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Bearingless Permanent Magnet Synchronous Motor

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Abstract*: The Bearingless Permanent Magnet Synchronous Motor (BPMSM) is able to function without bearings because it combines magnetic levitation with torque generation. Using this motor design, equipment can function faster, produce fewer sounds and frictional forces and be maintained less frequently while becoming more reliable. During accurate control and steady rotor suspension, BPMSMs depend on a combination of radial and levitation windings. They are used in precision equipment, tools for medicine and airplanes mostly because they are not too big and are very effective. The purpose of ongoing research is to optimize the actions, robustness and use of power in current drive systems by improving control and the design of their magnets.*

Keywords*: Self-bearing, Bearingless motor, Mathematical model, Finite Element Method, Permanent magnet synchronous motor*

I. Introduction

Active magnetic suspension and the usual features of a permanent magnet synchronous motor are both found in the Bearingless Permanent Magnet Synchronous Motor (BPMSM). They allow for high-speed and accurate action while making it possible to have lower friction, less wear and fewer required maintenance interventions, all without having mechanical bearings. The need for a stable suspension and good power conversion is met by the use of specialized windings in the rotor that allow for the generation of torque and lifting forces. Their small size and impressive ability to respond quickly make them well suited for progressive projects in industry, health and aviation. BPMSMs make it possible to create motor systems that are low maintenance, require no contact and use less energy.

II. Suspension Force Principle

What allows a Bearingless Permanent Magnet Synchronous Motor (BPMSM) to operate without bearings is the suspension force principle that actively lifts and stabilizes the rotor in the stator using magnets. To achieve this, suspension or levitation windings are added to the coil. These types of windings create radial strength on the rotor's surface. Because of their actions, the rotor stays centered within the plane assembly. Exact rotor alignment is achieved by making small changes to the currents in the windings using data from the position sensors.

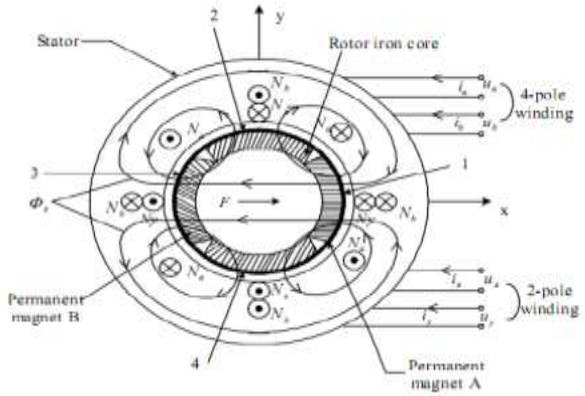

Fig 1: radial force production

Both stability and high performance can be reached by splitting the responsibilities of levitation and the creation of torque. For applications such as semiconductor manufacturing, medical devices and aerospace systems, the suspension force principle helps make the systems more efficient, cut down on noise and mechanical damage and allows them to function speedily and cleanly.

