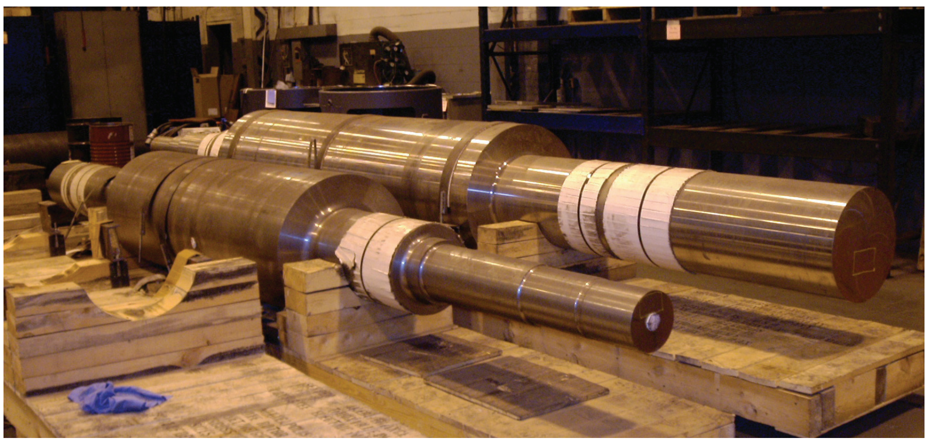
2-Pole Turbine Generators

Rotor Construction

The rotor is designed to withstand cyclic duty and rapid loading. Radial ventilation provides even cooling. Low vibration levels are achieved by dynamic balancing and machine design.



Rotor Forging and Machining

The rotor forging is a special alloy steel containing nickel, chromium, molybdenum, and vanadium. It has the physical properties required to withstand the stresses encountered over a wide range of temperature and load conditions. The forging material is produced from an electric furnace vacuum degassed ingot. All forgings are heat treated after the forging operation and stress relieved after rough machining. To control quality, a chemical analysis is made of each heat cycle, and radial test samples are taken from the rotor body to indicate the physical properties. Longitudinal tensile and impact test specimens are taken from the extra material at the end of the forging. The holes from which the radial samples were taken are tapped and plugged with steel, and are positioned to be at the centers of the poles. The forging manufacturer performs an impact test to determine the low temperature ductility of the steel. In addition, ultrasonic tests and magnetic particle tests are made to assure that the forging is sound.

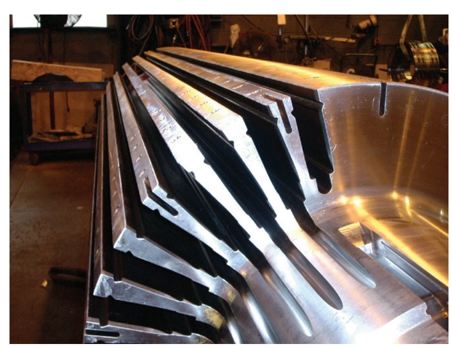
Rotor Slots

Slots for field windings are step milled over the entire length of the rotor body. They are milled in a pattern to give the 2-pole configuration and also to provide liberal area for field copper. Step milling minimizes stress level at the roots of the teeth, one of the most critical parts of the rotor. Grooves for slot wedges are accurately machined into the slot walls. Slots for rotor ventilation are positioned directly under the rotor coil slots and are reduced width extensions of the regular milled coil slots.

Field Coils

- Rotor coils are made of silver-bearing strap copper for greater creep resistance. The coil is accurately formed to precisely fit in the rotor slot with minimum distortion. Ventilating slots are punched in the straight portion of the coils to allow for radial discharge of cooling air.
- The rotor body coil slot is lined with a Nomex insulating cell formed to the exact shape of the slot. The slot cell ground insulation level is checked before the coils are installed.
- Each field coil is suspended over a pole and inserted, turn-by-turn, into the slots. Individual turns are insulated with Nomex which is coated with a B-state resin. The coils are pressed to a specified size, then heated to cure the resin and bond the turns. Aluminum alloy slot wedges are inserted to hold the winding firmly in place.
- A teflon coated strip is placed on top of the coils to help in providing a controlled slip plane for coil expansion and contraction that occurs during start/stop and loading cycles.

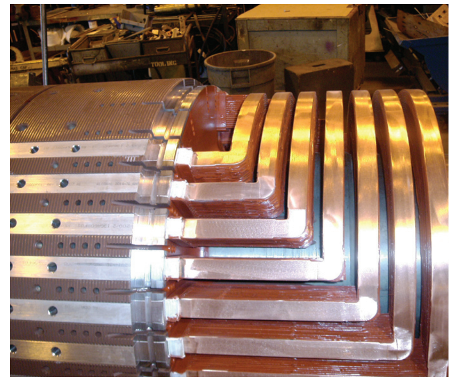
Machining radial slots in rotor forging.



Rotor slots for field winding.

Rotor retaining rings.

Rotor winding process.



Rotor end turn area.

Retaining Rings

Retaining rings support the rotor coil end turns against the centrifugal forces encountered during high-speed operation. They are made from forgings that meet rigid specifications and are resistant to stress corrosion cracking. Compliance with these specifications is assured by tests for physical properties made on prolongations allowed at the end of the forging. Ultrasonic tests are conducted to assure soundness of the forging. Any forging found to be defective is rejected. Circular steel plates are shrunk into the outer end of the retaining ring to add section and to reduce distortion. The retaining rings are shrunk on a machined fit on the rotor body. This fit is calculated to provide firm centering of the ring on the rotor body even under overspeed conditions.

Circumferential keys at the rotor body lock the rings in place. In effect, the retaining rings nest the end turns inside a shelf or extension of the rotor body and prevent displacement and consequential unbalance. Since the retainers do not depend on the shaft for support, shaft deflections cannot transmit forces that cause such displacements and unbalance. The field coil end turns are cooled by air passing circumferentially and axially between the coils and discharging through radial slots in the rotor windings and wedges.

Rotor Fans

Steel axial flow fans are fabricated, tested and balanced. The fans are keyed and shrunk on the rotor body outboard of the retainer rings.

Balance And Vibration

Precautions are taken throughout the design and manufacturing operations to ensure precise balance and minimize vibration. For example, account is taken of the fact that the stiffness of the usual 2-pole rotor varies as the rotor turns. When the poles are positioned vertically, the rotor is more resistant to bending and deflection than when the poles are horizontal. As the rotor turns, the position of these planes of stiffness changes twice each revolution, tending to cause 7,200 vibrations per minute at 3,600 rpm (120 per second). On larger ratings, to reduce the magnitude of the double frequency vibrations, transverse slots are milled into each pole face at intervals along the rotor body to equalize the rigidity of the rotor in these two planes.

Similarly, the critical speed of the rotor is controlled to avoid possible excitation of bearing oil whip and consequential vibration. This is accomplished by gradually stepping down the shaft diameter from the rotor body so as to provide optimum shaft stiffness.

The rotor is balanced in three places in a high speed balancing facility. An overspeed run is made with the rotor assembled in the generator.

Brushless Excitation

An axial hole is drilled in to the shaft at the exciter end and is used to carry DC power from the exciter, under the bearing journal, to the main field winding.

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