Three-Axis Active Control Magnetic Bearing with Asymmetric Structure for High-Temperature Machines

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Introduction
Mechanical bearing (contact)
- Need maintenance
- High noise
- Abrasion
- Friction loss
Magnetic bearing (contactless)
- Maintenance free
- Oil-less drive
- Active control
- Low friction loss

Five-axis active control magnetic levitation system

Problems
- Need motor and three bearings (Total 4 units)
- Increasing size of the system
- Reduction in the critical speed
- Have a flat disk in thrust rotor
- Poor assemblability
- Reduction of the speed limit

To solve these problems, triaxial active control magnetic bearings without flat disk have been proposed.

Proposed Magnetic Bearing Structure

- Axially asymmetric.
- Have a radial stator (8 coils), three thrust stators and a rotor.
- The rotor consists of a magnetic material and 2 non-magnetic parts.

Operating principle
- 2 adjacent radial coils are connected in series.
  - the radial coils consist of 4 circuits: (x1, x2) and (y1, y2)
  - The thrust coils z1 and z2 are connected in series.
  - A negative Z-axis thrust force is generated by the magnetic flux due to the thrust coil z3.

Verification using 3-D FEA

Analysis software: JMAG Designer 15.1
CPU: Intel(R) Xeon(R) CPU E5-2609 v2
Number of elements: 1,064,688
Number of nodes: 181,147

Single-axis excitation
- Maximum suspension force (Rotor is in initial position)
  - Radial force: 179N
  - Thrust force: 830N
- Radial suspension force affected by X-axis displacement.
- Z-axis displacement has little effect.
- As the current increases, the force hardly increases.
  → Magnetic saturation in radial rotor.

Multi-axis excitation
- Effect of thrust current on radial force
  - Thrust current decreases radial suspension force.
  → Magnetic saturation in radial rotor.
- Radial current has little effect on thrust suspension force.
  → Magnetic saturation is local.

Conclusion
- We proposed a novel magnetic bearing with asymmetric structure for rotary machine that rotor is attracted only in one axial direction due to a negative pressure of the fluid. The feature of the proposed structure is to have non-magnetic material parts for control the magnetic path.
- Its basic characteristics were verified by 3-D FEA. Due to asymmetric structure proposed magnetic bearing can generate high thrust force to practical use.