THE MORRISON BEARINGLESS SWITCHED RELUCTANCE MOTOR

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About the Motor:

Switched reluctance motors typically consist of pairs of poles protruding outward from a central rotor, surrounded by pairs of coils protruding inward from a stator. The pairs of coils, positioned a short distance from opposing sides of the rotor, are connected in series. A current runs through the coils, generating a magnetic flux between the coils. This attracts the protruding poles on the rotor, and just as the poles on the rotor approach the coils, the current to the coils is inverted, repelling the rotor's poles as they pass the coils. This current switching, back and forth, provides a continuous rotational torque to the rotor.

Traditional switched reluctance motors possess many positive traits, including reliability, durability, low cost, and operation in adverse environments such as high temperatures, extreme temperature variations, and high rotational speeds. However, because rotors are often manufactured with minute flaws due to imperfections in the machining process, traditional switched reluctance motors often suffer from substantial amounts of vibration. In addition, the current in the coils imparts a strong radial magnetic force on the rotor; the continuous alternating of the direction of this force also causes vibration. As a result, switched reluctance motors require bearings that, run at high speeds, can require lubrication apparatus and are subject to problems with heat and wear.

My mentor's recent invention, the "Bearingless" Switched Reluctance Motor, actually uses magnetic bearings instead of traditional physical bearings. Sensors are used to continuously determine the position of the rotor. A computer reads the position sensor input, performs calculations, and outputs a current to a set of extra coils (in addition to the coils rotating the rotor). This current provides a magnetic force that counters and damps the vibration.

The sense-calculate-update loop iterates more than thirty thousand times per second. For now, our goal is to have the rotor rotate at about 6000 rpm, and at that speed, the magnetic bearing is adjusting the rotor's position more than 300 times per rotation.

It is hoped that this new invention will increase load-carrying capacity, stiffness, and vibration-suppression capacity for the switched reluctance motor.

My Work:

While my mentor's invention has been patented, it has not yet been fully, successfully implemented. I have been working closely with my mentor to help get his motor operating. In the lab, I have been providing my input on various general troubleshooting tasks.

At the beginning of the summer, our focus was on the motor alone; the magnetic bearing part of the code in the computer was deactivated entirely. After making some changes in the code and tweaking the positions of some of the sensors, along with a variety of other hardware adjustments, the motor successfully ran, but, at this point, only on mechanical bearings.

Next, we activated the magnetic bearings, and attempted to levitate the rotor between the bearings, without the motor running. For a time, this was completely unsuccessful. We delved into the code, looking for some sort of error that could be causing our problems, but no error could be found. We finally brought in a hardware analyzer, which created a simulated sensor signal that was inputted into the control system. The analyzer also accepted the output, and this was compared with the known input to determine whether the output was reasonable. We ultimately determined that our problem was something related to the hardware input. This was quickly solved. A few tweaks to the control program's settings later, and the motor was both levitated and running.

Up to this point, the motor has run, levitated, as fast as 4000 rpm. We continue to make both hardware and software adjustments in an effort to push that number higher. Also, we plan to take various measurements, including torque measurements, to help determine more clearly the full capabilities of the motor.

Additionally, throughout the summer, I have been working on converting my mentor's code and control system, written in a fairly old DOS format, to a more professional and modern dSpace/MATLAB/Simulink solution. If successful, this would likely allow substantially more robust control of both the motor and the magnetic bearings, lowering the control program's loop time by as much as two-thirds. It would also allow us to design a cleaner user interface for adjusting the control program's settings.

References:

Morrison, Carlos R. 2004, *Bearingless Switched Reluctance Motor,* US Patent 6,727,618 B1.

Acknowledgements: