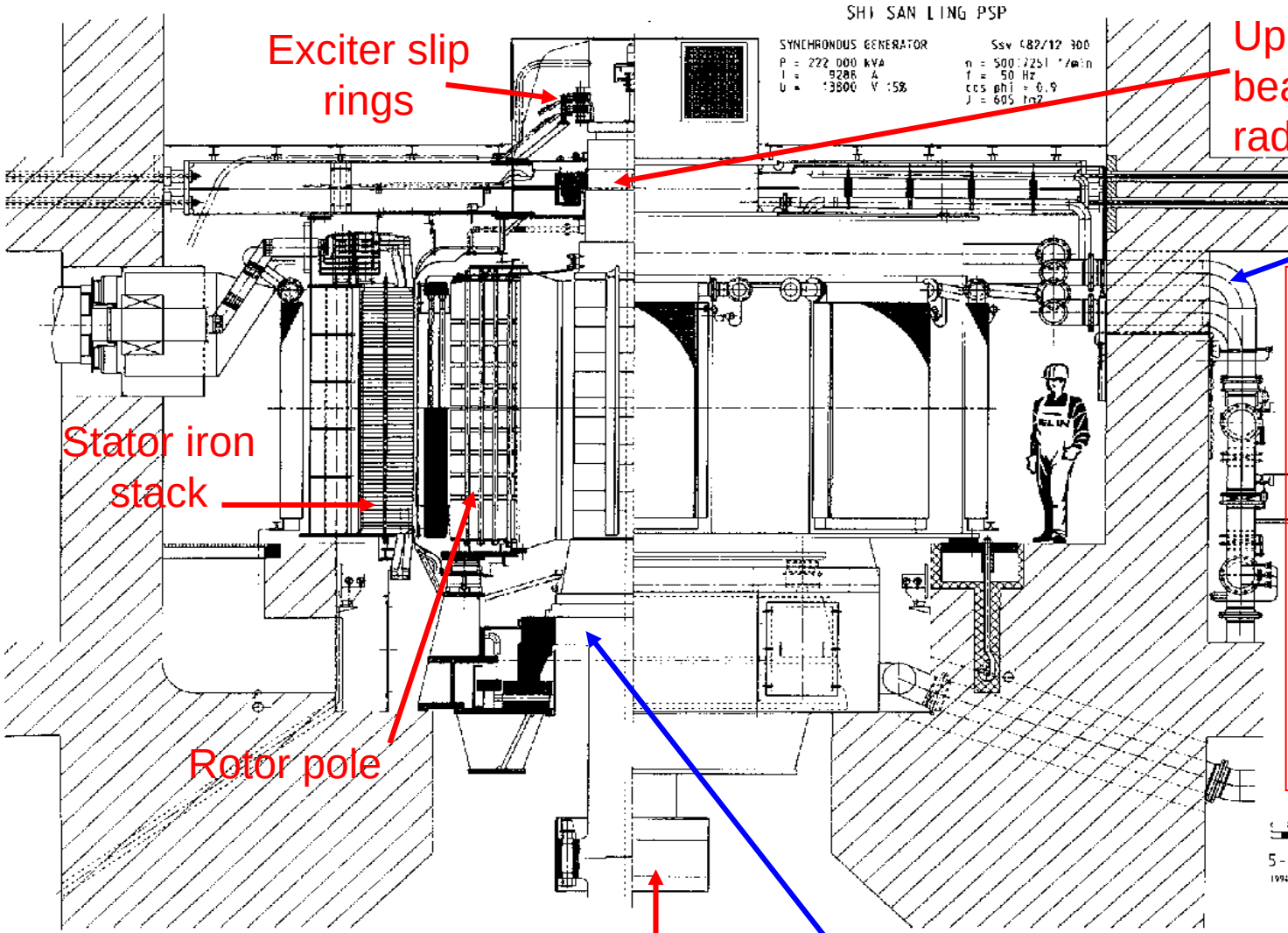
VATech Hydro, Austria

High voltage stator winding of synchronous hydro generator - Pressing of winding bars in the slots

Source:

VATech Hydro, Austria

Vertically mounted salient pole “big hydro” generator



Exciter slip rings

Upper combined sleeve bearing for horizontal and radial load

Oil supply

Stator iron stack

Rotor pole

Turbine coupling

Lower guiding sleeve bearing

Hydro power plant
Shi San Ling / China

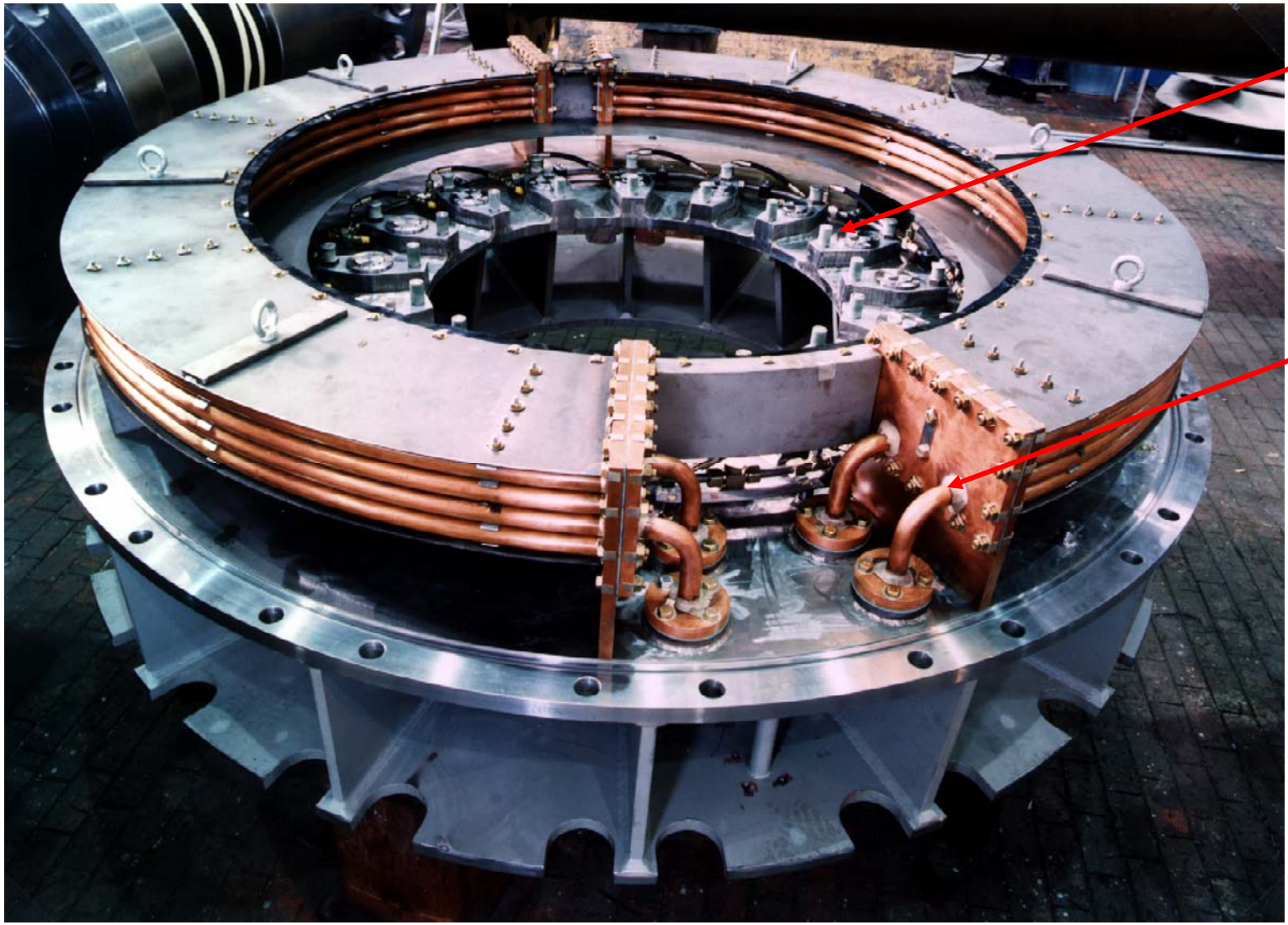
222 MVA, 2*p* =12
13.8 kV Y, 50 Hz
9288 A per phase
cos phi = 0.9 over-excited
500/min rated speed
over-speed 725/min
inertia 605 000 kg·m^2

Source:

VATech Hydro, Austria

Manufacturing of the segmented sleeve bearings

Segment sleeve bearing for vertical load



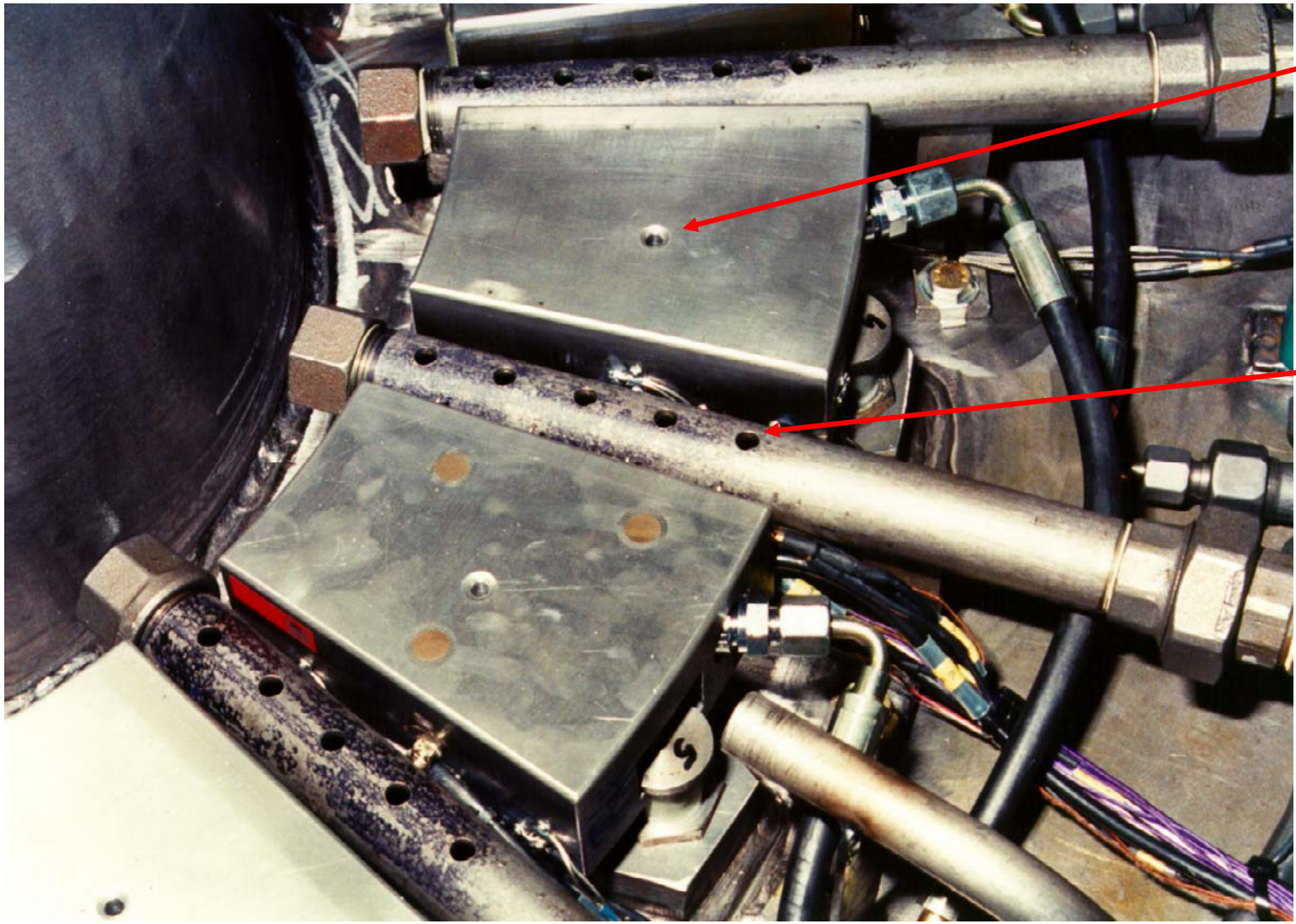
Bolts for bearing segments

Oil supply for lubrication and cooling

Source:

VATech Hydro, Austria

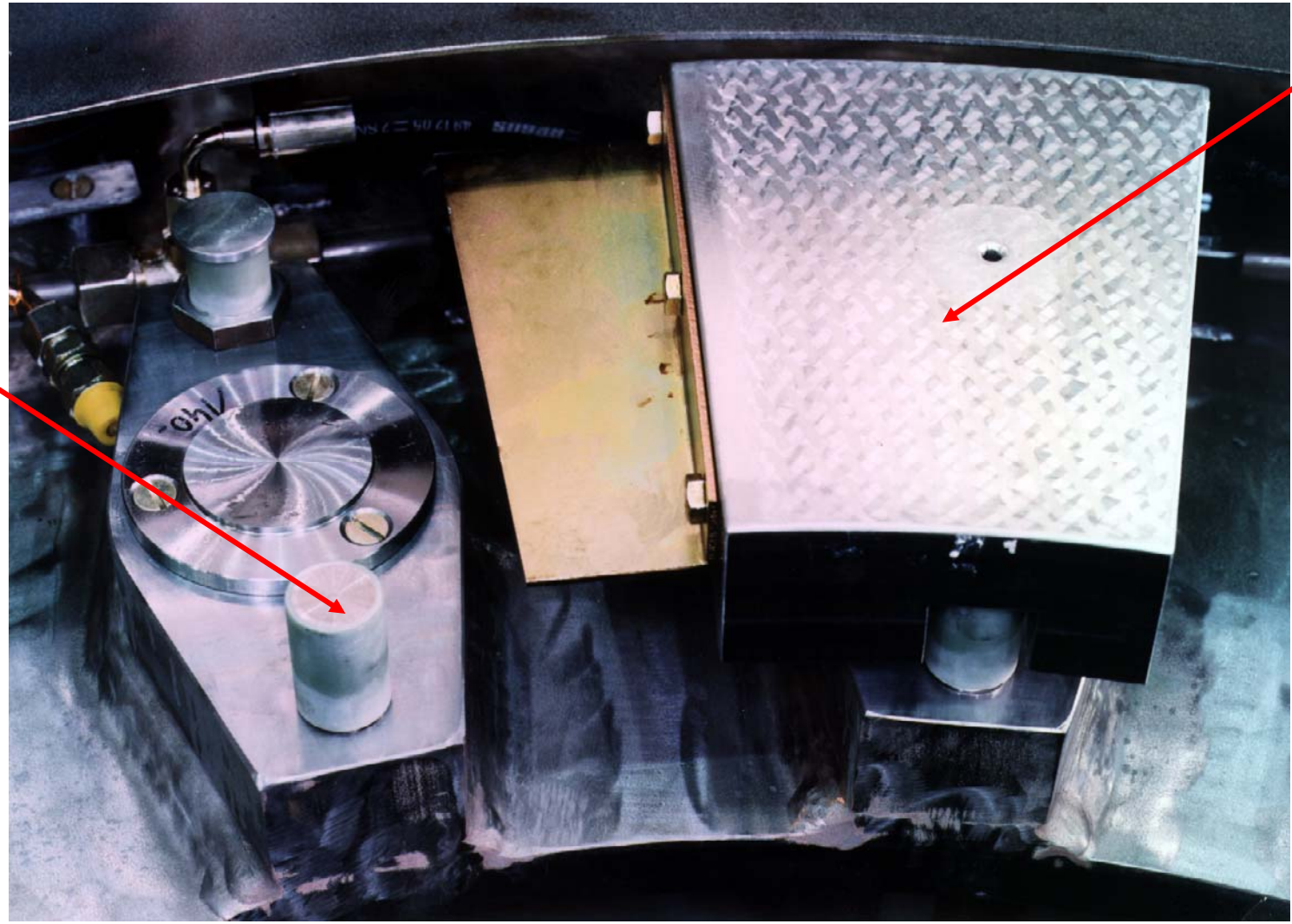
Segment sleeve bearing for vertical load



Source:

VATech Hydro, Austria

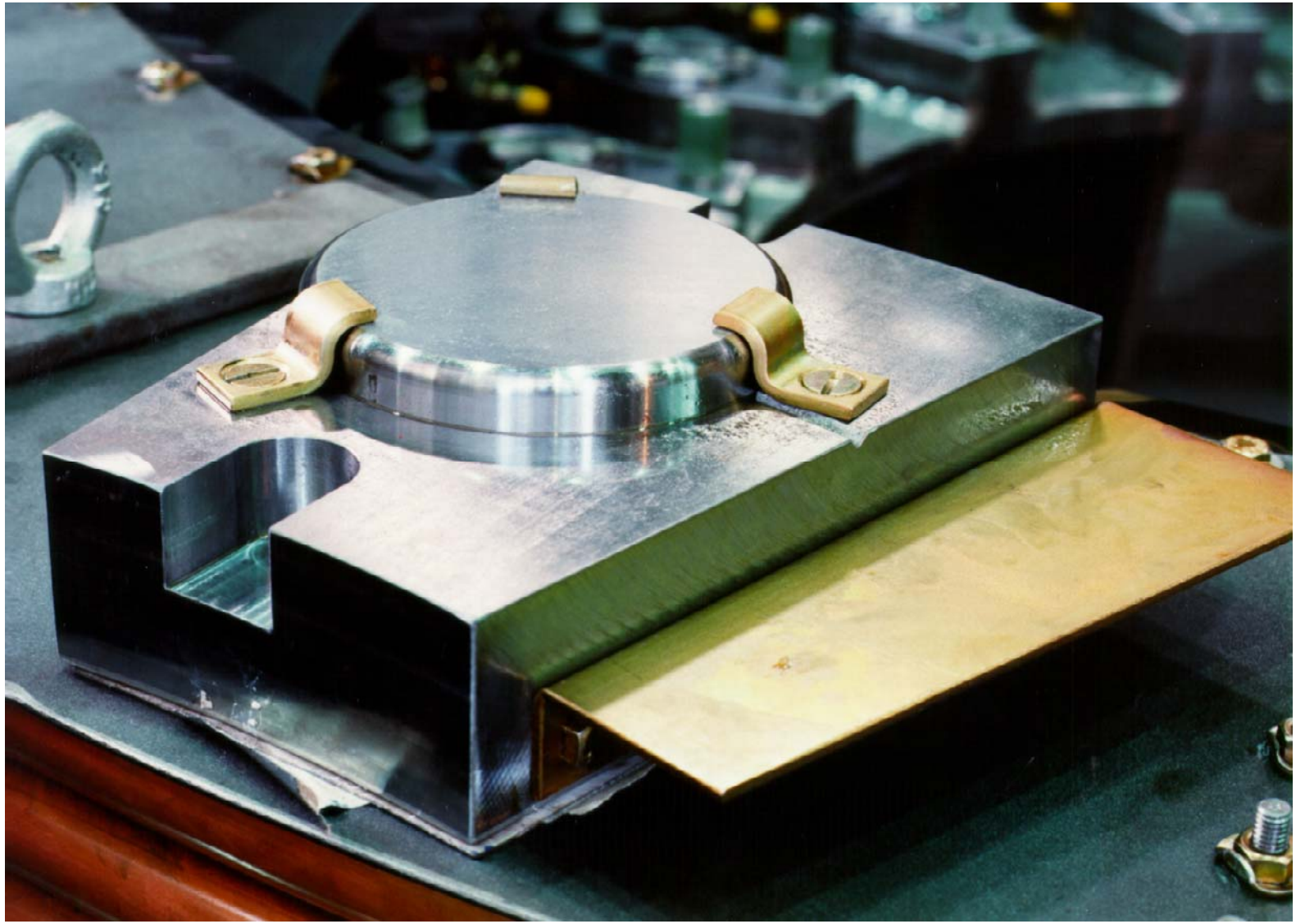
Mounting of sleeve bearing segments for vertical load



Source:

VATech Hydro, Austria

Detailed view of bearing segments for vertical load

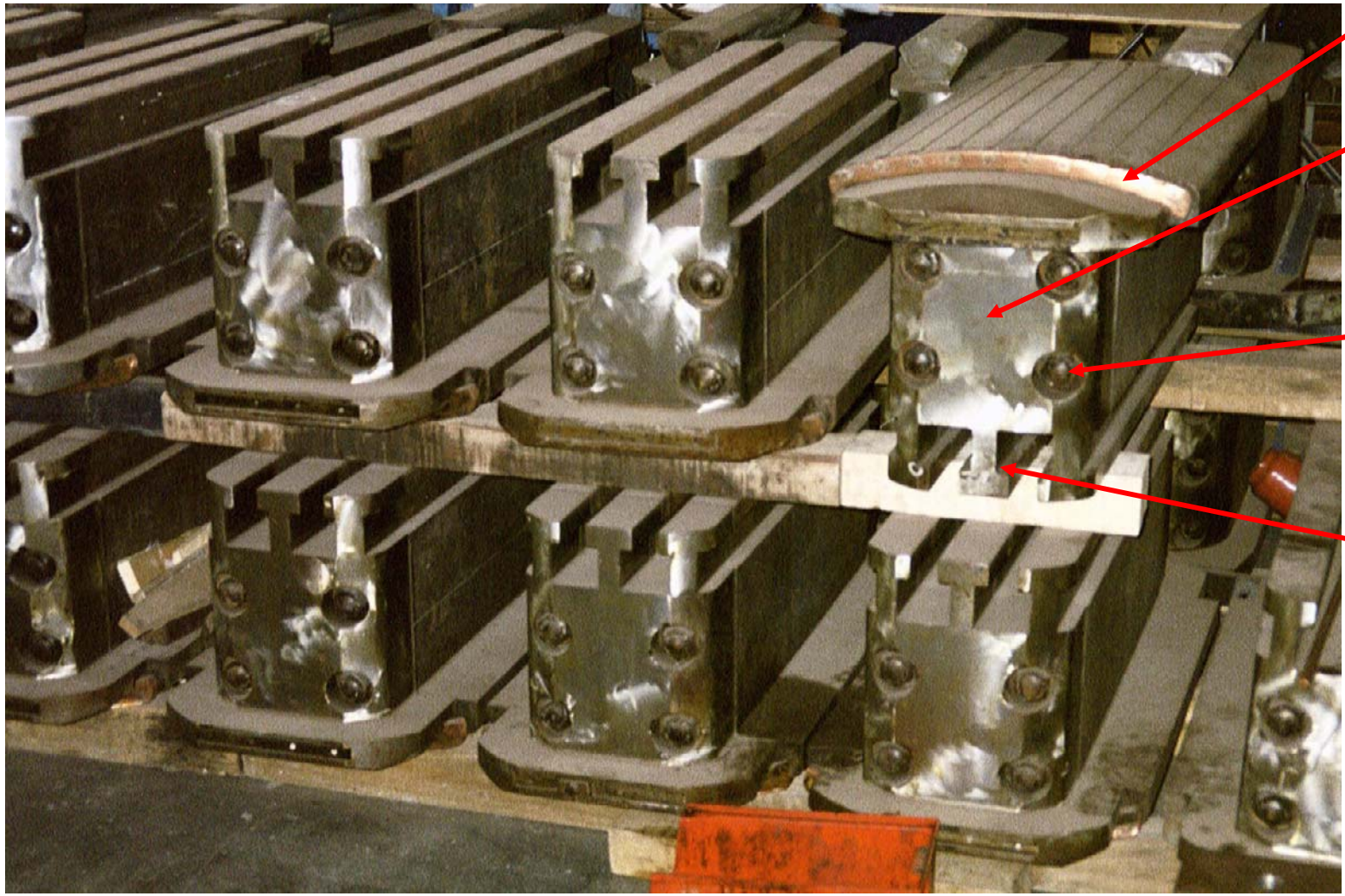


Source:

VATech Hydro, Austria

Manufacturing of the salient rotor

Fixation of rotor poles for high centrifugal forces (e.g. pump storage plants)



Source:

VATech Hydro, Austria

Manufacturing of field winding for salient pole machines

Non-insulated flat copper winding provides good heat transfer to cooling air at front sides

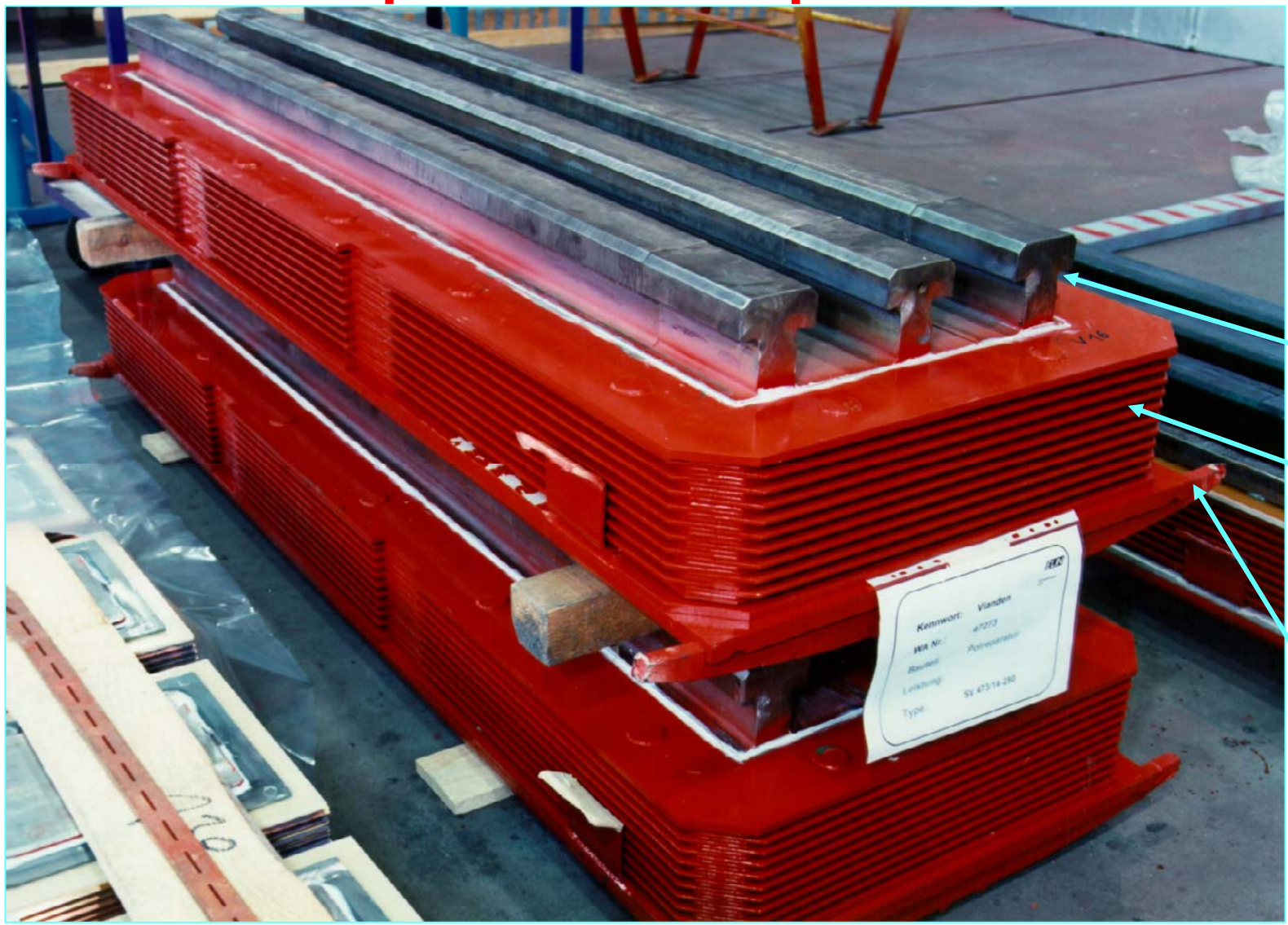
Inter-turn insulation

“Cooling fins” by increased copper width

Source:

