

The progress of Energy Magnetics to improve Motor Energy efficiency

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The energy supply problem becomes very serious day by day due to background that the world economy is getting huge by shifting from the developed nations economy of 700 million people to the global economy with 7 billion people. The manufacture of automobiles, home appliances and information devices is exploding twice after 20 years. In order to solve energy supply problem, new research into electric vehicles, energy efficient appliances, renewable energy, and the smart grid has been progressing rapidly. In automotive field, a lot of applications of motors expand by replacing from the engine, the hydraulic machines and small devices operation of which three categories on motors applications are shown in Fig.1.

MSJ held the first Energy Magnetics Symposium in 2013 at Sapporo to discuss on the challenges of magnetics technology to solve the energy supply problem and established the study group working on the Energy Magnetics (EMSG) in the beginning of this year. The EMSG held the first meeting and plans to organize the second EM symposium focusing on how to improve the efficiency of PM motor by the means of high rotation motor design

Energy Magnetics on PM motor consists of the reactor to increase the electric voltage, the motor to transfer the electric energy to kinetics energy through the magnetic energy and magnetic transmission to use magnetic gear and bearing. These systems in Fig.2 request high performance magnets and magnetic materials. The most important target must be how to improve the energy efficiency of EV motor system from the loss of 30% at present to the loss of 5% in future.

Nowadays The EV traction motors have been developed to make various designs using the suitable magnets shown in Fig. 3. The kinds of IPM motor designs have been proposed to have one layer, two layer and 4 layers of magnet as well as SPM motor design, spoke type motor and axial motor design. These developments have been challenged by some kinds of magnets which are Nd sintered magnet, Nd anisotropic bonded magnet and ferrite magnet.

The rotation speed of the EV motors increased from 6000rpm to 12000rpm to achieve the improvement in the efficiency and the motor weight. However the more increase of the speed must meet the heating up problems for Power control unit caused by silicon on-resistance, the heating up of Nd sintered magnet caused by eddy current and transmission caused by frictional heat. Power control unit will be solved by the development of SiC IGBT instead of Si and the frictional heat of transmission will be solved by the development of magnetic gear.

The heat up of Nd sintered magnet under IPM motor operation is caused by vibrating magnetic field with the frequency of 200Hz by rotation speed of 200Hz, of 1200Hz, 2400Hz, 3600Hz, 4800Hz by slot harmonics and of 5400Hz, 10800Hz by carrier harmonics shown in Fig.4. The magnet is damaged to fall into demagnetizing. Next generation type IPM motor must be operated under more high speed of 30Krpm controlled by more high carrier frequency of 20KHz. The heating up problem of Nd sintered magnet must become serious to be impossible to use.

EMSG makes first challenge to solve this magnet problem by the development of Nd anisotropic bonded magnet free from heating up problem caused by eddy current, by the development on the measuring equipment to examine the magnetic fatigue coecivity against the vibrating magnetic field and by establishment of the database on the magnetic fatigue coecivity of various magnets and by the research on how to make nucleation of reverse magnetic domain and its expansion using micro magnetics analysis technique. And Final target must be to develop the computer simulation technique to make design on high speed motor.

EMSG holds the second Energy Magnetics Symposium in the annual congress of MSJ and will invite 14 experts to introduce the basic research progress on the magnetic fatigue coecivity caused by vibrating magnetic field and the development on the bonded magnet and the status of EV motor development.

In this symposium, I hope that the magnetics researchers will have interest in the challenges of Energy Magnetics to solve the energy supply problem and join to EMSG project.

Reference

- 1) Magnetics Society of Japan, 2nd Iwasaki Conference Materials, 2013/5/13-14
- 2) Fujisaki et. , 2015 IEE International Magnetics Conference, FQ-12, 2014/5/4-8

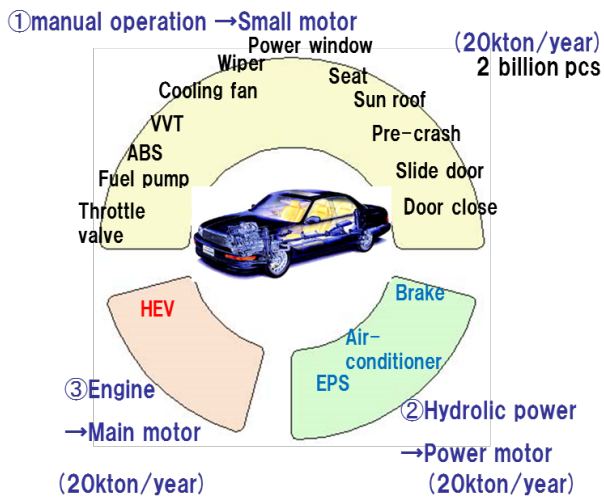


Fig.1 automotive use motors replacing from Engine, hydraulic system and manual operation.

