

Permanent Magnet Motor (PMM)

The innovative environment-friendly motor

With a return on experience of more than 3,000 PMMs since 1999, Alstom brings you unsurpassed PMM expertise and track record in rail transport, across the spectrum of train types.

KEY REFERENCES*

VAL (Lille, Toulouse, Roissy in France &

Torino in Italy): 2,104 motors - 1999

Dualis (Lyons & Nantes in France): 288

motors - 2010

Istanbul Tram: 148 motors – 2010

NTV, Italy: 250 motors - 2012

Aubagne Tram: 32 motors - 2014

Regiolis, France: 665 motors - 2014

*Date of revenue service

HIGHLIGHTS

- **Proven solution:** 3,000 PMMs in operation
- **Energy savings:** 15%
- **Efficiency:** 97%
- **Light weight:** Up to -40%
- **Compactness:** Up to -25%
- **Power-to-weight ratio:** Up to 1.33 kW/kg
- **Dirt reduction:** - 15%
- **Noise reduction:** - 4%

GENERAL DESCRIPTION

PMMs belong to the synchronous motor category. The stator produces a rotating magnetic field while the rotor creates its own flux thanks to embedded permanent magnets. A PMM rotates at the same speed as the magnetic field produced by the stator windings: If the field is rotating at 1,800 rpm, the rotor is also turning at 1,800 rpm. The only difference with an asynchronous motor is that the rotor winding is replaced by permanent magnets.

In a railway market which is more and more focused on technology and processes that are environmentally responsible, Alstom's PMM achievements deliver energy savings at train level up to 15%. This is thanks to increased efficiency (97%) and lower mass (up to -40%). Additional benefits include: Less bulk and noise generation as well as easier maintenance.

CUSTOMER BENEFITS

Energy consumption reduction

A PMM contributes to train mass savings as it is lighter than an asynchronous motor for a given power rating. A PMM is a strong lever to reduce energy consumption thanks to its improved efficiency (~+3%), and considering that asynchronous and PMM efficiency gap is higher at lower speed, it is estimated that net energy savings can reach up to 15% with a PMM.

Closed self-ventilated technology

A PMM enables to switch from open to closed motor, impacting maintenance costs thanks to fan elimination and dirt reduction (roughly -15% at motor level). This technology also ensures protection against polluted environment and extreme climatic conditions (Humidity, snow, ice).

Power-to-weight compactness

A PMM has a higher power-to-weight (kW/kg) ratio than asynchronous motors which enables either to build lighter motor by keeping the same performance or to increase motor performance in the same envelope. Alstom is able to propose innovative train architectures thanks to PMM compacity (up to -25%) and outstanding power-to-weight ratio (up to 1.33 kW/kg). For example, PMM enables to keep the same performance as a water-cooled motor. Cancelling the need for water-cooling unit directly saves space on the roof for other equipment, saving water-cooling unit maintenance costs. More generally, PMM solutions enable to keep the same power with a lighter & more compact motor, easier to integrate, thereby contributing to train mass savings.



Alstom Citadis Tramway PMM

Noise reduction

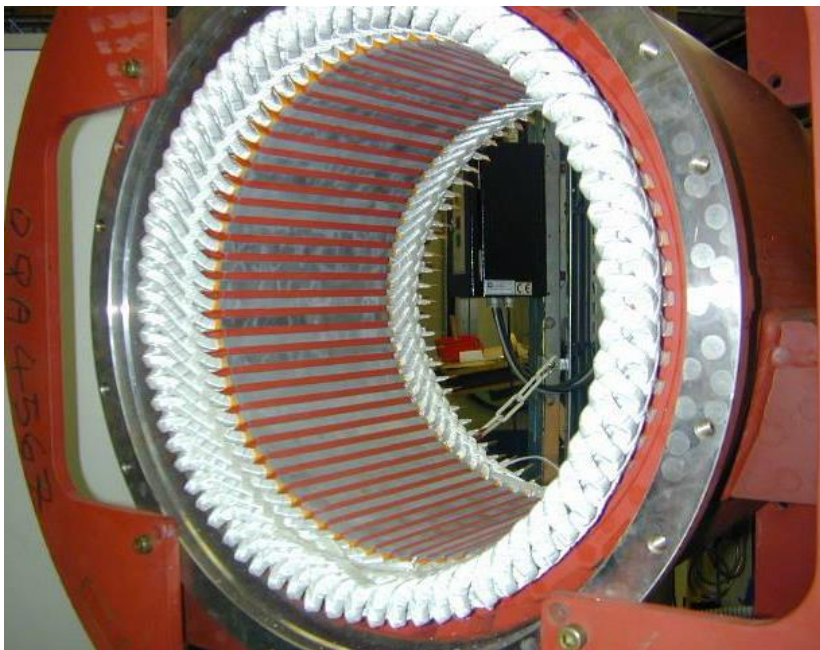
Thanks to its high torque density (N.m/kg), a PMM enables to provide its continuous power rating (kW) at a lower speed rotation than self-ventilated asynchronous motors. As a consequence, noise is lower at maximum speed compared to equivalent self-ventilated asynchronous motor. Moreover, as there are fewer losses to eliminate thanks to PMM higher efficiency, ventilator is smaller. PMM sound power level is then reduced by 4% compared to equivalent open asynchronous motor.

Easy maintenance

As described, a PMM has no cooling auxilliary, no filter and no internal cleaning, therefore simplifying maintenance operations compared to open forced ventilation motors. Alstom has developed technologies, for instance the motor bearing replacement, without dismantling the motor, dividing the maintenance time by 2, and thereby creating immediate gains on total cost of ownership (TCO).

Reliability & availability

As the PMM is axle-controlled (1 converter per motor), the level of availability of the traction chain is higher. Electrical braking also has a better availability, as an asynchronous motor power at high speed is decreasing while a PMM power is stable, and as the PMM rotor has an autonomous magnetic flux which enables electro-dynamic brake capability even in case of power shutdown.



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