Study on Analysis Method of Asymmetric Permanent Manget Assistance Synchronous Reluctance Motor Considering Magnetic Neutral Plane Shift

Hyunwoo Kim, Hyungkwan Jang, Ju Lee

University of Hanyang, 222, Wangsimni-ro, Seongdong-gu, Seoul, South Korea

MT 26 International Conference on Magnet Technology
Vancouver, Canada | 2019

Background

This paper establishes an analysis method of permanent magnet assistant synchronous motor (PMA SynRM) with asymmetric barrier. In a general motor analysis method, the inductance is calculated using the *dq*-axis vector diagram. In addition, the characteristics of the motor are analyzed by separating the magnetic torque and the reluctance torque. However, in an asymmetric motor, the magnetic neutral plane (MNP) is shifted because the magnetic permeance is asymmetric. Therefore, it is difficult to analysis the characteristic of the asymmetric motor because it involves errors applying the general analysis method. In this paper, the magnetic property of the asymmetric motor is analyzed and the analysis method of asymmetric motor is proposed. To verify the proposed analysis method, PMA SynRM is designed as a conventional model. Furthermore, the magnetic torque and reluctance torque are separated through the proposed analysis method. The validity of the proposed analysis method is verified through finite element analysis (FEA) and manufacture of the conventional model.

Conclusion

- ❖ The asymmetric motor have the shift of mangetic netural plane shift, so the error occur using the conventional mathematical model
- ❖ Therefore, we propose the analysis method of asymmetric motor through the proposed mathematical model.
- ❖ In order to verify the proposed mathematical model, we design the PMA SynRM.
- ❖ The MNP is shifted in PMA SynRM with asymmetric barrier because the permenance of motor is asymmetric.
- ❖ Therefore, we propose the mathematical model considering the shift of MNP.
- ❖ As the result, the analysis result and FEA result are the same.
- ❖ The asymmetric motor with the shift of MNP should be analysis considering the shift of MNP

Conventional Mathematical Model

- ❖ The analysis models of PMA-SynRM is classified as conventional model and asymmetric model

