



HYDROGENERATORS



AnsaldoEnergia
A Finmeccanica Company

Hydrogenerators

Hydrogenerators have an extremely wide range of rotational speed depending on individual site condition.

Due to this range (usually 50 - 1200 rpm), the construction configuration of the shaft and bearings, diameter and structure of the rotor, have a several possibility.

Ansaldo Energia currently produces three basic types of hydrogenerators both for new plants and in service application:

- generators for river flow (low/medium speed);
- generators for high-head plants (medium/high speed);
- motor-generators for pumped storage systems.

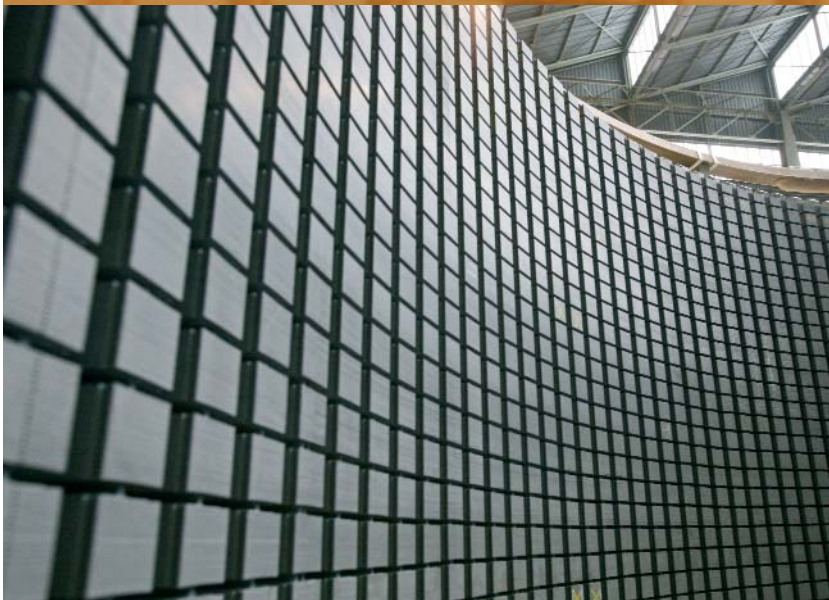
The design of electric machinery for hydro plants involves electrical and mechanical matters.

Also, insulation reliability, efficient ventilation and cooling of active parts, are of fundamental importance in all hydroelectric machines.

Ansaldo Energia has produced more than 500 hydrogenerators since 1920 and many of them are still in operation.

Up to the beginning of the Sixties, the Company operated almost exclusively in the domestic market.

Afterwards its presence in global market becomes is growing up.

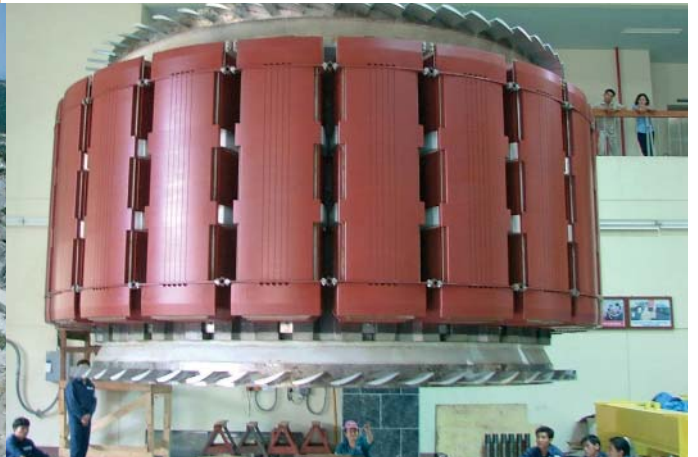


Reliability

The strong competition on the global markets has meant progress in design, manufacturing and quality control techniques with rationalization both in work methodology and in suitable use of modern CAD/CAM technology. The machinery is designed for continuous operation and faults like sudden short circuits are handled without destructive damage. Most sophisticated operation plans can be realised in our modern manufacturing facilities covered by an efficient Quality System organisation. Our comprehensive, reliable after-sales service is reviewed regularly to assimilate operating experience. Product oriented R&D guarantees constant, gradual evolution in line with customer needs.