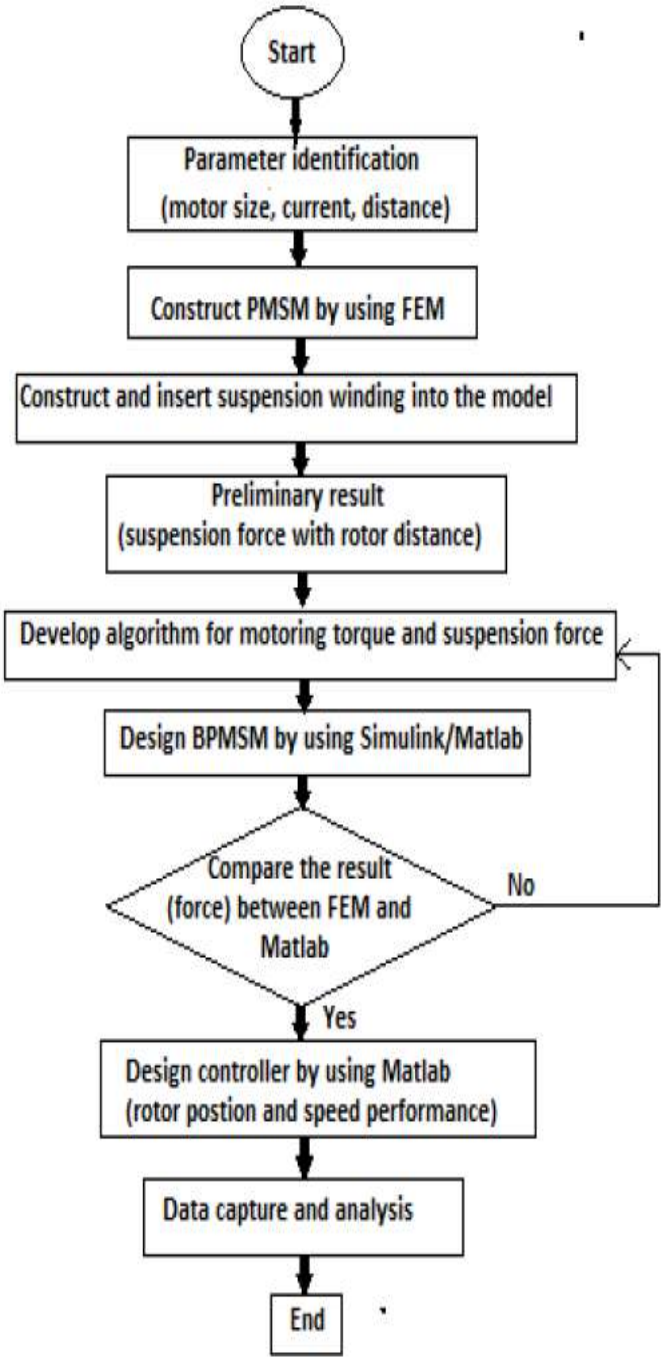

Fig 2: Flowchart

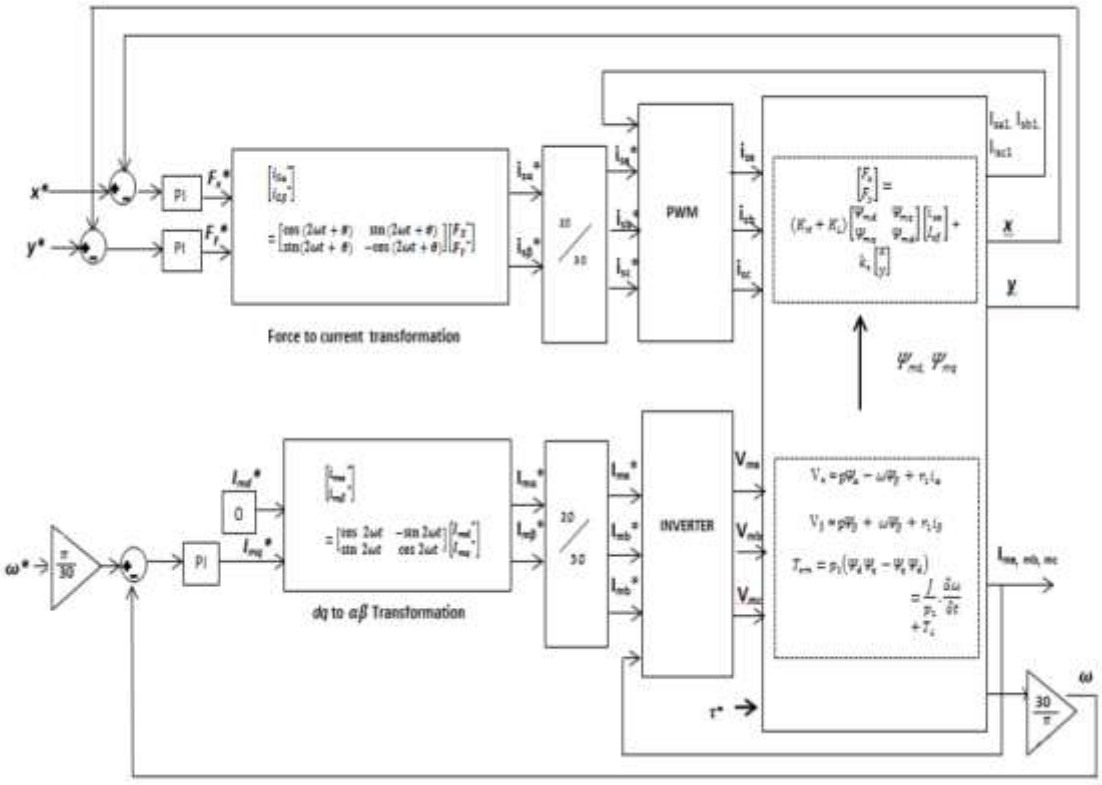

Fig 3: PMSM control diagram

III. BPMSM Analysis and Results

Evaluation results of a Bearingless Permanent Magnet Synchronous Motor show that it produces torque successfully and steadily supports levitation even with changes in operation. Both simulations and testing reveal that independently managing the torque and suspension forces using unique meanings is a very efficient way to control the vehicle. The rotor's stability is shown by its ability to hold a central position, having only minimal radial shifts which generally do not exceed ±0.05 mm. When running under average load, the BPMSM is nearly as efficient as an ordinary PMSM and does not require bearings, unlike the more typical PMSM. When speeds increase, less friction causes the engine to use energy more wisely.