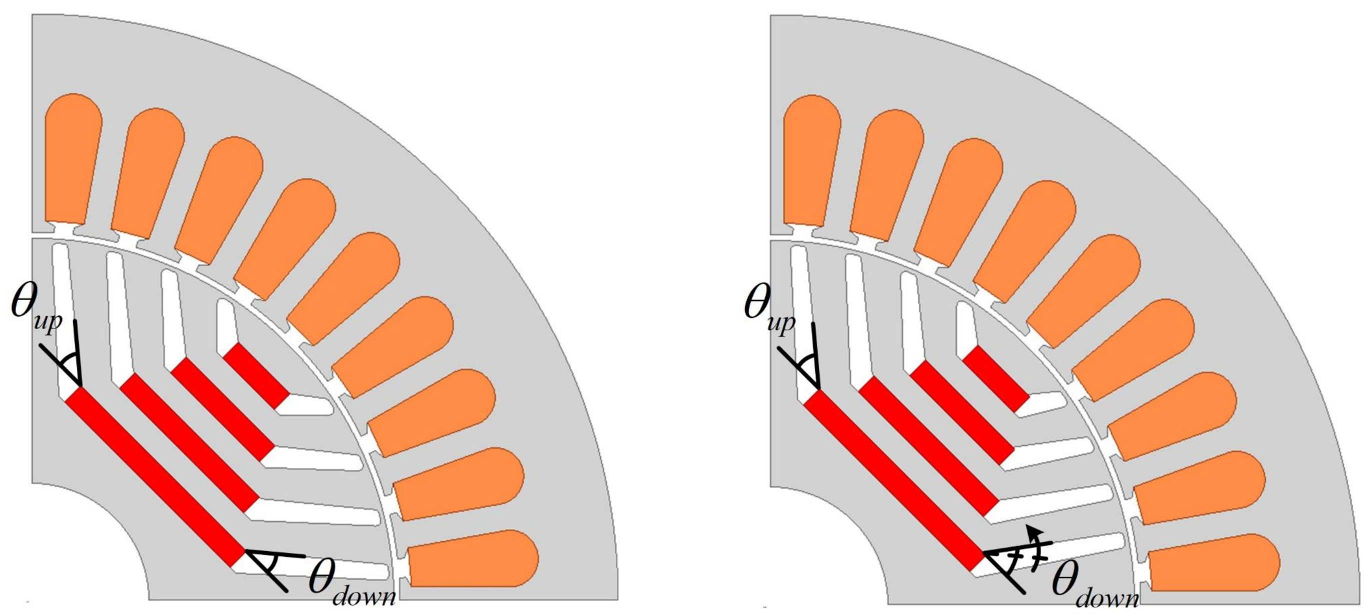


Fig 1. Analysis models (a) conventional model (b) asymmetric model

- ❖ the flux linkage by permanent magnet is d-axis in the conventional mathematical model
- ❖ But, the error occur in the asymmetric motor uing the conventional mathematical model

▣ The *dq*-axis inductance

$$L_d = \frac{\lambda_o \cos\delta - \lambda_a}{i_d}$$

$$L_q = \frac{\lambda_o \sin\delta}{i_q}$$

▣ The voltage equation

$$\begin{bmatrix} v_d \\ v_q \end{bmatrix} = \begin{bmatrix} R_s + pL_d & -\omega_e L_q \\ \omega_e L_d & R_s + pL_q \end{bmatrix} \begin{bmatrix} i_d \\ i_q \end{bmatrix} + \omega_e \begin{bmatrix} 0 \\ \lambda_a \end{bmatrix}$$

▣ Torque equation

$$T_m = \frac{3P}{4}[\lambda_a i_q + (L_d - L_q) i_d i_q]$$

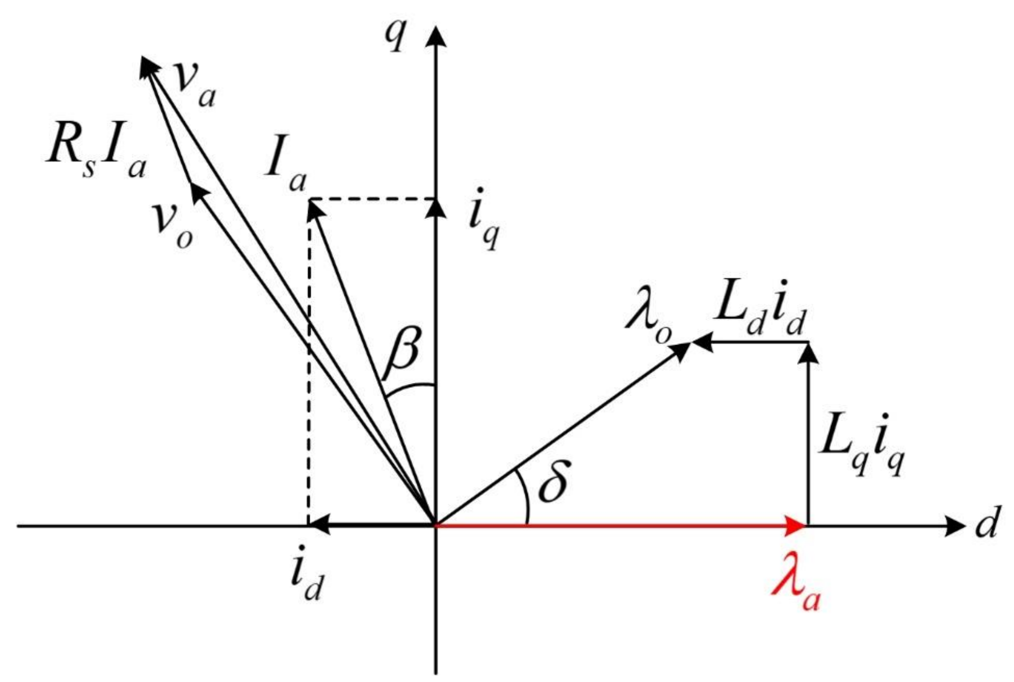


Fig 2. Vector diagram of conventional mathematical model

- ❖ The torque derived from the mathematical model and the results of the FEA analysis are different.

