Electromagnetic Contact Force and Mechanical Deformation Due to Various Force Calculating Methods.

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Introduction: Electromagnetic force and density in the electric-machinery dynamic system are fundamental forces which cause physical phenomena such as structural deformation, vibration, noise etc. But when two materials are contacted, electromagnetic contact force and distribution by conventional methods don't have consistency. In this paper, new method to solve it is introduced and compared with various force calculating method to prove validity.

Computational Methods: To solve a problem conventional methods have, Virtual Air-gap scheme combined with FEM is applied. This converts the method of surface density to volume density by inserting a small and thin airgap around each finite element. The schematic representation is shown in Fig 1.

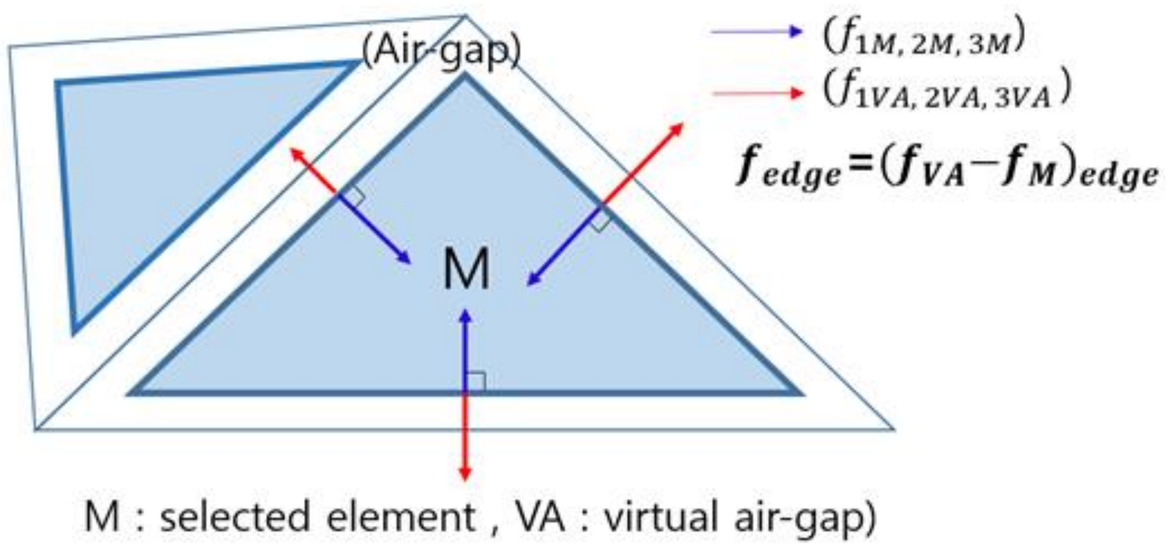

Figure 1. Volume force density with virtual air-gap scheme

In case of Korteweg-Helmholtz method with virtual airgap, volume force density is calculated as below.

$$\mathbf{f}_{GKH}^{edge} = (\mathbf{f}_{VA} - \mathbf{f}_{M})_{edge}$$

$$= \left[\mathbf{H}_{VA}(\mathbf{B}_{VA} \cdot n) - \left(\frac{\mathbf{H}_{VA} \cdot \mathbf{B}_{VA}}{2} \right) n \right]_{VA-side}$$

$$- \left[\mathbf{H}_{M}(\mathbf{B}_{M} \cdot n) - \left(\frac{\mathbf{H}_{M} \cdot \mathbf{B}_{M}}{2} \right) n \right]_{M-side}$$

Results: Results of various force calculating methods were calculated by MATLAB. And then deformation reflecting these results was simulated with COMSOL. The model used for simulation is depicted in Fig 2. Force distribution and mechanical deformation are shown in Fig 3 and 4.

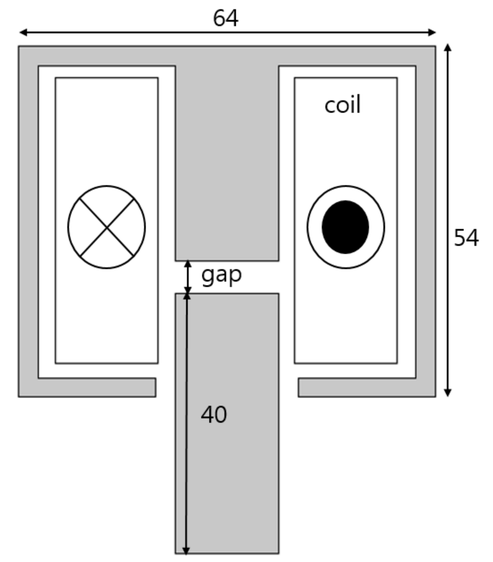

Figure 2. 2D plunger model

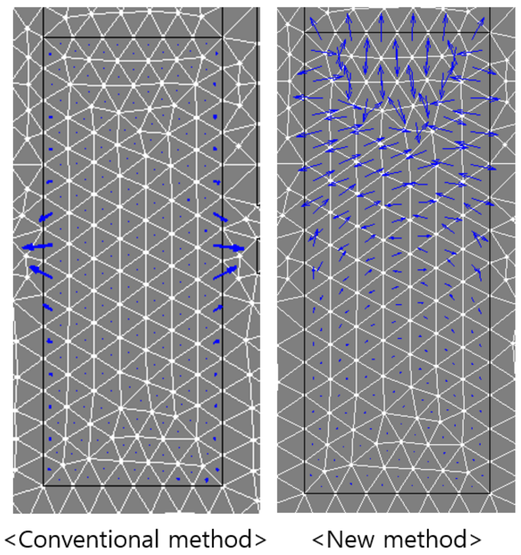

Figure 3. Force distribution

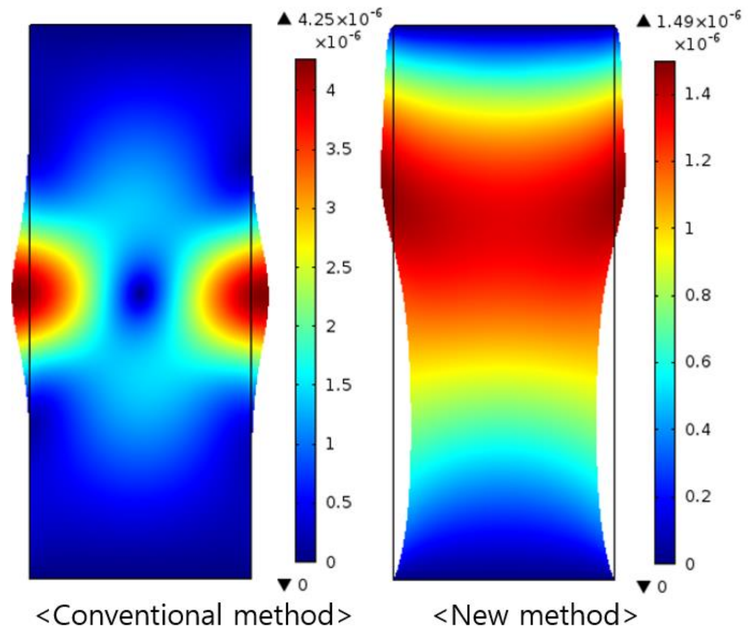

Figure 4. Mechanical deformation on each method

Conclusion: As above simulation, new method result in reasonable contact force and deformation Therefore this method can be applied to motor and electrical machine as below.

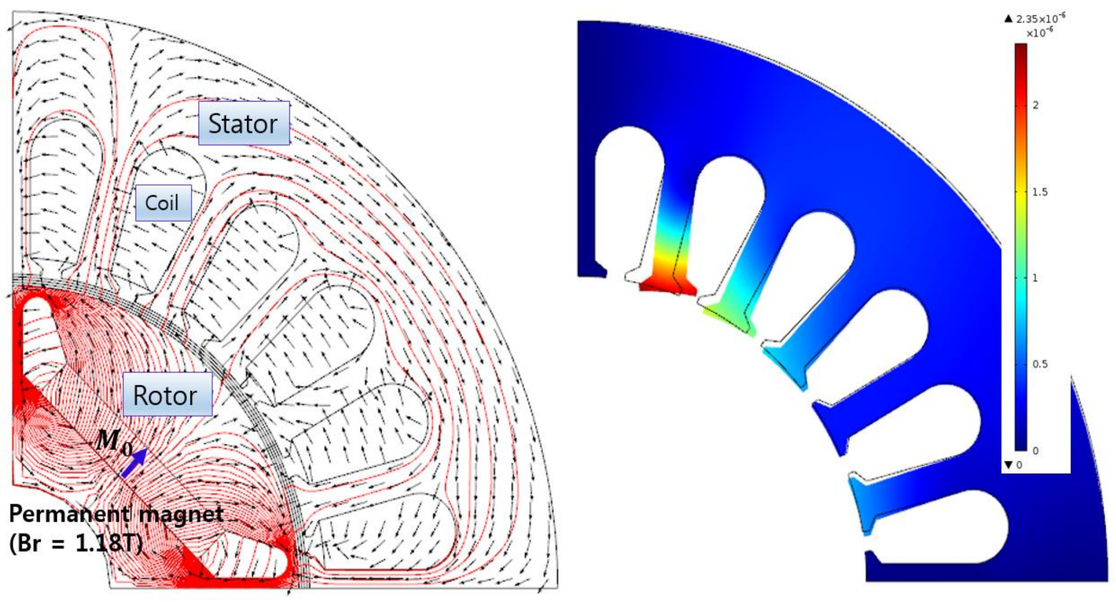

Figure 5. Mechanical deformation on 3-phase IPM-BLDC motor