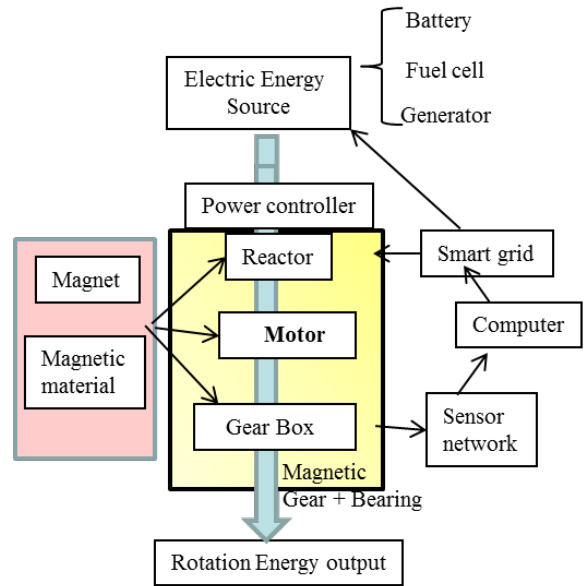


Fig.2 Energy Magnetics challenges to improve Efficiency by Advanced Magnet and Magnetic Materials

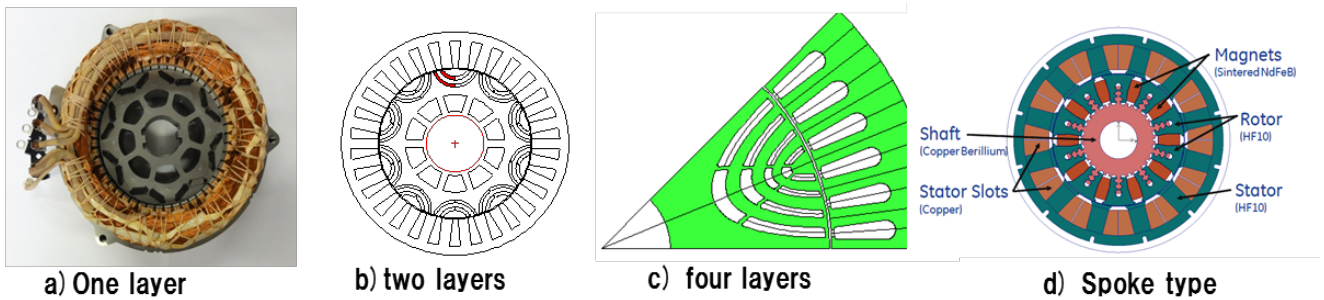


Fig.3 some IPM motor designs for EV traction motors.

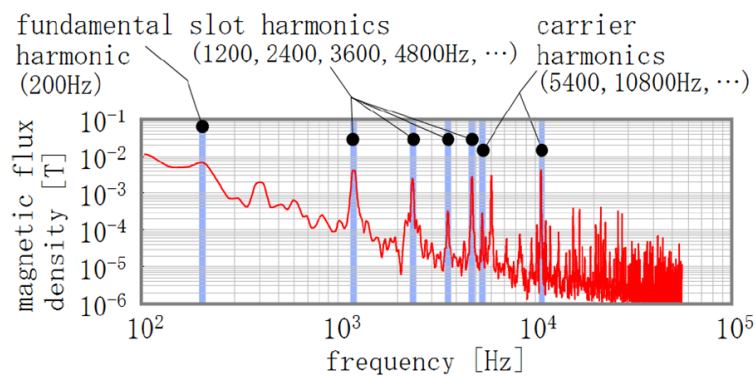


Fig.4. Result of frequency analysis