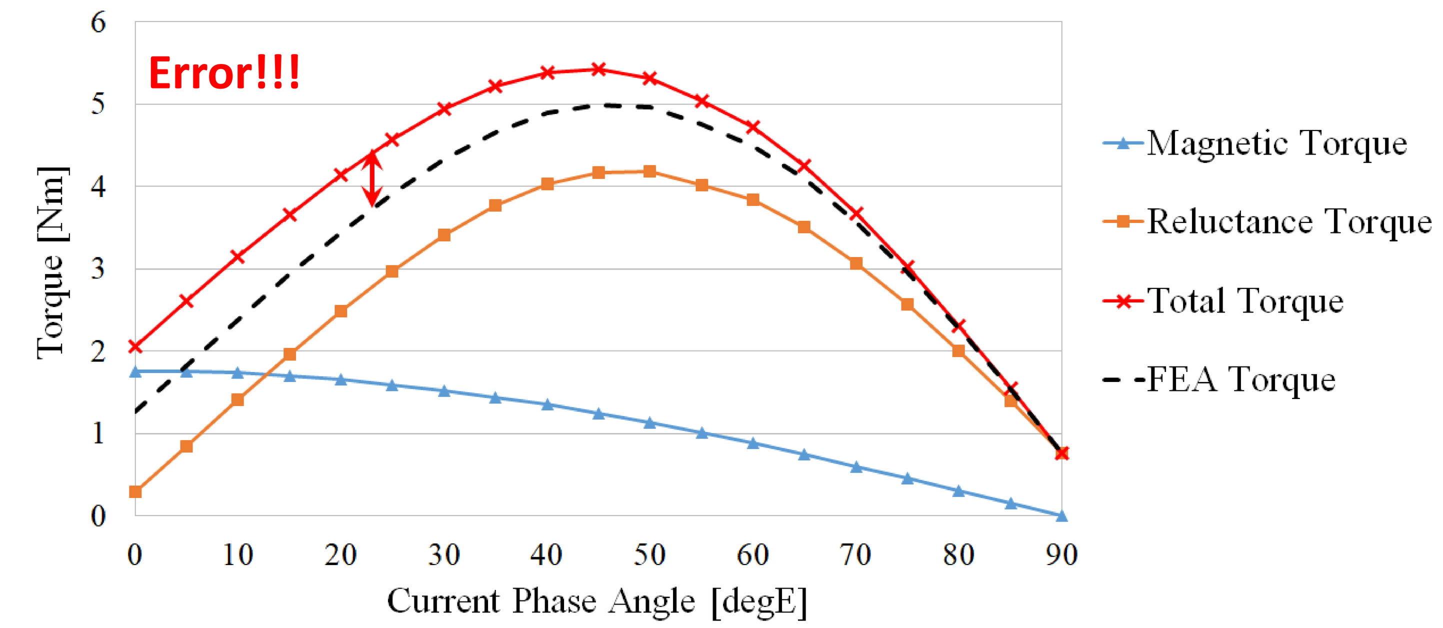
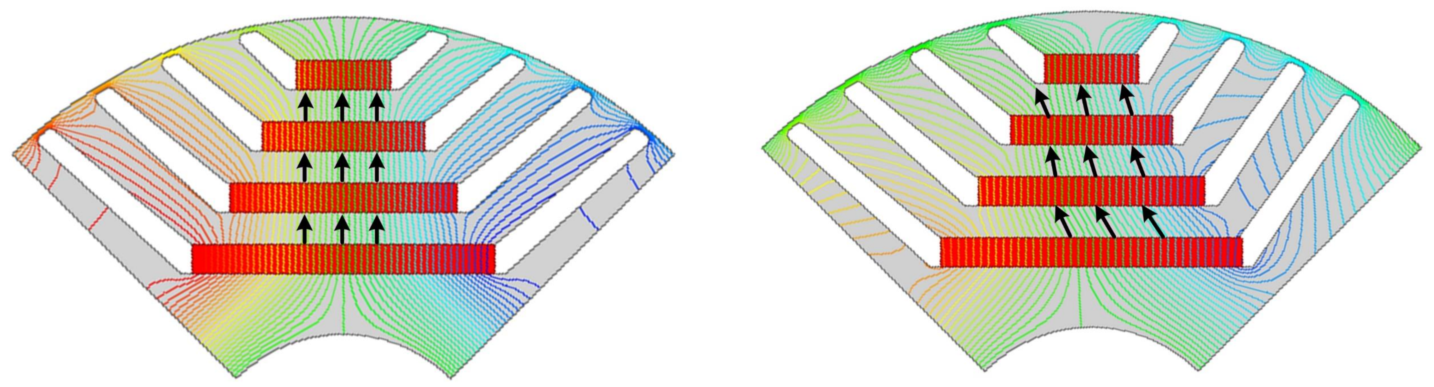


Fig 3. Separate magnetic and reluctance torque of asymmetric model using conventional method

Proposed Mathematical Model

- ❖ In the asymmetric model, the MNP is shifted because the magnetic permeance is asymmetric.
- ❖ Therefore, the error occurs in asymmetric motor applying the conventional method.
- ❖ Fig 4. shows the shift of MNP



(a) (b)

Fig 4. Flux line of analysis models (a) conventional model (b) asymmetric model

- ❖ We propose the mathematical model considering the shift of MNP

▣ The *dq*-axis inductance

$$L_d = \frac{\lambda_o \cos\delta - \lambda_a \cos\gamma}{i_d}$$

$$L_q = \frac{\lambda_o \sin\delta - \lambda_a \sin\gamma}{i_q}$$

▣ The voltage equation

$$\begin{bmatrix} v_d \\ v_q \end{bmatrix} = \begin{bmatrix} R_s + pL_d & -\omega_e L_q \\ \omega_e L_d & R_s + pL_q \end{bmatrix} \begin{bmatrix} i_d \\ i_q \end{bmatrix} + \omega_e \begin{bmatrix} -\lambda_a \sin\gamma \\ \lambda_a \cos\gamma \end{bmatrix}$$

▣ Torque equation

$$T = \frac{3P}{4}[\lambda_a i_q \cos\gamma - \lambda_a i_d \sin\gamma + (L_d - L_q) i_d i_q]$$

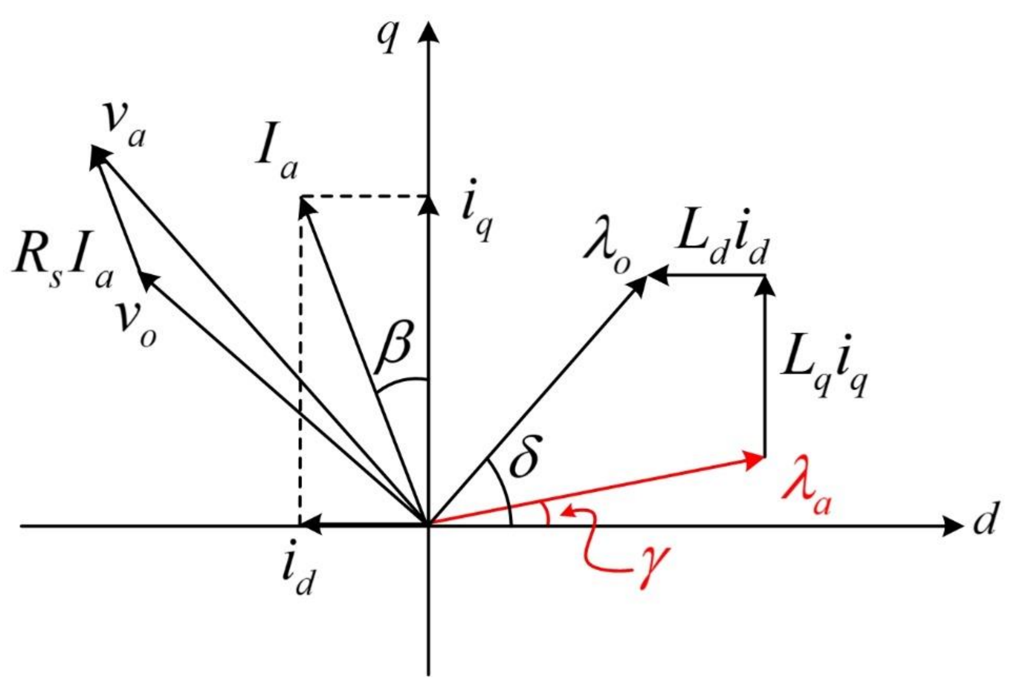


Fig 6. Vector diagram of proposed mathematical model

- ❖ The analysis result and FEA result are the same using proposed mathematical model.

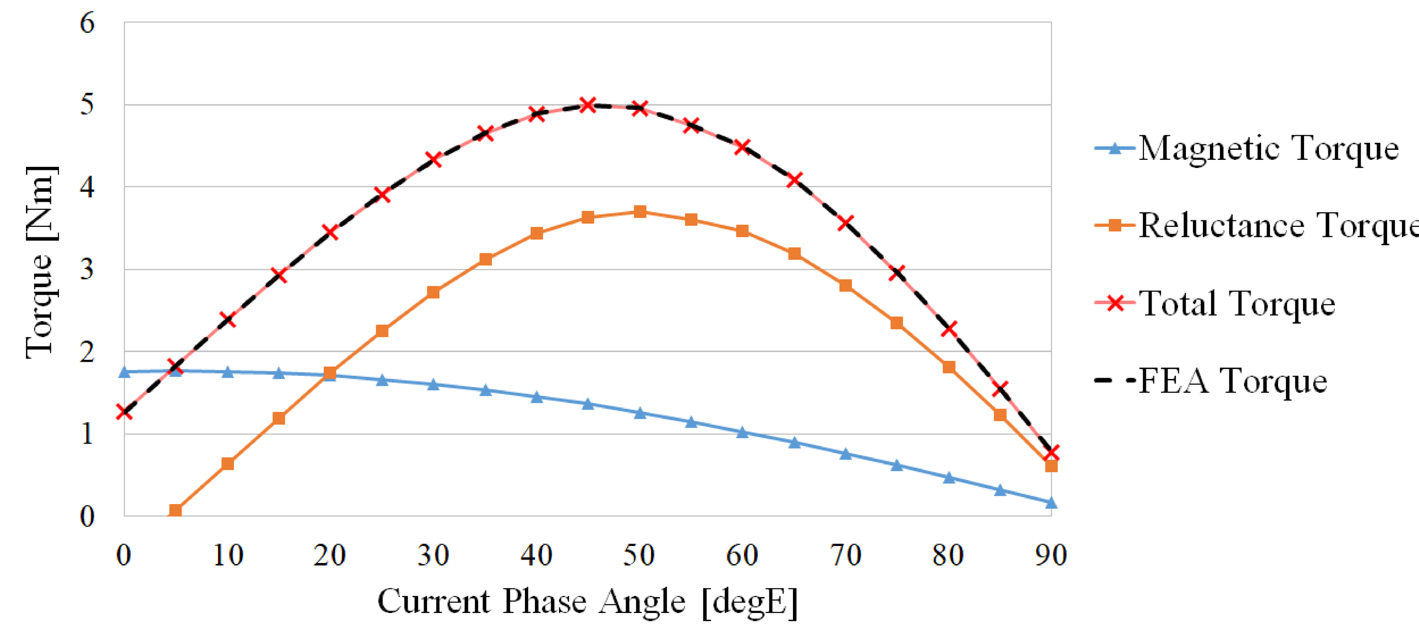


Fig 7. Separate magnetic and reluctance torque of asymmetric model using proposed method

Energy conversion lab.

Energy Conversion Lab., Dept. of Electrical Engineering, Hanyang Univ., Haengdang-Dong, Seongdong-Gu, Seoul 133-791, South Korea