Design features and manufacture

Ansaldo Energia hydrogenerators are self-ventilated in an open or closed circuit with air to water coolers with indirectly cooled stator and rotor winding. The stator comprises the frame, the stacked stator core and the winding. According to transportation and erection limits, the stator can be divided, each section being assembled onto successive one with bolts and dowels. The stator core comprises several lamination packets fabricated from high quality magnetic silicon steel sheets coated on both sides with class F insulating varnish. The core is cooled by air passing through radial ducts between lamination packets. The stator has a two-layer winding insulated with class F glass fabric and continuous mica sheet pre-impregnated with epoxy resin filler (resin-rich system).



The stator winding is lap or wave type, closed coils or two half-coils, according to suitable design. After curing, the insulation meets all class F requirements as well as having excellent long-term in-service durability and outstanding mechanical and electrical properties. Conductive varnish and tapes prevent corona discharges between the insulation and the slot wall or in the end region. Coils are firmly braced in the slots by means of epoxy-glass slot wedges and a ripple spring to prevent loosening after long service.

In low speed hydrogenerators the rotor comprises the poles, the laminated rotor rim, the welded spider and the shaft. Both through shaft and stub shaft solutions are available.

The laminated rotor rim consists of segments assembled on site at the plant, thus overcoming any transport problems.

Each segment is made of punched steel plate with well-defined surface finish, flatness and thickness characteristics and other mechanical properties. In alternative, if allowed by mechanical stresses and transportation limits, the rim consists of an integral rolled rotor ring with appropriate holes for poles attachments.

The spider, made of welded steel plates, consists of a central hub and radial arms welded to the central hub. Slots are axially obtained at the end of the arms suitable for wedge-shaped keys.

They lock the spider to the rim in a tangential and radial direction.

The most frequent configuration of rotor for high speed generators and generator-motors involves forged rings with cast hub and stub shafts.

Forgings are comprehensively inspected by sampling and ultrasonic testing.

Purchasing specifications include heat treatment quality after reforging, residual stresses and surface finishing.