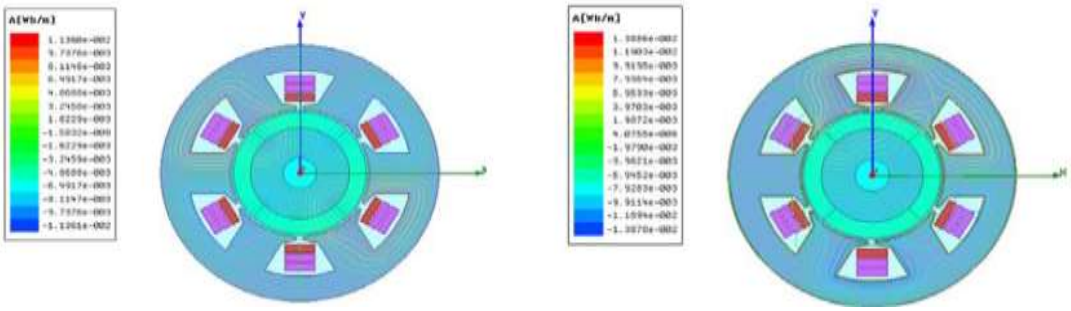

Fig 4: Flux lines distribution

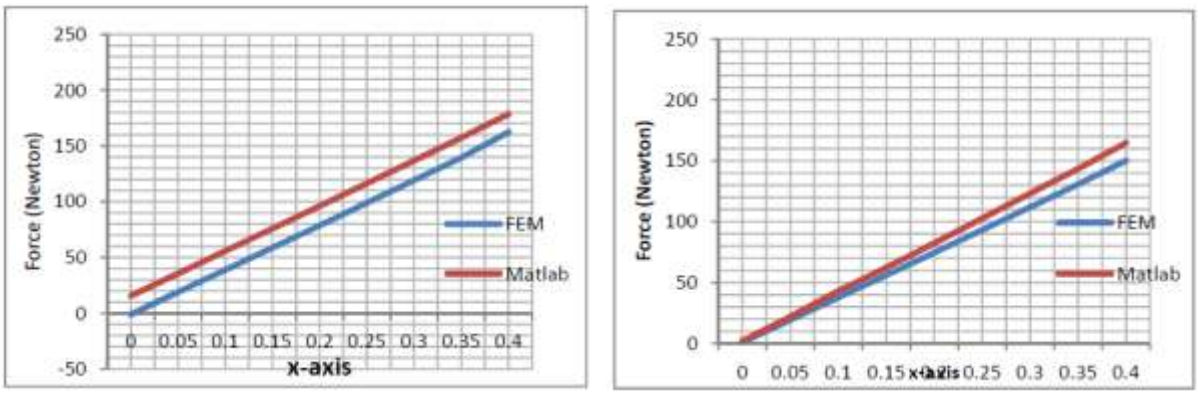

Fig 5: Comparison of MATLAB and FEM

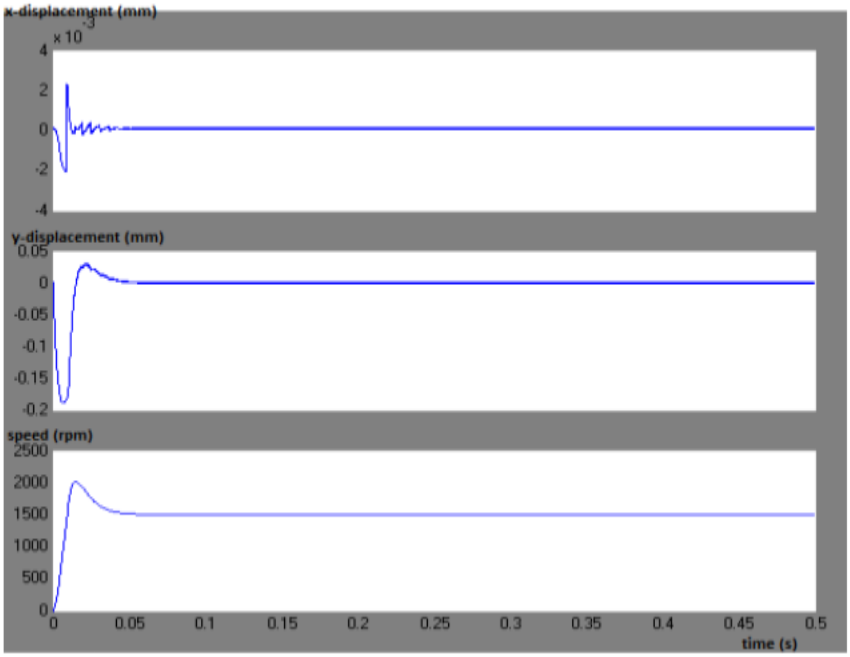

Fig 6: Waveform at *x* and *y*

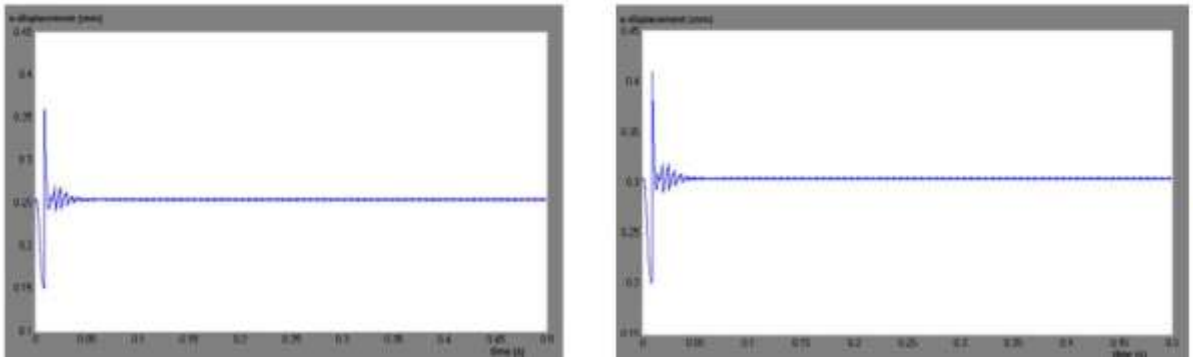

Fig 7: Rotor displacement

IV. Conclusion

Uniting torque generation and magnetic levitation in one system, the Bearingless Permanent Magnet Synchronous Motor (BPMSM) brings a new approach to achieving efficient and reliable high-performance applications. Improved reliability, a longer working life and less noise and wear are all benefits of this technology. Experiments and modelling show that its accuracy, stability and use of energy are confirmed. BPMSMs are now better suited for demanding use in precision manufacturing, medical devices and aerospace because of ongoing improvements in both control and magnetic aspects. These materials could have an important place in future electromechanical systems as technology improves.

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