Integrated Motor Propulsor Magnet Design with Hybrid Halbach Array for Torque Ripple Reduction.

J. Ahn[1,2], C. Han[1,2], C. Kim[2], C. Park[3] and J. Choi[2]

1. R&D, MAGNETAR, Daejeon, The Republic of Korea; 2. Electrical Engineering, Chungnam National University, Daejeon, The Republic of Korea; 3. Advanced Manufacturing Systems Research Division, Korea Institute of Machinery and Materials, Daejeon, The Republic of Korea

Motivation for research Recently, integrated motor propulsors (IMPs) have been under extensive research and development because of the numerous advantages of underwater propulsion for vehicles, such as a simple, quiet, lightweight, and small-size structure [1]. IMPs require minimized torque ripple for smooth and quiet operation when used in undersea vehicles or unmanned submarines. Thus, torque ripple reduction should be considered in the design stage. In the IMP case, a permanent magnet (PM) design with a Halbach array should be developed. Because the motor consists of an impeller and a rotor in the same shell, the inner diameter of the rotor is limited. PMs with radial array (magnetized in the radial direction) are not available because of the minimized flux leakage. With regard to torque ripple reduction, numerous methods have been proposed in the literature, and researchers have proposed various designs for IMPs. However, these research activities did not consider the influence of the width ratio and material of PM in IMPs with a Halbach array. Therefore, this paper presents a magnet design with a Halbach array for torque ripple reduction according to the width ratio, and deals with influence of material of radial array permanent magnet. We believe that the proposed method is useful and effective in designing other models. **Magnet design with halbach array for torque ripple reduction according to magnet width** In this paper, the design and analysis of an IMP for a 30-hp 1,500-rpm-class unmanned submarine are presented. This paper is divided into two main parts: the PM width ratio optimization with torque ripple, the influence of the back-emf that changes according to the PM material. The first part focuses on the PM width ratio, which use a downscaled PM to compensate for the torque pulsation. Because the magnetization of a magnet in the x-axis direction is the same as that in the air gap, the torque ripple varies. The second part is based on the PM material. Generally, the same arrangement is used in the Halbach array, but the back-emf is affected by the magnet width in the y-axis direction. The material of radial array (magnetized in the x-axis direction) PM does not matter if the material cahges because x-axis does not significantly affect the magnetic flux. The results are calculated by a two-dimensional finite element method (FEM). In a future study, a more specific comparison with an accurate initial design method in consideration of the mechanical structure will be thoroughly investigated for its contribution to related researches and industrial applications.

[1] Suryanarayana Ch, Satyanarayana B, Ramji K, "Performance evaluation of an underwater body and pumpjet by model testing in cavitation tunnel," International Journal of Naval Architechture and Ocean Engineering, vol. 2, 2010, pp. 57-67, doi:10.3744/JNAOE.2010.2.2.057

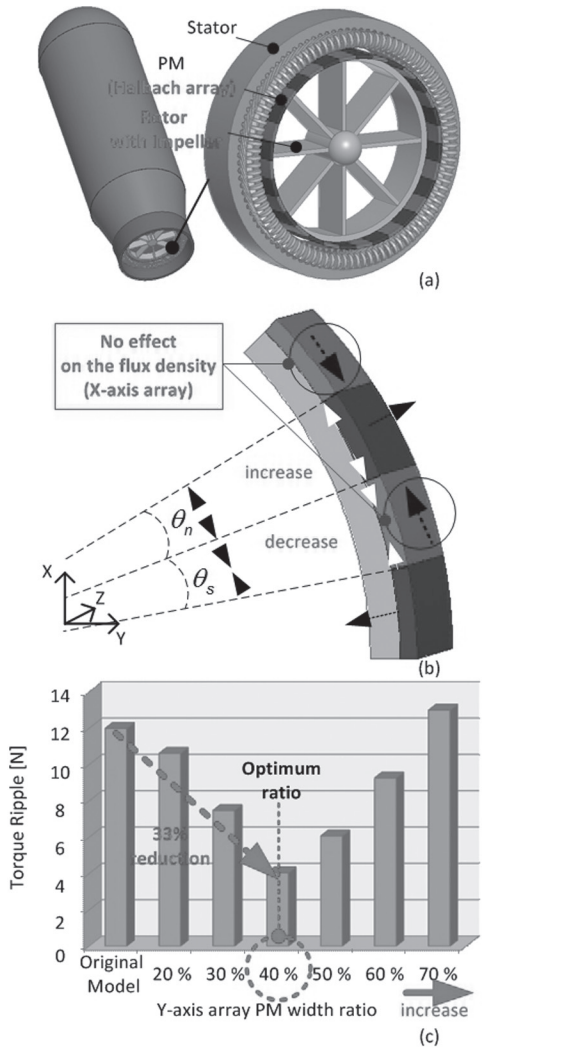

Figure 1. (a) the concept of IMP, (b) PM width ratio variation for torque ripple reduction, and (c) the result of torque ripple according to PM width ratio.