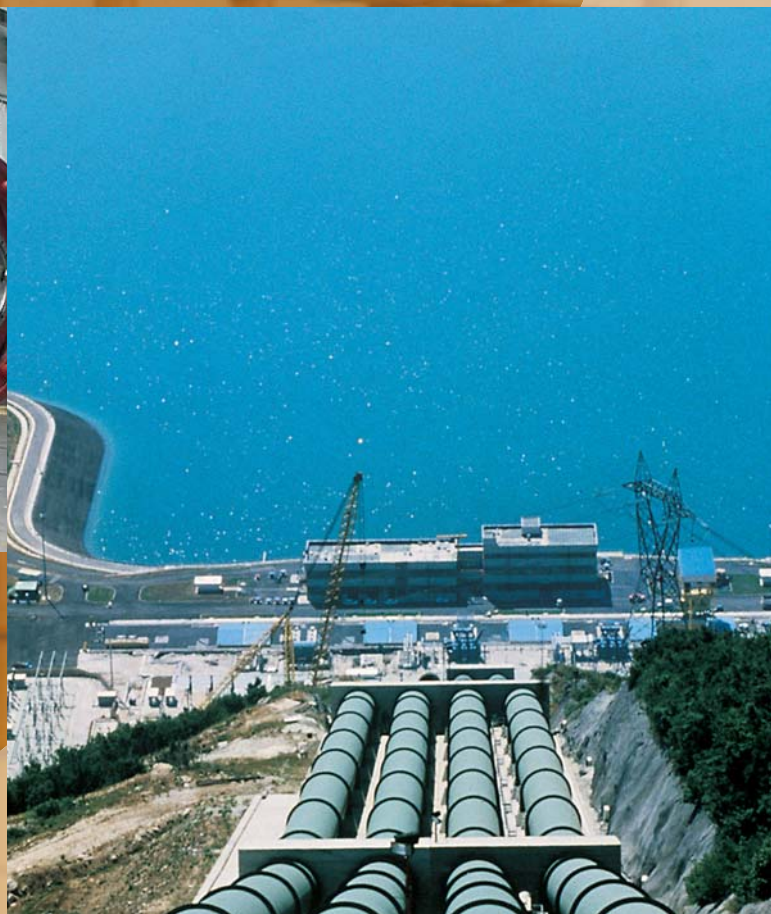
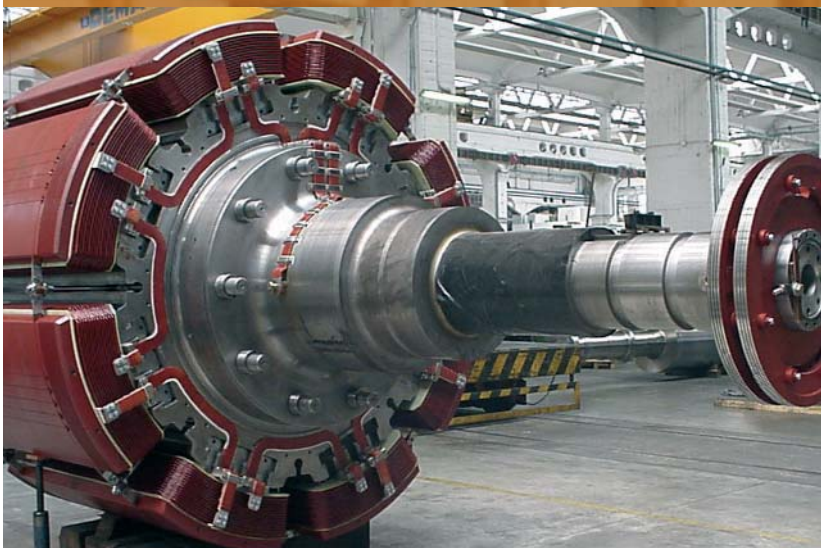
Appropriate tests are performed to ensure compliance to specifications.

The mechanical and magnetic properties of materials are tested at the supplier's workshop.

Recently, when stresses allow, the preferred solution is with laminated rotor rims in high speed machines too.

The poles consist of punched steel laminations with high mechanical and magnetic specification.

The pole stack is compressed between two steel pole end-plates of high mechanical specification with strong pole tie bolts. The pole body is normally of rectangular shape.



A typical feature of high speed machines is the trapezoidal pole body, which has inclined longitudinal sides to allow the corresponding coil bar centre-line to be positioned at a right angle to the rotor radius.

This configuration, used in case of high mechanical stresses, may be the only option open for designers to solve problems caused by centrifugal forces acting on the rotor winding.

