A Review of In-Wheel Motors for Electric Vehicle Propulsion

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Abstract

This paper presents a comprehensive review of the recent developments of In-wheel motors (IWMs) and discusses their potential future advancements. The major topologies of IWMs are systematically reviewed, such as permanent magnet IWMs (PM-IWMs), magnetic-geared IWMs (MG-IWMs), in-wheel switched reluctance motor (IW-SRMs), and wireless IWMs (W-IWMs). The advantages and drawbacks of these IWM topologies are investigated and compared.

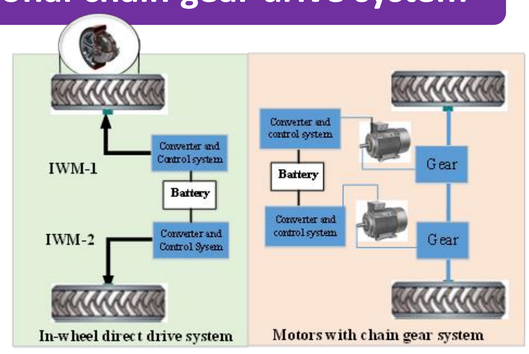
Research Objectives

The main objectives of the research are to:

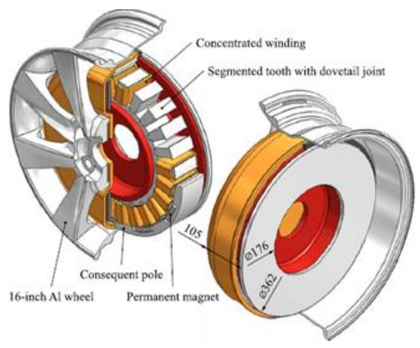
1. Present an overview of the recent developments in IWMs EV propulsion,
2. Survey the state-of-the-art
3. Determine the future trends in IWMs
4. Provide guidelines in choosing IWMs for specific applications

The in-wheel drive system and conventional chain gear drive system

1. Concept of in-wheel motor was originated in 1884,
2. It eliminates the transmission system and the associated losses,
3. More space is available for battery installation and the mileage per charge of the EVs can be increased accordingly.

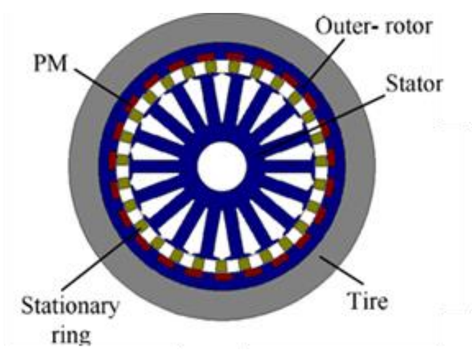


Permanent Magnet In-Wheel Motors (PM-IWMs)



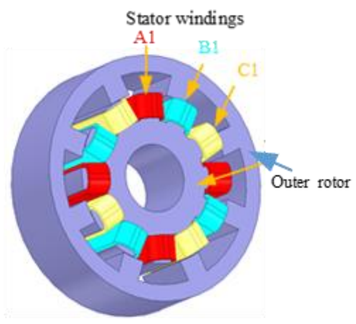
20-pole–24-slot SPMSM with consequent pole rotor [1]

Magnetic-Geared In-Wheel Motors (MG-IWMs)



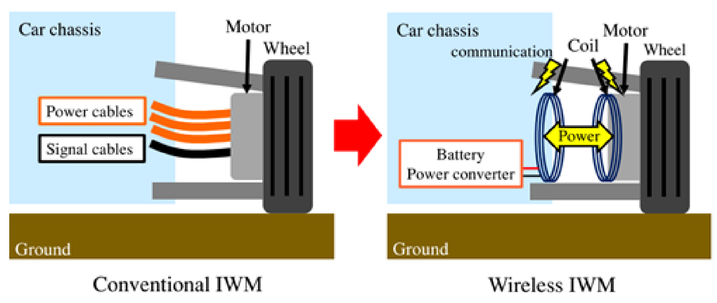
Configuration of an MG-IWM [2]

In-Wheel SRM



Configuration of an IW-SRM [3]

Wireless In-wheel Motors

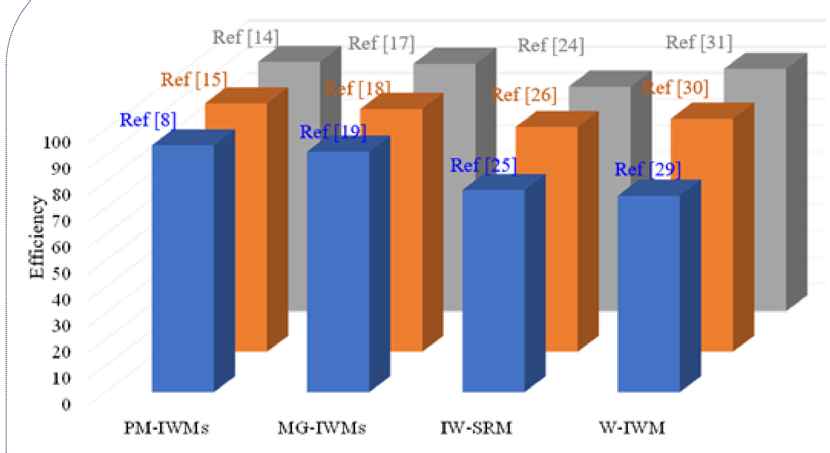


Concept of a Wireless-IWM system [4]