VATech Hydro, Austria

Completed salient pole before mounting



Pump storage hydro power plant *Vianden/Belgium*

Refurbishment

Three-fold hammer head fixation

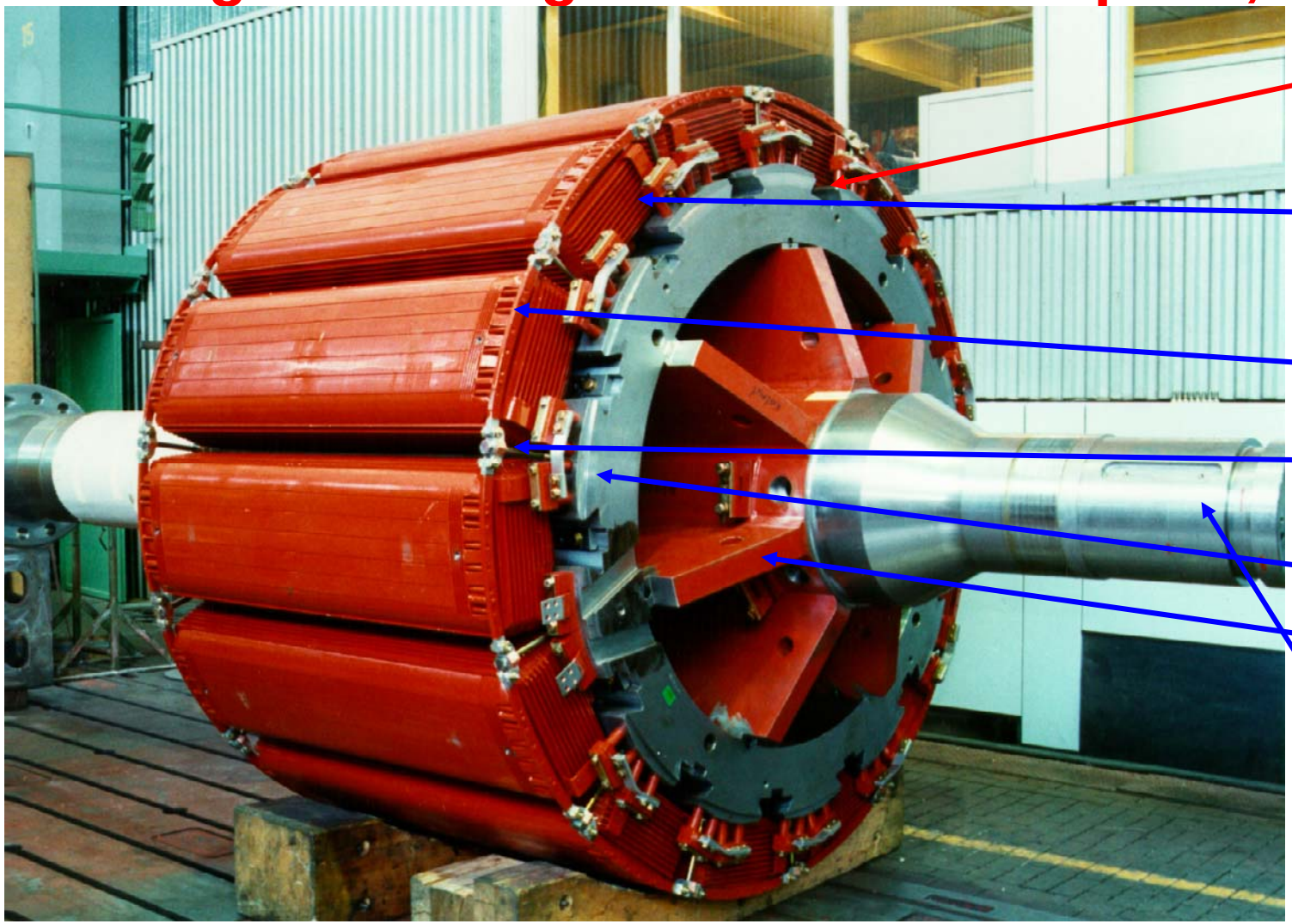
“Cooling fins” by increased copper width

Damper ring segments

Source:

VATech Hydro, Austria

Completed “big hydro” salient pole synchronous rotor for high centrifugal force at over-speed, 14 poles



Dove tail fixation of rotor poles

“Cooling fins” by increased copper width

Damper ring

Damper retaining bolts

Rotor back iron

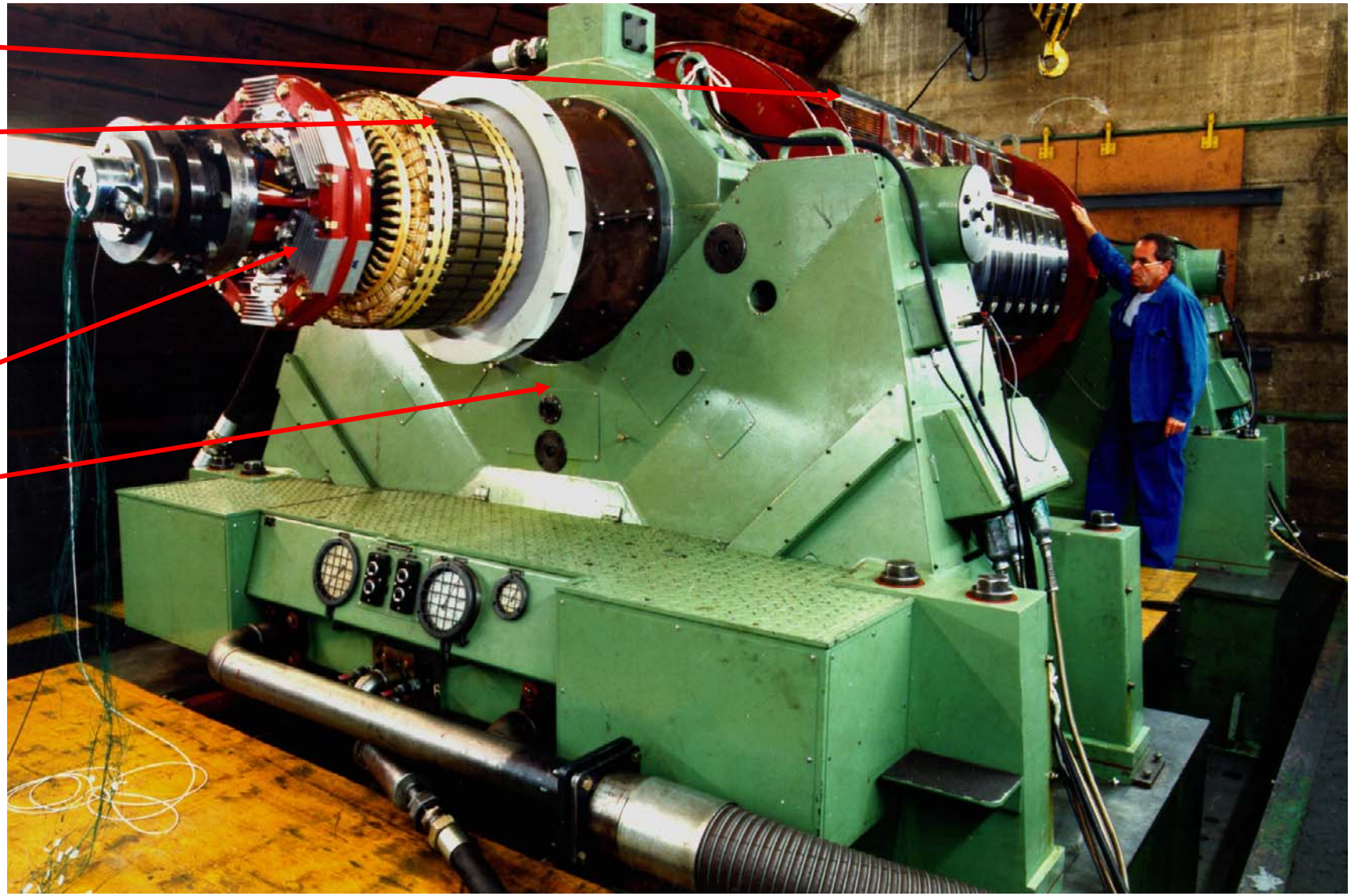
Rotor spider

Generator shaft

Source:

VATech Hydro, Austria

Balancing & over-speed test of salient 4 pole rotor in test tunnel



Source:

VATech Hydro, Austria

Manufacturing of the salient rotor of bulb type generator

Ring synchronous generator with high pole count for river hydro power plant (bulb type generators)

Rotor with spider, rotor poles with field winding and damper cage

At plant site *Freudenau/Vienna, Austria*

River *Danube*

Mounting of rotor to turbine shaft

32 MVA, 50 Hz
92 poles
rotor diameter 7.45 m
rated speed 65.2/min
over-speed 219/min

circumference velocity at over-speed:
$v_{u,max}$ **= 85 m/s**

centrifugal acceleration at over-speed: a/g = 200

Source:

VATech Hydro, Austria

Rotor spider during milling before mounting of rotor yoke

Manufacturing of bulb type hydro generator for *Freudenau* power plant

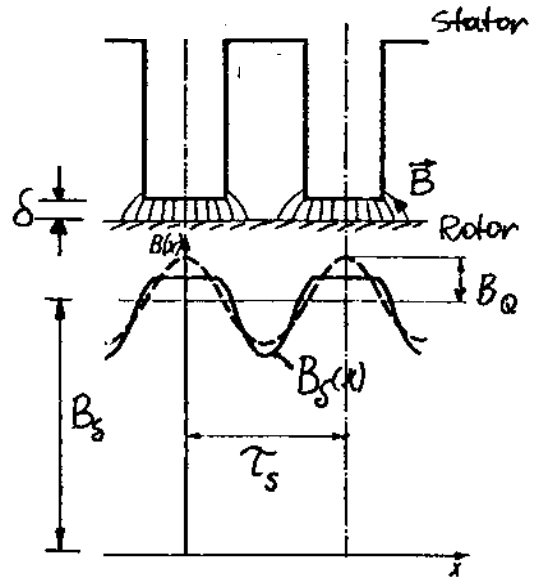
Source:

VATech Hydro, Austria

Manufacturing of poles for high pole count low speed ring generator

Pole shoes, built as laminated iron stack to suppress eddy currents, which are induced by slot ripple magnetic air gap field due to stator slot openings

Slots for damper bars



Source: VATech Hydro, Austria

Massive rotor pole shaft welded to laminated pole shoes

Source:

VATech Hydro, Austria

Drilling holes into massive pole shaft to fix them to rotor yoke ring with screws

Welding machine

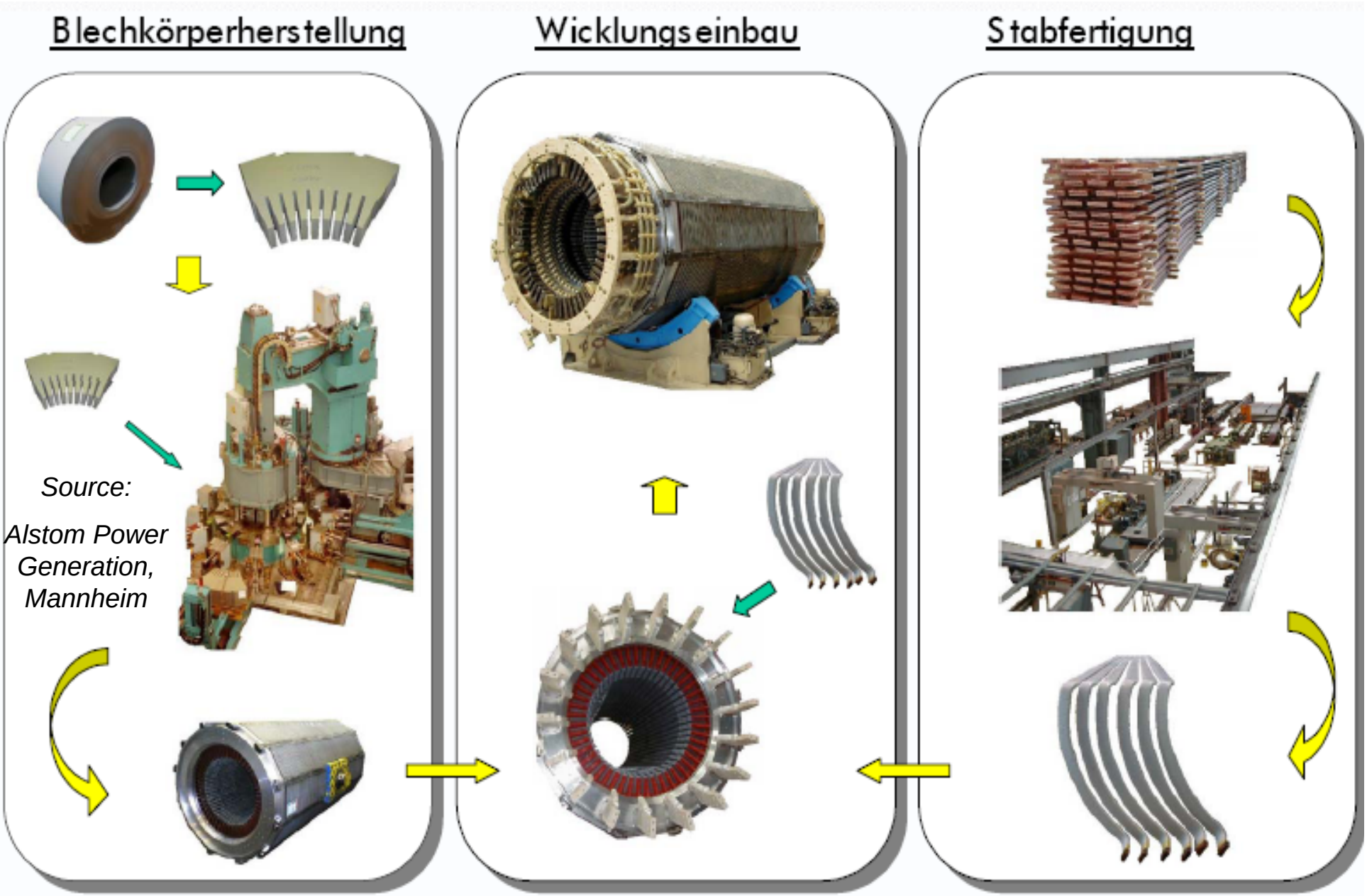
Welding of massive pole shaft o laminated pole shoes

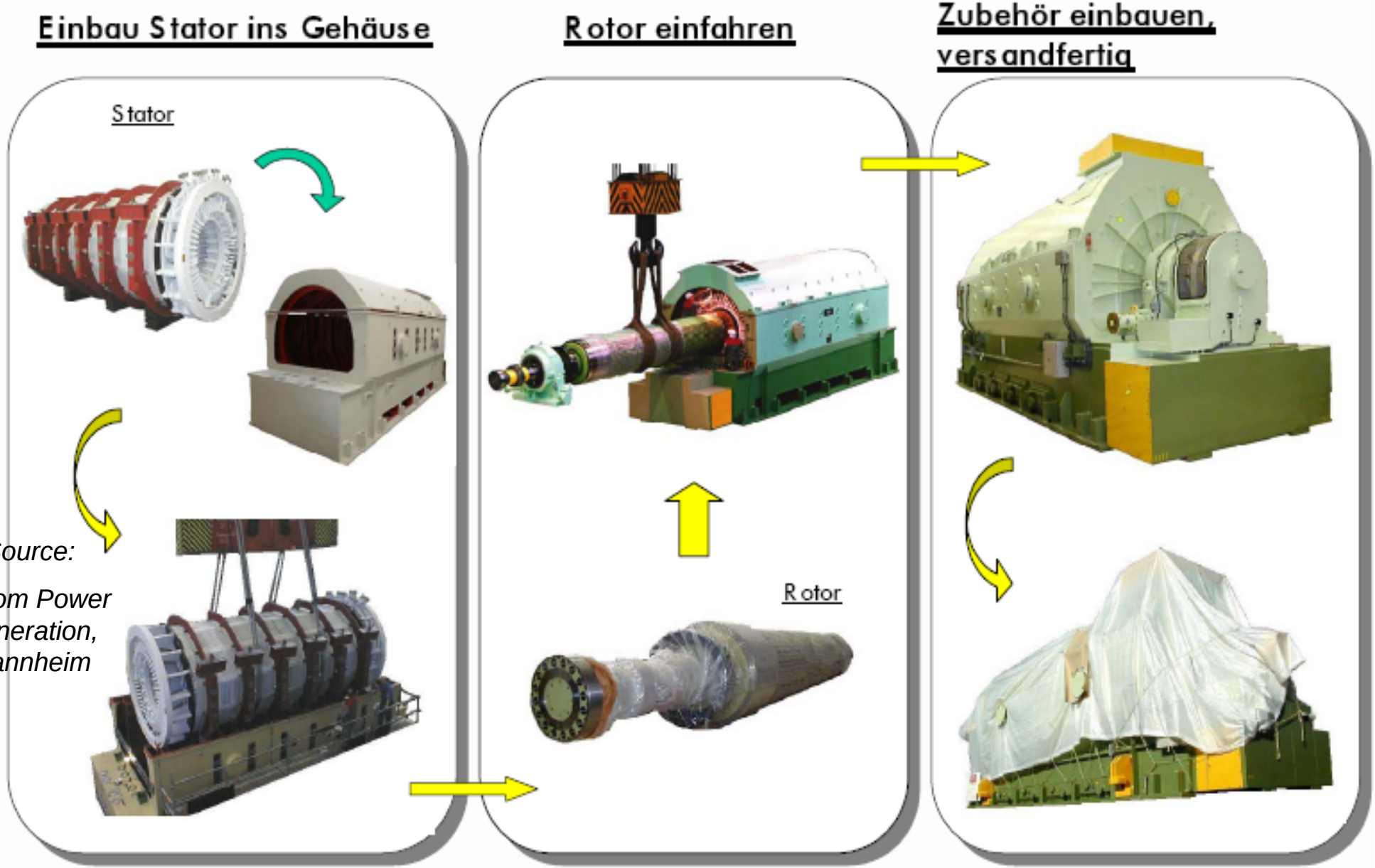
Source:

VATech Hydro, Austria

1. Manufacturing of Large Electrical Machines

Manufacturing of turbine generators


Blechkörperherstellung
Wicklungseinbau
Stabfertigung
Source:
Alstom Power Generation, Mannheim



Source:

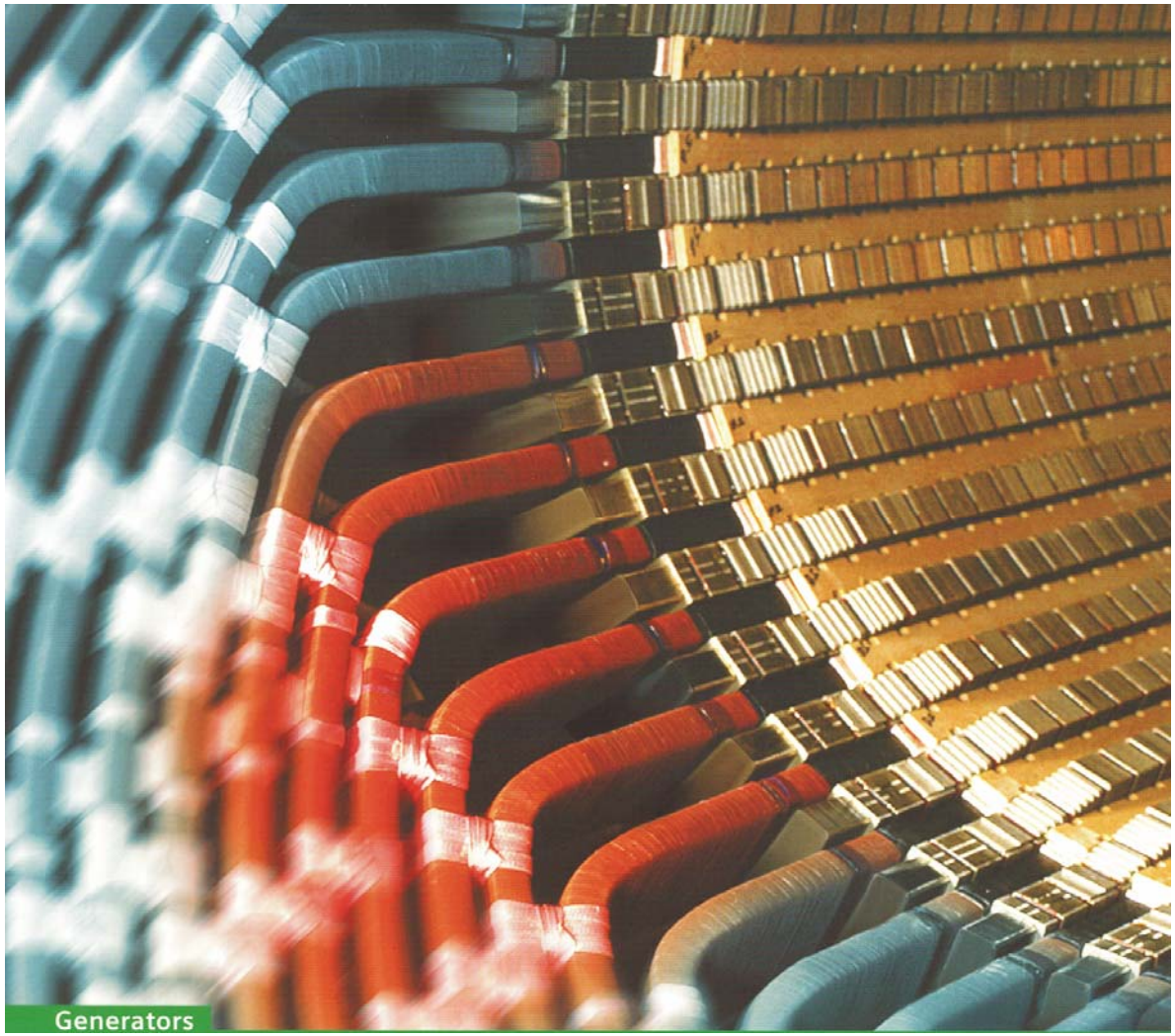
Alstom Power Generation, Mannheim

Fixation of coil overhang of stator winding

Source:

Siemens AG, Mülheim/Ruhr, Germany

Stator end zone of an air-cooled turbine generator: press plates, winding overhangs, stepped end packets

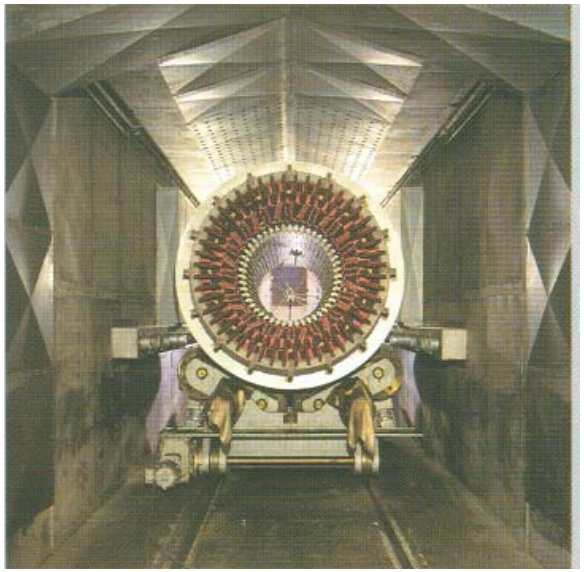


Source:

