Development of Wheel Hub Motor Drive Application in Electric Vehicles

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ABSTRACT

In order to choose the optimum type of electric motor for Formula Student type race car applications, literature review has been conducted. Electric motor types such as AC Induction Motor (ACIM), Brushless DC (BLDC) Motor, Permanent Magnet Synchronous Motor (PMSM) and Stepper Motor & Switched Reluctance (SR) motors are compared. Results have shown that Permanent Magnet Synchronous Motor is the best option with its 95 percent efficiency. Further research has done comparing sub categories of PMSMs which are Interior Permanent Magnet motor (IPM) and surface mounted PM machines (SPM) in which IPM motors are selected as the best candidate for traction applications with their higher capacity of torque production. Finally, SolidWorks design of wheel assembly parts comprising planetary, upright and motor has been done using design parameters and dimensions.

INTRODUCTION

Electric motor concept revolutionized the industry by their extensive advantages over the internal combustion engines (IC) by means of low environmental effect and efficiency (Çakır, 2004, p.1). The electric motor under this project was designed for the Formula SAE competition which is an international university student design competition (Carraro, Degano, Morandin & Bianchi, 2013). Four-wheel independent drive configuration concept is considered in which every wheel is controlled by its own torque source which is the motor (Çakır, 2004, p.2).

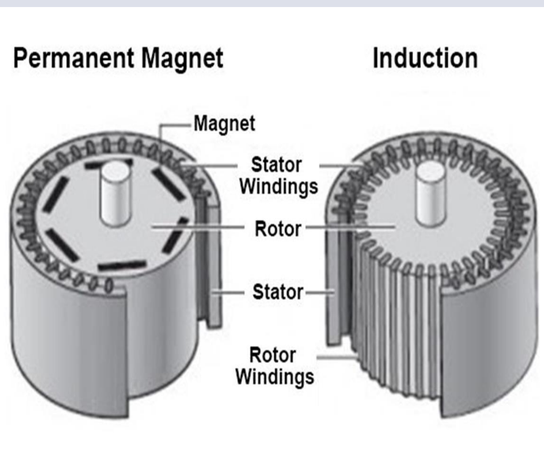
https://motorwallpapers.org/protean-hub-motor/

Advantages of Electric Vehicles

- Low environmental effect
- Fast response
- High torque capability
- Interior vehicle space utilization
- Elimination of gearbox, differential box, drive shaft (Çakır, 2004, p.2)

OBJECTİVES

- Selection of a wheel hub motor for Formula Student type race car applications.
- SolidWorks design of wheel assembly



http://empoweringpumps.com/ac-induction-motors-versus-permanent-magnet-synchronous-motors-fuji/

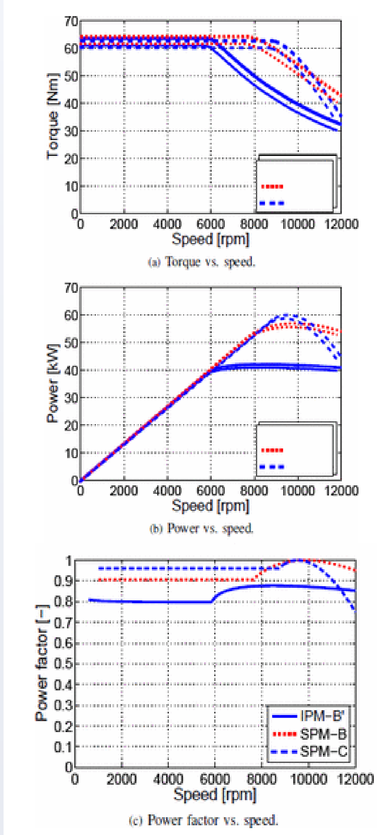
Induction motor and a PMSM are compared where PMSMs outran IMs in terms of high air gap flux density, high power-to-weight ratio, large torque-to-inertia ratio, efficiency and high-power factor (Puranen, 2006, p.34). Researchers point out that the best candidate for traction application is Permanent Magnet Synchronous Motor which has the highest power density and efficiency, around 95% (Hooper, 2011, p.31).

Working Principle

These motors have two main parts which are stator that carries a number of electrical coil windings and a rotor with permanent magnets attached to its surface. Coil windings of stator is given an AC current which creates a revolving magnetic field (RMF). RMF interacts with the fields of PMs on the rotor creating a force for the rotor to rotate.

Project Details

PMSMs have one drawback which is the high cost of its permanent magnets. One possible solution is to use a synchronous reluctance machine which has no windings nor magnets attached on its surface thus eliminates the cost of PMs (Carraro et al., 2013). However, efficiency drops from 95% to <90% with the use of this engine (Hooper, 2011, p.29).