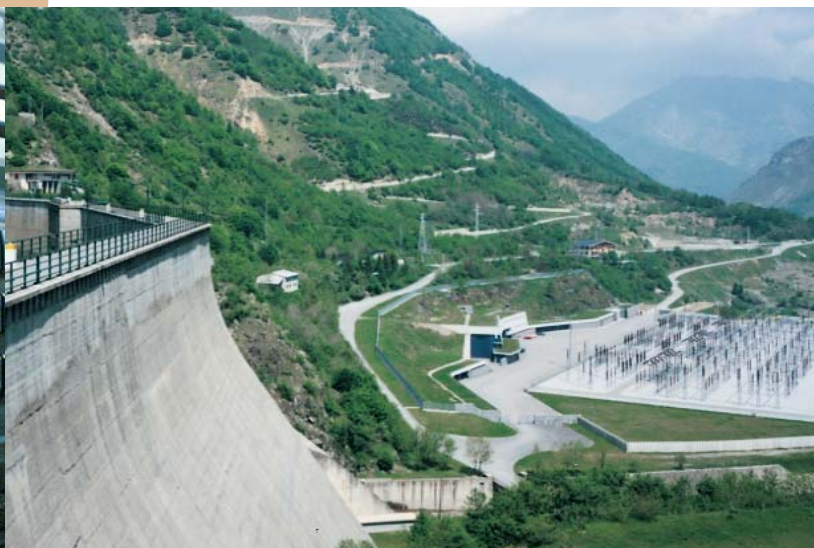
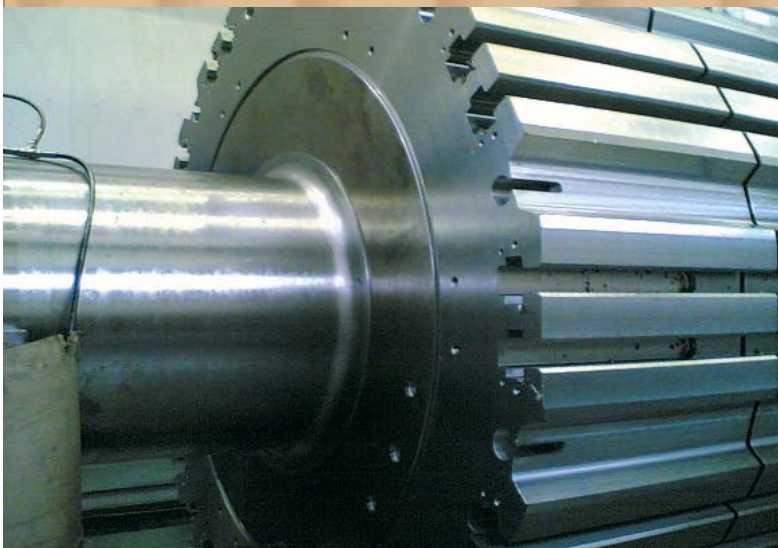
The poles are fixed to the rotor rim with T-head pole joints and wedge shaped keys. With rolled rotor rim ring the poles are fixed by means of bolts. Usually, to improve the generator behaviour during transients, poles are equipped with a damper winding (complete cage). The rotor winding consists of edge-wise wound strips of electrolytic copper.

The coils are obtained by brazing copper plates with butt joints. The insulation between the turns is given by inserting glass-cloth of appropriate thickness pre-impregnated with epoxy resin, class F.

All hydrogenerators and generator-motors manufactured by Ansaldo Energia have indirect air cooling.

Both axial and radial self-ventilating configurations are adopted. While radial ventilation is a possibility for generator-motors, cooling by electric blowers is advisable. Rim ventilation systems offer a more typical design solution for low speed machines but are not exclusive to them. Two axial fans mounted on the rotor initiate an axial airflow, which combines with an additional flow from the rim and the spider. Increased cooling is achieved using a duct in the central part of the rim and holes in the spider disks. This reduces aerodynamic resistance in the circuit by opening a route parallel to the space between the poles. The goal is to keep uniform temperature along stator and rotor avoiding any possible hot spots in the central part of the rotor winding.

According to generator arrangement, the rotor is supported with guide, thrust, combined thrust-guide bearings or pedestal bearings in horizontal morphology.



Excitation system

Both fully static (standard) and brushless excitation arrangements are available.

The fully static excitation system comprises an excitation power transformer, a power converter with controls and protections and a static circuit breaker.

The brushless excitation system comprises an AC main exciter and a rotating rectifier. Brushless exciters can be configured for either self ventilation or with air draw from the generator cooling path.

Testing

All generators are subjected to a standard program of tests including:

- stator core magnetization
- winding resistance
- insulation resistance
- impedance measurement
- high potential

Ansaldo Energia has a centrifugation facility to balance and overspeed test high speed machines with an output of over 300 MVA, runaway speed over 1,000 rpm, fly wheel effect over 6,000 tm² and rotor weight over 400 tons. All tests are performed in compliance with IEEE and IEC standards.



Braking and lifting plant

Cyclical service of vertical hydrogenerators units calls for frequently stopping and starting. Braking and lifting plant is furnished to achieve rapid deceleration of the unit and to lift the rotor during maintenance.

The plant consists of a number of jacks placed on the lower bracket or directly on the foundations, connected to the compressed air reservoir (braking), and to the high pressure oil reserve (lifting).



