

# Application note

## Synchronous motors for lift irrigation systems

Synchronous motors are well suited for the combination of high power and low speed required in lift irrigation and other vertical pump applications.

For lift irrigation projects in India, ABB has supplied more than 20 custom-built synchronous motors rated in the range 4 - 30 MW.



Lift irrigation can transform farming conditions in high or arid areas where it would otherwise be difficult to grow crops. Pumps are used to lift large volumes of water from a river to a higher level, and the water is then redistributed in channels, either by means of gravity or using pump-equipped booster stations. Water can be distributed at pumping capacities of close to 700 cubic meters per second to large areas involving distances of up to 300 kilometers and 60-meter altitude differences.

At the heart of lift irrigation projects are one or more pumping stations with three to 10 pumps each. Pumping typically requires high power at a constant, low speed – the kind of operating conditions where synchronous motors are highly efficient. For projects in India, ABB has designed and supplied AMZ type synchronous vertical pump motors. Rated from 4 to 30 MW, most of the motors have pumping capacities in the range 10 – 25 cubic meters per second. They were provided in conjunction with a large pump manufacturer, which was responsible for delivering, erecting and commissioning the pumps. The pump arrangement itself is a vertical assembly with the motor on top, connected to an impeller through a bolted flange coupling.

### Application details in brief:

Type:	Synchronous motors in vertical pump applications
Delivered:	2008-2011
Purpose:	lift irrigation projects, India
Designation:	AMZ
Voltage:	11 kV
Frequency:	50 Hz
Power output:	4-30 kW
Speed:	300-600 r/min
Poles:	10-20
Shaft height:	1,250-2,500 mm
IP class:	54 and 55
Cooling:	air-to-water

## Direct-on-line or frequency converter starting

Depending on the capacity of the grid, the motors are either started direct-on-line (DOL) or using a frequency converter. Motors in water pumping applications must be accelerated against the full pump counter-torque curve. At zero speed the load will be 20 percent of the maximum, depending on the properties of the pump itself. During start-up the load torque will increase exponentially up to 100 percent; this is a significant challenge when a motor is started DOL and moves to full speed in about three to six seconds. Therefore it is essential that the supply network has sufficient short-circuit capability and the motor is designed to withstand the resulting current and heat generation in the rotor.

Starting the motor using a frequency converter is, in fact, the most common choice in large volume pump applications. The motor is started and accelerated to full speed by a frequency converter before it is synchronized to the network. This type of starter consists of several switchgears, transformers and a load commutated inverter (LCI) type frequency converter.

As soon as the motor has been synchronized, the frequency converter is bypassed and the system moves to operation at constant speed. The starting time is about 60 seconds longer than with DOL starting, but this is usually acceptable in water pumping applications. Most importantly, electro-mechanical stress during starting is significantly reduced. Frequency controlled starting limits the current drawn from the network

to between 50 and 60 percent of the rated current, avoiding voltage dips that could damage the motor and cause network disturbances. Frequency converter starting also means that a smaller motor can be used – it only needs to be the size required for constant speed operation – so the required investment is reduced and the motor consumes less energy.

## Mechanical design considerations

In terms of mechanical design, synchronous motors for vertical pump applications have to be customized for each project. The main variables are the speed and power required for the specific pump, as well as the actual pump design. On the basis of this information, the shaft dimensions and bearing arrangement can be determined.

For design purposes, the motor-pump assembly should be regarded as a single system. The shafts are connected through a rigid coupling, so they must be considered as one long shaft in stress calculations. The design therefore involves shaft lengths of up to ten meters, which increases the risk of resonance between the operating speed and lateral frequencies. There may be excessive vibrations in the assembly, resulting in fatigue damage and shortening the lifetime of the shaft and bearings. This problem is solved by modifying the diameter and length of the shaft, or changing the position of the bearings, so that the operating and lateral frequencies are safely separated.

The motor and pump shafts are forged in solid steel, and the bearing arrangement includes two guide bearings and a thrust bearing for axial loads. The bearings are all journal bearings specially designed for vertical operation and fitted with an oil circulation and cooling system. The axial loads range between 300 and 1100 kN, while radial loads are relatively low. Journal bearings are preferred over rolling bearings because they can bear high axial loads.

## Main benefits of ABB synchronous motors

ABB synchronous motors are designed for low losses, resulting in high efficiency, and the network power factor can be compensated by adjusting the motor's power factor during operation. When the initial investment, energy consumption and maintenance costs are taken into consideration, these motors represent a cost-efficient and reliable solution for lift irrigation and other vertical pump applications. ABB therefore believes that synchronous motors will continue to be the preferred choice for lift irrigation projects in the future.

ABB is a major supplier of large synchronous motors, which provide reliable and efficient service in process industries, the marine and offshore sectors, utilities, and a number of special applications. A global network of service centers ensures that local support is available quickly, no matter where the customer is located in the world.

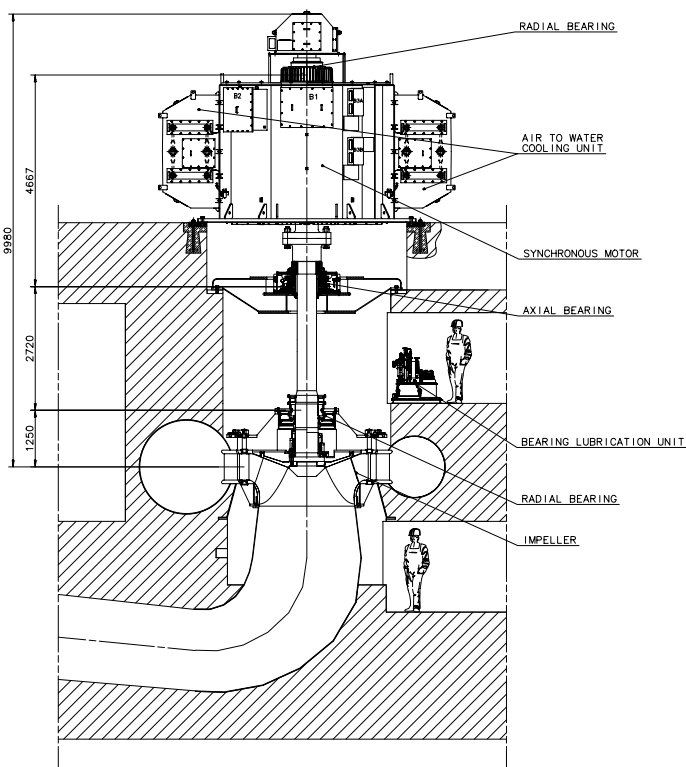


Figure: The pump assembly is vertical, with the motor on top of the pump.

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