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Comparison of EV Traction Motor performance according to magnetic materials

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Recently, air pollution policies have been actively implemented Internationally. The regulations for carbon-producing products are gradually being strengthened with the aim of creating a low-carbon green village. Moreover, to reduce carbon emissions from automobiles, an eco-friendly vehicle such as electric vehicles (EVs), hybrid electric vehicles (HEVs), and fuel cell electric vehicles (FCEVs) are recommended. In particular, for EV structure, the electric motor is the most important part since it acts as a combustion engine of the conventional vehicle. Thus, the energy efficiency improvement of the electric motor will be one of the biggest concern increasing the mileage of the EV.

In this paper, the effect of the magnetic materials was analyzed in the aspect of energy efficiency of the EV traction motor. First of all, the concept model for EV vehicle was adopted and depicted in Fig.1. The type of this motor is the interior permanent magnet synchronous motor (IPMSM) with 8 poles and 48 slots. The shape of the permanent magnet inserted in the rotor is 1-layer U-shape. The permanent magnet and the electrical steel sheet used for this model are N39UH and 50PN470 respectively.

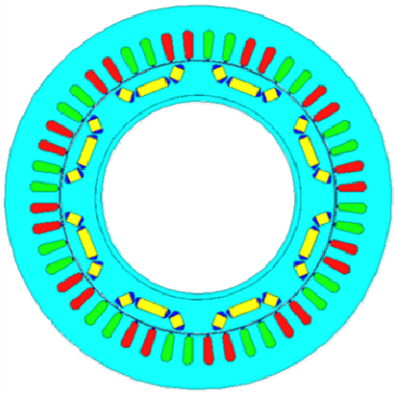
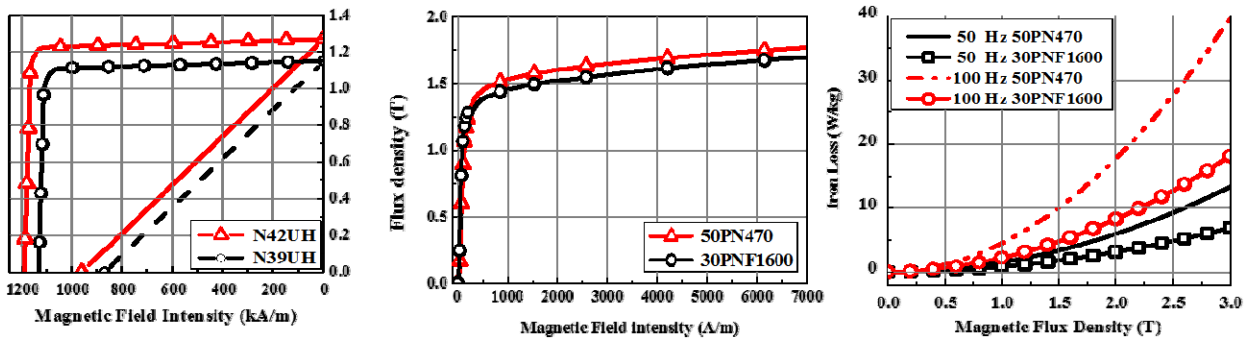


Fig. 1. Cross-sectional view of traction motor



(a) Demagnetization Curve (b) B-H Curve (c) Iron Loss

Fig. 2. Magnetic material characteristics

After that, the loss calculation procedure of the copper loss and the iron loss were introduced. However, the mechanical loss was excluded for observing the change of the electric motor characteristics due to the changing of magnetic materials. Based on magnetic material characteristics as shown in Fig 2, efficiency variation was researched depending on using different magnetic materials in permanent magnet and steel sheet. To compare with concept model, the permanent magnet and the electrical steel sheet were replaced by N42UH and 30PNF1600.

When residual induction value is increased by the change of the permanent magnet, the magnetic torque increases and current will be decreased. This result is advantageous in that the copper loss can reduce in the low speed-high torque section. Also, iron loss is proportional to the square of the frequency, so the iron loss will be rapidly increased when the vehicle speed increases. In order to overcome these disadvantages, it is possible to reduce iron loss at a high speed-low torque section by using low iron loss steel sheet.

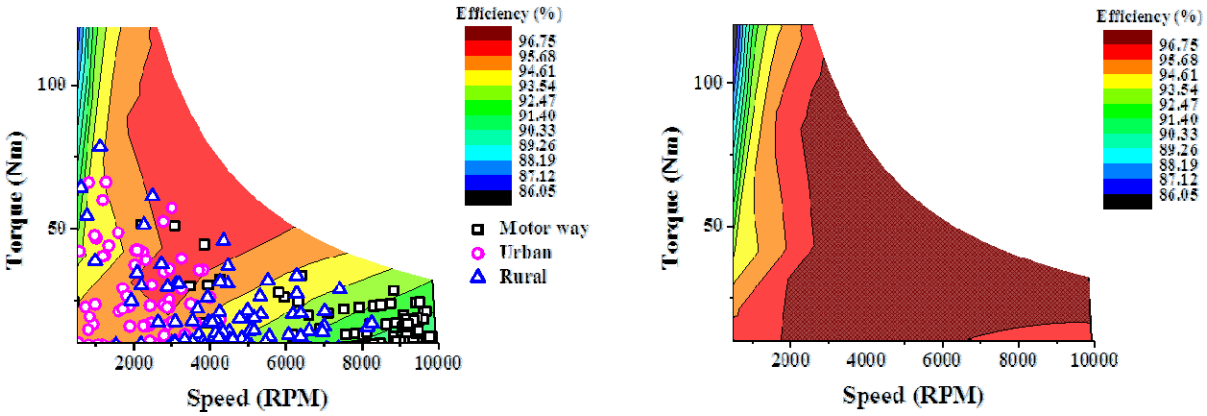
The efficiency results of magnet material changing are shown in Fig 3. As a result, the efficiency of most driving sections was increased, especially in a high-speed section. However, the efficiency was not increased in the low-speed section below 500 RPM because the B-H curve characteristic of 30PNF1600 is relatively bad. Therefore, the input current increased, and it caused copper loss increased. But, this section is not the main driving section, so there is no influence on energy efficiency.

Target vehicle specifications were shown in Table 1. and operating areas by using the Artemis driving cycle are marked in Fig 3(a). The points indicate each driving area such as urban, rural, motorway.

In future work, vehicle simulation will be conducted by using a concept model and improved model efficiency map. For this simulation, urban, rural, and motorway driving condition will be considered. It will show that how much magnetic material affects the energy efficiency in each driving conditions.

Table 1. Target vehicle specifications

Width (m)	1.3
Height (m)	1
Wheel radius (m)	0.3
Curb weight (kg)	900
Air density (kg/m^3)	1.275
Gear ratio	8.5 : 1
Drag coefficient	0.24
Rolling resistance coefficient	0.01



(a) Concept Model (b) Improved Model

Fig. 3. Efficiency map