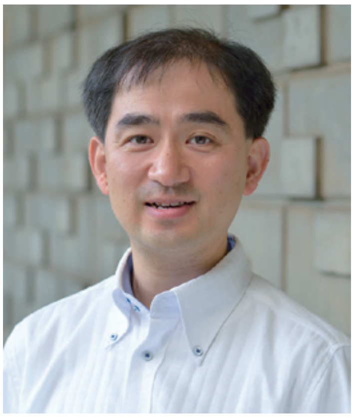
Development of High-Efficiency Induction Motors for EMUs

Minoru KONDO
Senior Researcher, Drive Systems, Vehicle Control Technology Division



1. Reducing energy consumption by EMUs is very important from the viewpoint of saving costs and helping preserve the global environment. High-efficiency traction motors are important for commuter transport EMUs because they have large traction motor losses that account for an enormous amount of energy consumption. This is because the service requires repeating powering and regenerative braking operations frequently. Thus, the Railway Technical Research Institute (RTRI) has conducted research and development to raise the efficiency of induction motors that are widely used as traction motors for EMUs. To promote this research theme, we had a prototype high-efficiency induction motor manufactured. We maintained the fundamental performance and dimensional characteristics of the existing motor and implemented tests to verify the performance of the prototype motor. See Fig. 1 for a photograph of the prototype motor.

2. To raise the motor efficiency in this research, we kept within the general scope of conventional design technologies, in that we used materials featuring small losses for iron cores, rotor conductors and stator windings. We also decided on the number of stator coil turns based on raising the traction motor efficiency rather than minimizing the required capacity of inverter. To ensure the high efficiency of the prototype motor, we also designed a cooling structure to reduce the flow rate of cooling air and subsequently the loss caused by ventilation. Furthermore, we adopted a rotor having a new structure developed to eliminate the loss (harmonic secondary copper loss) due to the current in the conductor surface generated by the magnetic field that is disturbed by the stator slots. For this purpose, the iron core profile is devised to make conductors evade the space around the rotor surface, which is prone to the effect of stator slots (Fig. 2).

3. Figure 3 compares the prototype motor and existing motors with respect to the loss rate (loss divided by input power) that has been evaluated though stationary tests. Figure 3 indicates that the loss rate of the prototype motor is approximately 4% (about 3% lower than that of existing motors) and thus the efficiency of the prototype is approximately 96%.

To estimate the energy-saving effect of the newly developed high-efficiency motor in passenger operations, we implemented a running simulation in which we calculated the rate of energy consumption decreased from that of existing motors recorded for sections between stations. We plotted the results against the inter-station distance, as shown in Fig. 4. The rate of decreased energy consumption is 6% to 11% for different station-to-station sections, which amounts to 9% for all the simulated section.

4. Through this research and development, we were able to demonstrate that induction motors can attain efficiency values as high as 96% to substantially cut energy consumption. In this study, we applied various techniques to raise the efficiency of induction motors, each of which is effective even when applied independently. We expect that the results of this study will be reflected in the design of induction motors to be manufactured in the future.

At the end of this report, we wish to add that this research and development project has been promoted partly by the use of subsidies from the government of Japan.

Fig. 1 Prototype motor

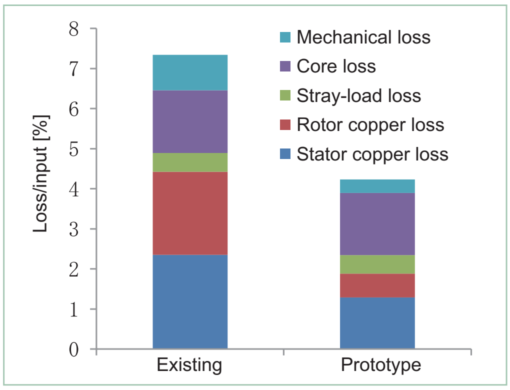


Fig. 3 Comparison of the loss at the rated point

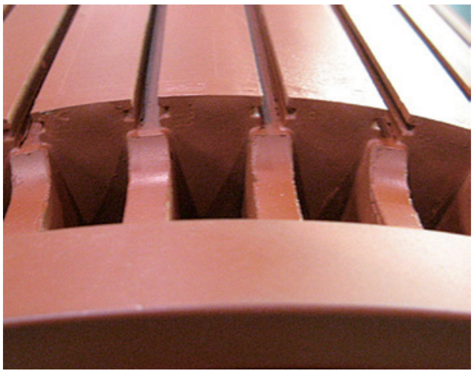


Fig. 2 Slots of the rotor of the prototype motor

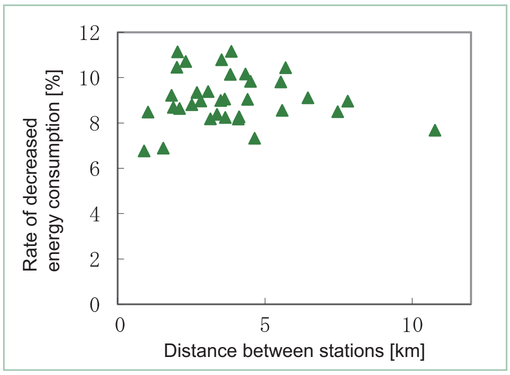


Fig. 4 Calculated rate of decreased energy consumption