Assembly and transport

Ansaldo Energia can assemble machinery both at its production facilities and on site according to transportation limits and customer requirements.

Laminated rotor rim is nearly always assembled on site.

Reference standards

Generators are designed in compliance with IEC 60034-1 and IEEE C50.12.

Coupling

Ansaldo Energia hydrogenerators can be coupled to Kaplan, Francis and Pelton turbines. The standard rotor coupling is integral with the rotor shaft. Different coupling arrangements including shrunk-on and double couplings for horizontal shaft configuration can also be supplied.

Start up and after sales services

Ansaldo Energia can meet all customer requirements in the hydrogenerator field, supplying:

- components
- aggregate lots
- turnkey plants
- refurbishment

Ansaldo Energia offers a full range of services and qualified personnel for erection and/or supervision, start-up and testing.

The Ansaldo Service Organisation provides technical assistance services worldwide in the fields of maintenance, spare parts supply and preventive maintenance programs, so ensuring that customers are in the best position to achieve optimum operation.

The Ansaldo Service Organisation also provides customers with personnel training courses organised in house using specially prepared didactic materials.

Main supplies

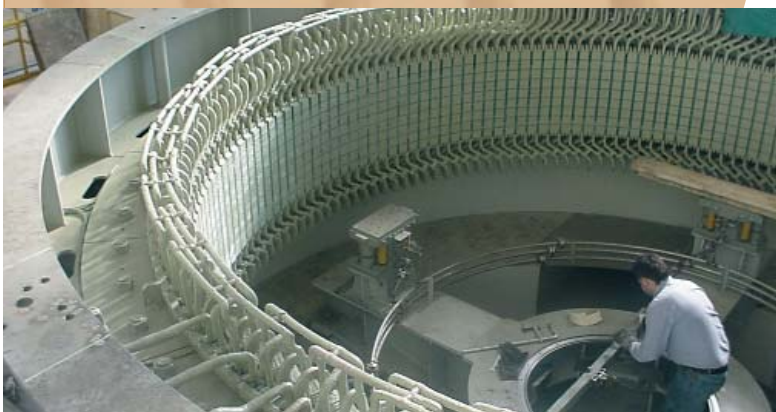
In the field of reversible motor generator units Ansaldo was already a technological leader in 1938 with the Provvidenza Hydro plant (60 MVA, 375 rpm).

Since then many different types of hydrogenerator with increasing technology ($TD = MVA \times rpm/1000$) and size ($S = MVA/rpm$) indexes (see table below) have been designed, manufactured and put successfully into service throughout the world.

Ansaldo Energia's main high speed generator-motor references are Presenzano (3 units, 300 MVA, 428 rpm) and Chiotas (4 units, 170 MVA, 600 rpm) in Italy and Mosul Dam (Iraq, 2 units, 150 MVA, 500 rpm) abroad.

The most important low-speed generators manufactured and designed by Ansaldo Energia are Itaparica (Brazil, 3 units, 290 MVA, 82 rpm), Betania (Colombia, 3 units, 211 MVA, 128 rpm) and El Caracol (Mexico, 3 units, 208 MVA, 128 rpm).

Other important low speed generators including ITA' (Brazil, 5 units, 305 MVA, 128 rpm), Salto Caxias (Brazil, 4 units, 345 MVA, 90 rpm) and Machadinho (Brazil, 3 units, 418.5 MVA, 120 rpm), were designed and manufactured on a joint basis with other companies.



Ansaldo Energia has over 150 years experience in the electrical and mechanical engineering business. It is a global player in the power generation sector with an installed capacity of over 170,000 MW. Ansaldo Energia offers the full range of manufacturing, engineering, contracting and service activities, as well as a flexible approach to power projects.

Steam fossil fired, gas turbine and combined cycle, hydroelectric, geothermal and nuclear power plants, supplied turnkey, in separate lots or by components. The Quality Systems, certified as complying with ISO 9001 by a recognised certification society, cover all aspects including, design, planning, manufacture, testing, inspection, installation and servicing.



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