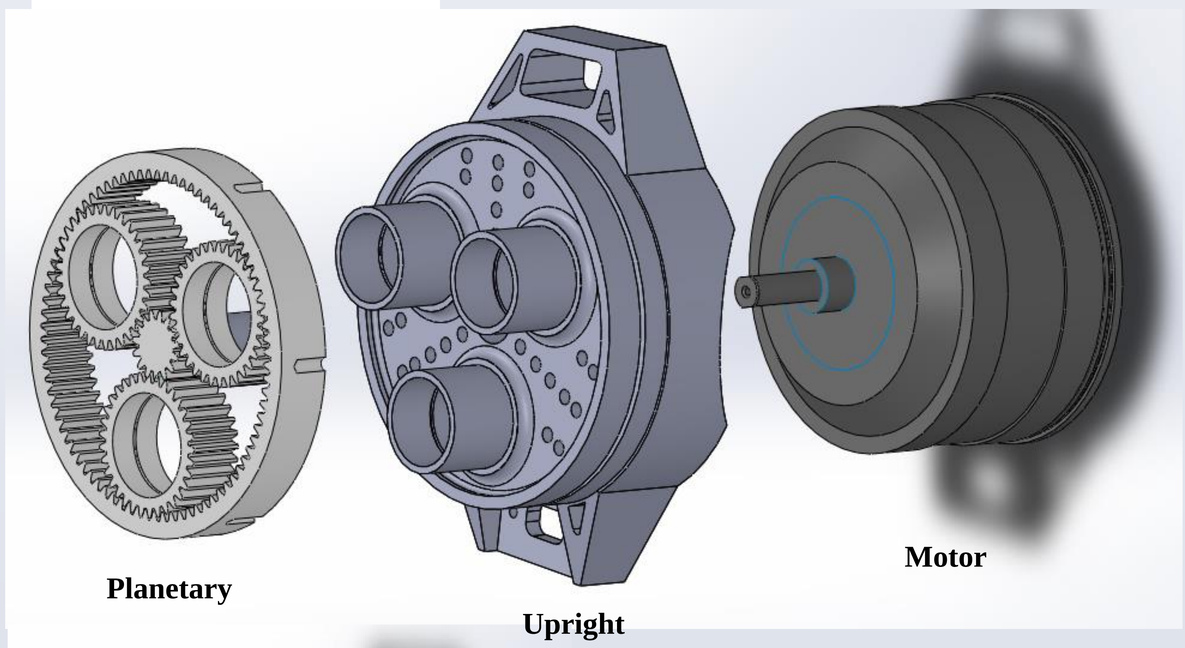


(a) Torque vs. speed.

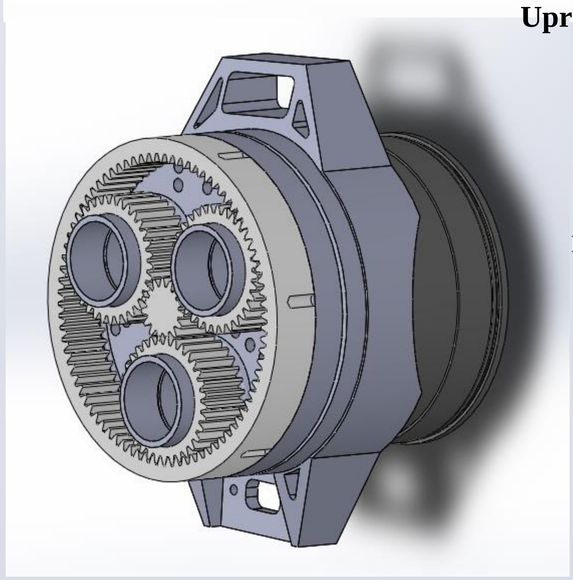
(b) Power vs. speed.

(c) Power factor vs. speed.

Based on an analysis that is conducted on two different stator geometries with same number of slots and poles (36-slot, 4-pole) but different outer diameters (IPM-A - 337mm, IPM-B – 276mm), minimum torque ripple of 12% is observed in IPM-B making it the optimum stator geometry (Carraro et al., 2013, p.1144). The selected IPM-B machine is compared with two other SPM machines of equivalent size (276mm) which are SPM-B with 36-slot and 4-pole rotor and SPM-C with 12-slot and 8-pole. Carraro emphasizes that the results show that best candidates are IPM-B showing best torque and power trends and SPM-C with a possible reduction in the motor mass (Carraro et al., 2013). Vagati, Pellegrino & Guglielmi (2010) also conducted a research comparing IPM and SPM permanent magnet machines in which IPM machine outran the SPM machine in terms of overload capability.



Planetary **Upright** **Motor**



SolidWorks Design

For the final step of the Development of Wheel Hub Motor Drive Application in Electric Vehicles Project, considering necessary scales and parameters, SolidWorks design of the wheel assembly is done. First part of the assmbly is called planetary in which it is composed of a sun gear in the middle, three planet gears around the sun gear and a ring gear outmost. The designed planetary has a gear ratio of 5.4:1. Second part is upright which carries all the load inside of a wheel. The last part is the cage of a motor which is suitable for the selected upright design.

Conclusion

Literature rewiev on the best candidate for an electric motor for traction application is done. Results have shown that sub catagory of Permanent Magnet Synchronous Motor (PMSM) which is Interior Permanent Magnet Motor (IPM) is selected. Further, SolidWorks design of wheel assembly was constructed.

References

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