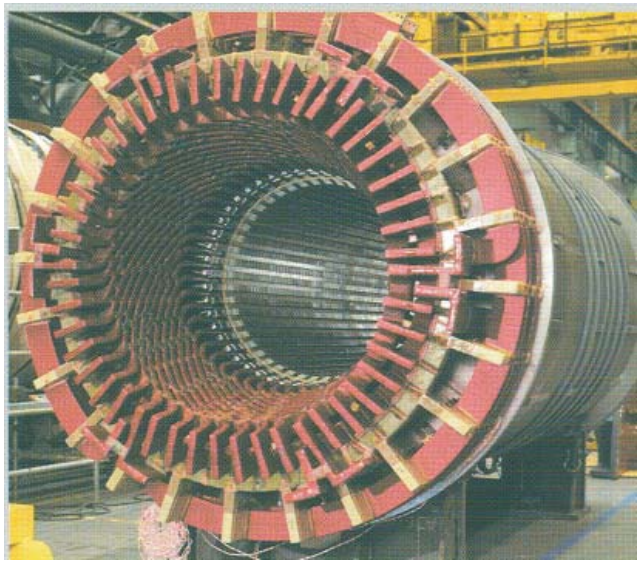
Siemens AG, Mülheim/Ruhr, Germany

Stator manufacturing

Stator core assembly with bonded stator core packs



Stator coil winding insulation system in the resin oven

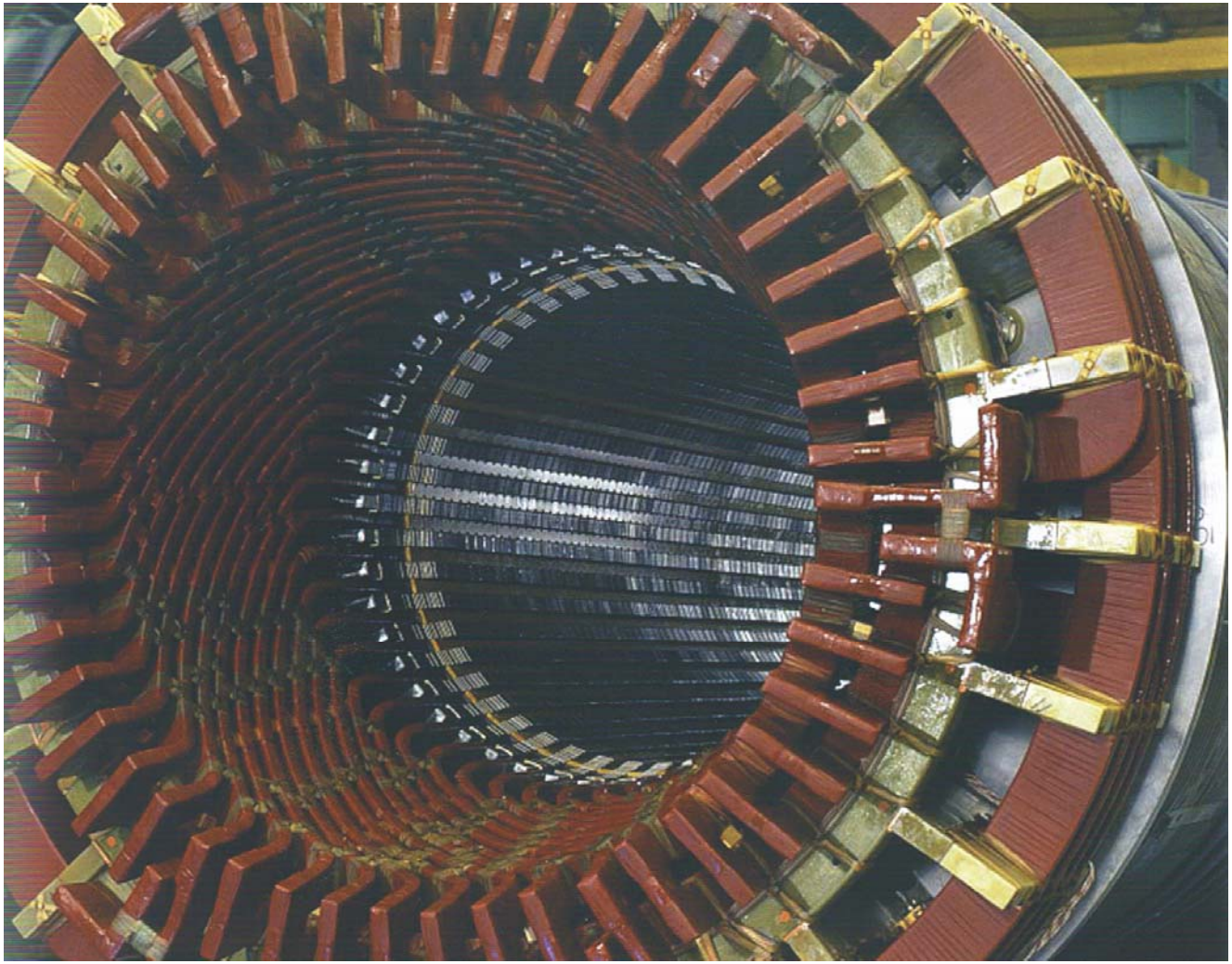


Support system of stator winding overhang

Source:

Siemens AG, Mülheim/Ruhr, Germany

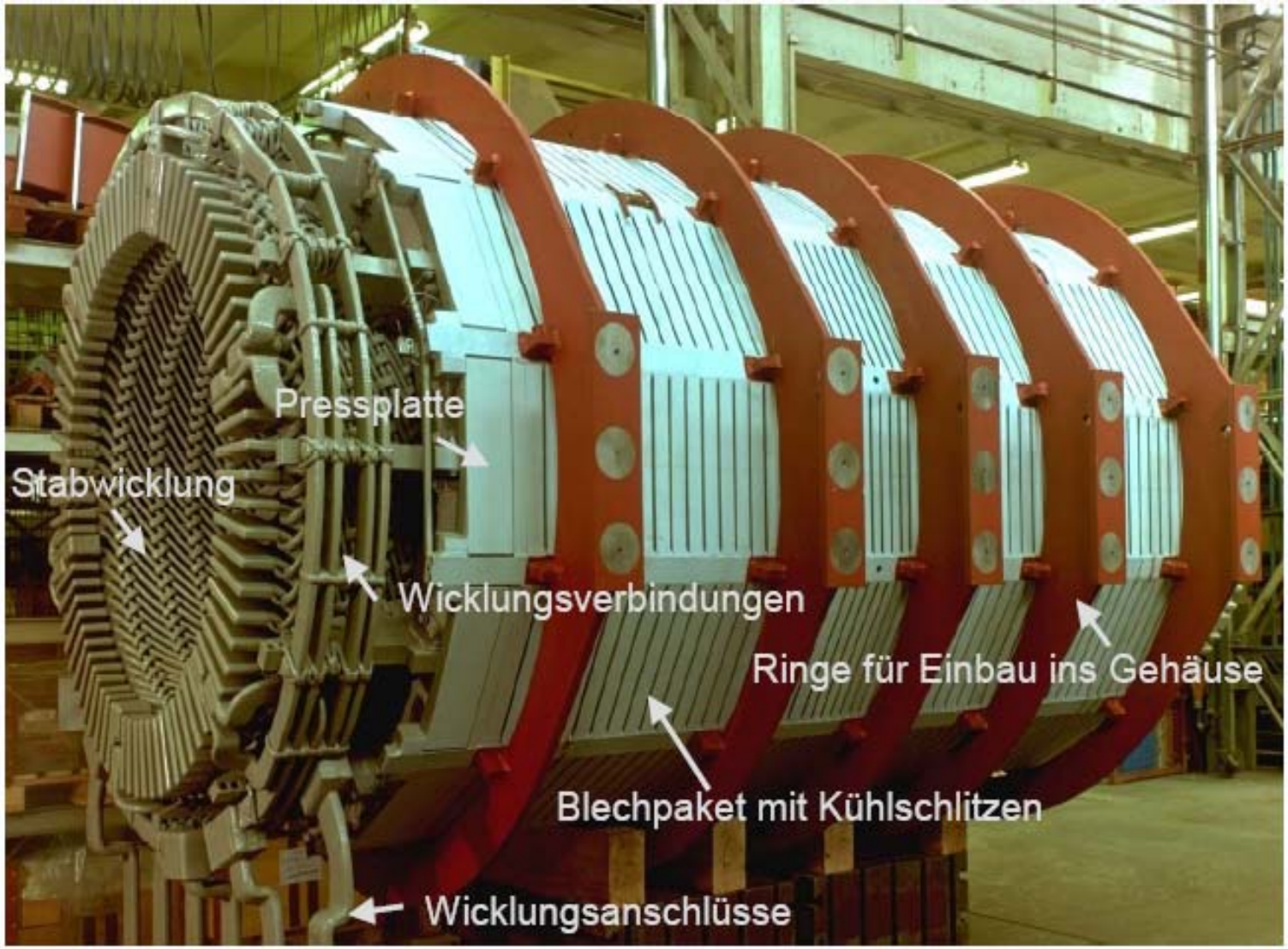
Completed stator with three-phase winding and coil connections



Source:

Siemens AG, Mülheim/Ruhr, Germany

Manufacturing of Air-cooled Stator



Source:

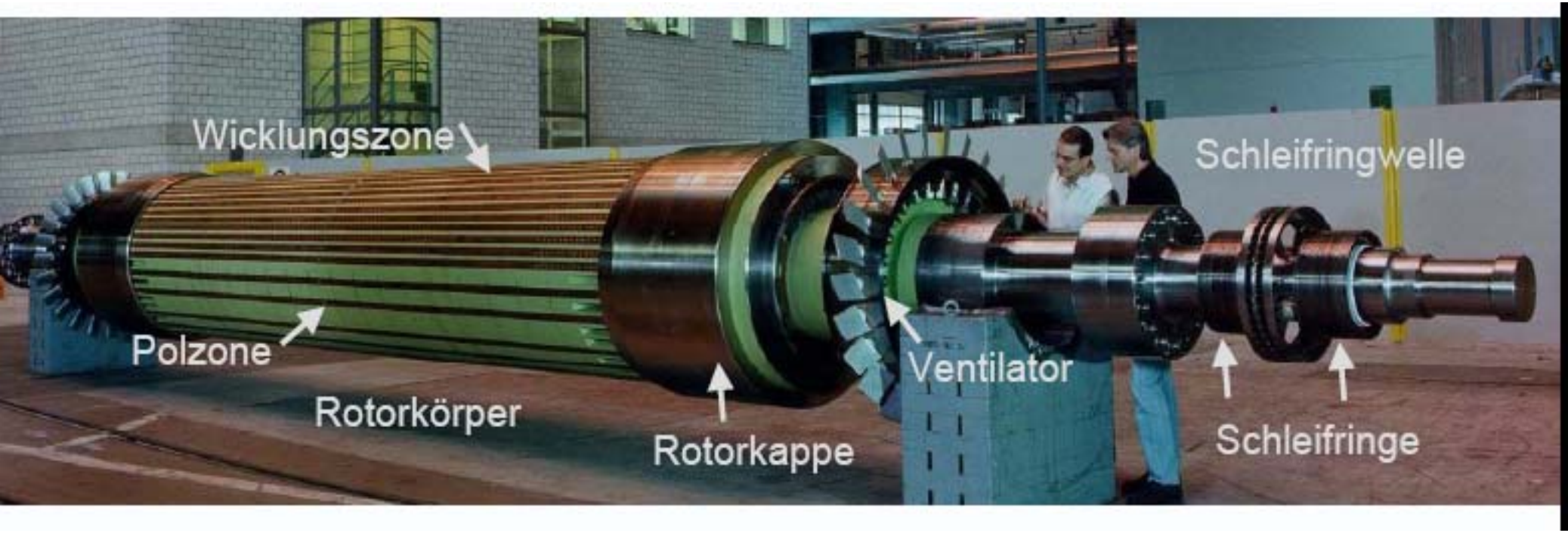
Alstom Power Generation, Mannheim

Manufacturing of stator housing

Source:

Alstom Power Generation, Mannheim

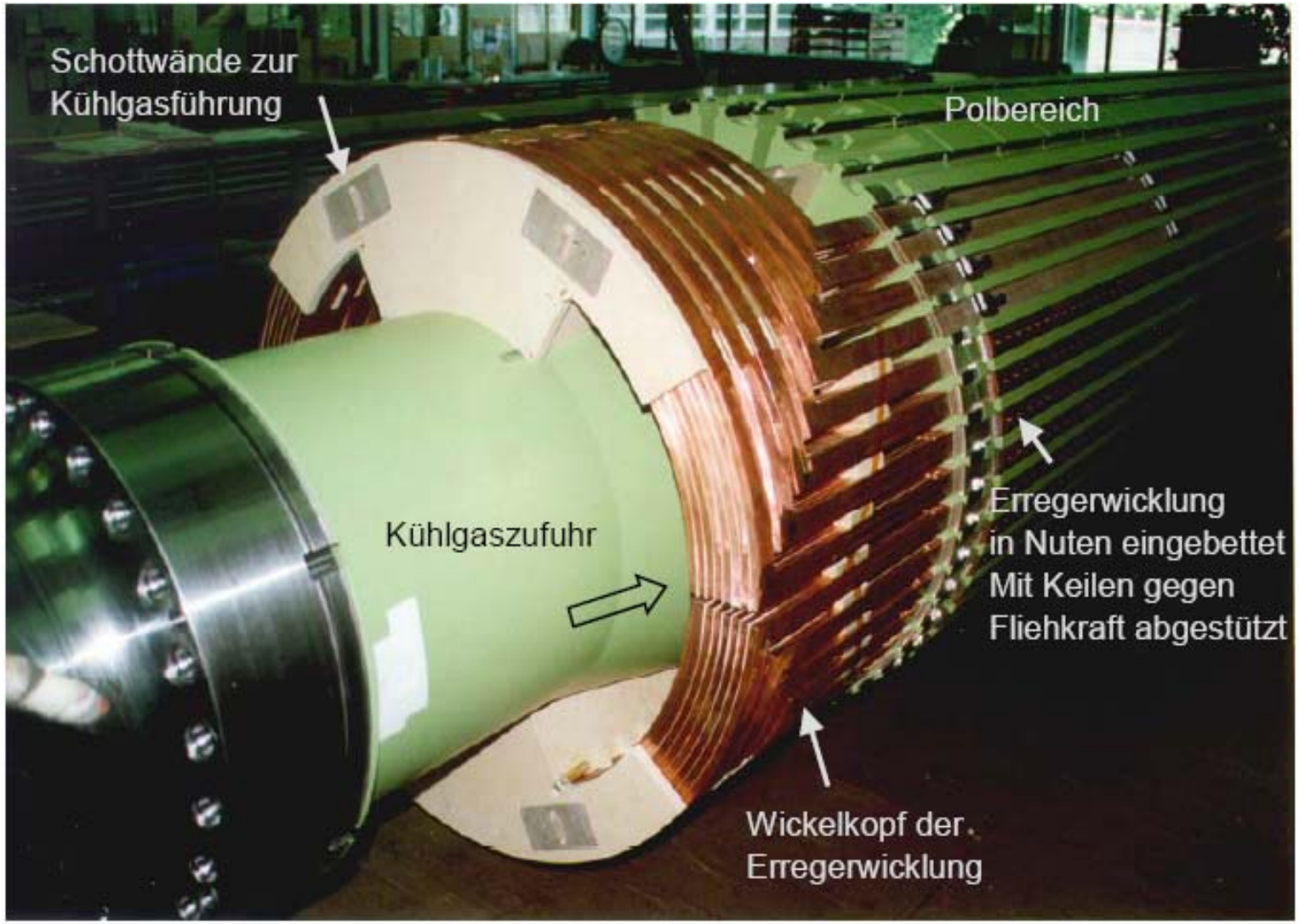
Manufacturing of Gas-cooled Two-pole Rotor



Source:

Alstom Power Generation, Mannheim

Two-pole Rotor Excitation Winding



Before the mounting of the stainless steel end caps

Source:

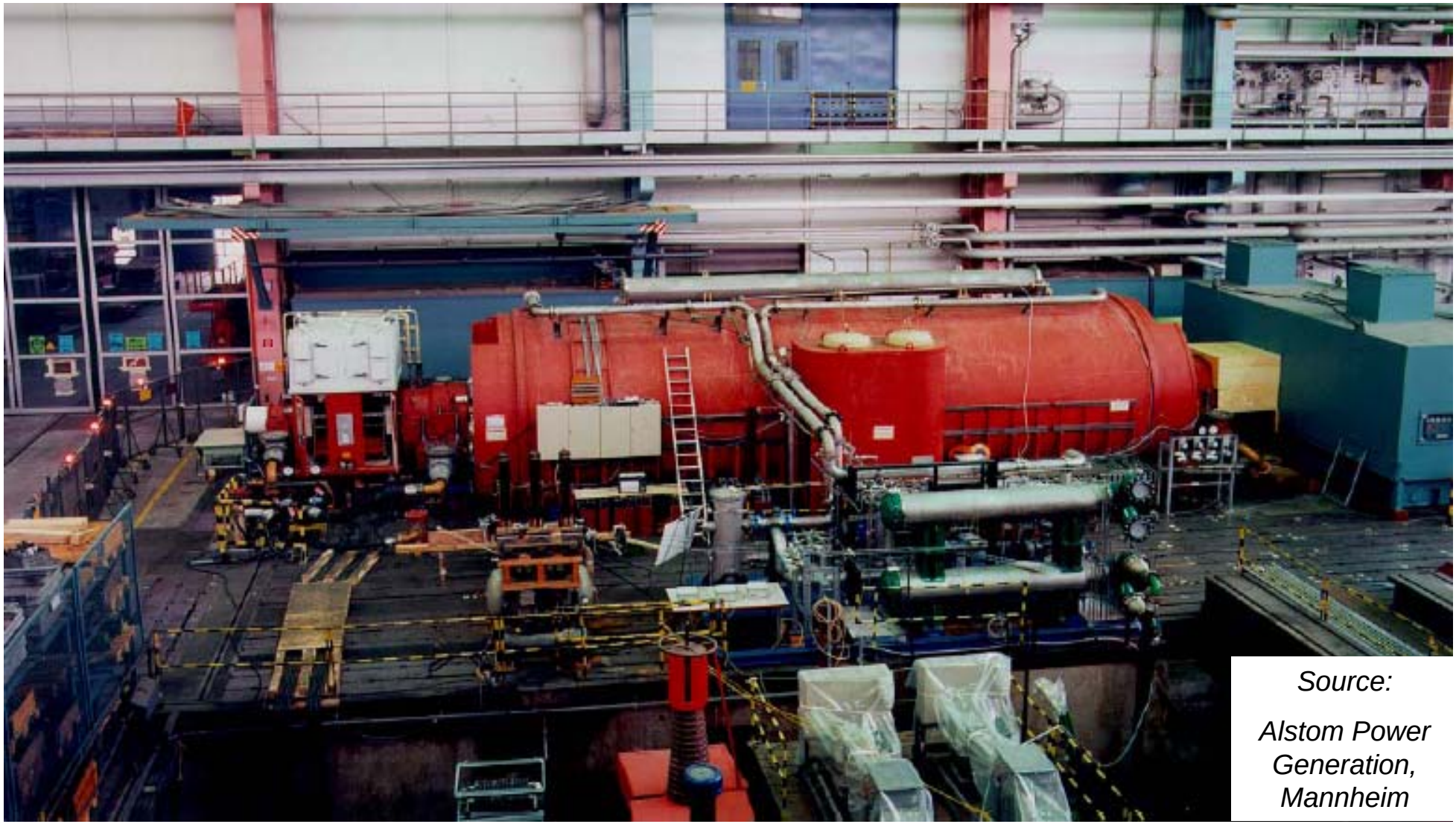
Alstom Power Generation, Mannheim

Fitting of the Two-pole rotor into the stator of an air-cooled generator for a gas turbine power plant

Source:

Alstom Power Generation, Mannheim

Testing of a turbine generator in the manufacturers test rig



Source:

Alstom Power Generation, Mannheim

Transportation of a turbine generator stator via the road

Source:

Siemens AG, Mülheim/Ruhr, Germany

Fully assembled turbine generator for easy installation on-site

Railway transportation

Car transportation

Source:

Siemens AG, Mülheim/Ruhr, Germany