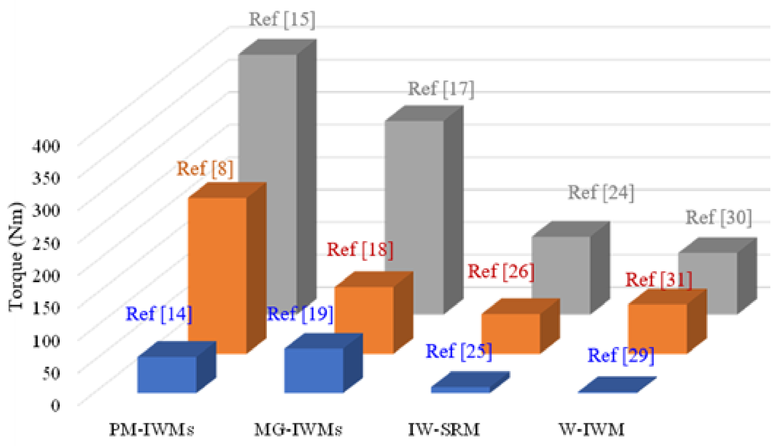
Future Research Trends in IWMs

Despite extensive research on IWMs for effective utilization in powertrains, there exist research challenges in IWMs. The electromagnetic, mechanical, and aerodynamic vibrations need more analysis and robust remediation approaches. Investigation of effective methods for thermal management in direct drives is also an open research challenge. More research on MG-IWMs and W-IWMs is expected in the future.

Comparison of Torque and Efficiency



Torque capacity comparison of different IWMs



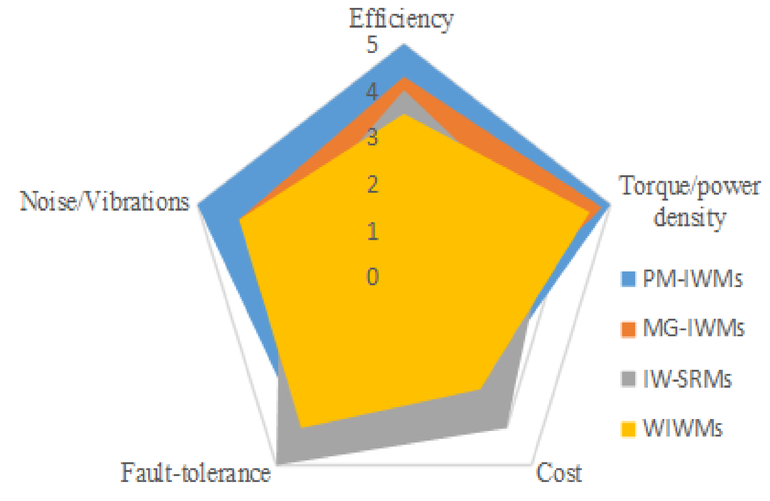
Efficiency comparison of different IWMs.

*Please see the paper for the references

Conclusion

This article has reviewed the recent developments in IWMs with a particular focus on major topologies such as PM-IWMs, MG-IWMs, IW-SRMs, and W-IWMs. The advantages and limitations of each topology have been discussed and compared to provide a guideline for the design of IWMs for future EVs

Comparison of key features



References

1. S. -U. Chung, S. -H. Moon, D. -J. Kim and J. -M. Kim, "Development of a 20-Pole–24-Slot SPMSM With Consequent Pole Rotor for In-Wheel Direct Drive," in IEEE Transactions on Industrial Electronics, vol. 63, no. 1, pp. 302-309, Jan. 2016
2. Y. Fan, X. Han, Z. Xue and H. Jiang, "Design, analysis and control of a permanent magnet in-wheel motor based on magnetic-gear for electric vehicles," *2011 International Conference on Electrical Machines and Systems*, 2011, pp. 1-6,
3. M. Zhang, N. Ali and Q. Gao, "Winding inductance and performance prediction of a switched reluctance motor with an exterior-rotor considering the magnetic saturation," in *CES Transactions on Electrical Machines and Systems*, vol. 5, no. 3, pp. 212-223, Sept. 2021
4. M. Sato, G. Yamamoto, D. Gunji, T. Imura and H. Fujimoto, "Development of Wireless In-Wheel Motor Using Magnetic Resonance Coupling," in *IEEE Transactions on Power Electronics*, vol. 31, no. 7, pp. 5270-5278, July 2016.

Acknowledgments

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