Model Change of Wound Rotor Type Induction Motors

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Abstract

In the current market, there are strong demands for renovation. As such, we changed the model of our wound rotor type induction motors by reviewing the frame size and worked on compact and light mass design. We also developed a brush pulling device. In doing so, we improved maintainability. In addition, for the aeration blower motor, we realized a standardization that requires no additional design (additional design-free) and quickly responds to a customer's request. We are further working on improving the power factor, efficiency, noise, and improving design accuracy to realize a reduction of body size.

The wound rotor type induction motors are suitable for cases such as: a voltage drop at the start-up, a large load torque applied at the start-up, or when the starting current is limited. The demands for the wound rotor type induction motors will continue in the future as long as the market makes best use of such features of these motors.

1 Preface

Given the rate of rainfall situation in recent years and the occurrences of frequent flood damages, the measures against heavy rain have been strengthened in public facilities. Demands for medium-voltage motors for pump applications are on the rise. Renewal work due to aging facility equipment is in solid demand of air blowing equipment for reaction tanks, and production equipment for industrial fields. The replacement of the induction motor is under way in a wide range of capacities, from small capacity motors to the medium-voltage motors. In this paper, we show the case study of the most effective application using our recently model-changed induction motor. This is an induction motor for an aeration blower for a reaction tank in a water processing facility. We worked on the reduction of body size, a lighter mass design, and the standardization of this motor.

2 Model Change Initiatives

We have delivered many wound rotor type induction motors for the above-mentioned facilities or applications. We continue producing products for future facility expansion or renewal work projects. Many conventional products, however, were early generation design models, and related material costs are now soaring with problems with product size and maintainability.

The wound rotor type induction motors are applied in such cases as when a power supply capacity and a distribution line capacity is small and this causes a problem of the voltage drop, when the starting torque is required to be larger than that of the reduced voltage start of the cage type induction motor, and when a lower starting current is required.

The demand for the wound rotor type induction motors will continue in the future as long as the market makes best use of such features of the motors. In this model change, we worked on the improvements or kaizen by solving the challenges of conventional products and by making it more eco-friendly.

3 Reduction of Body Size of Aeration Blower Motor

The aeration type reaction tanks adopt many induction motors with the output range: from 200 to 500 kW class. Many 2-pole wound rotor type induction motors are used, and we have a large number of supply records. In our standard design for this

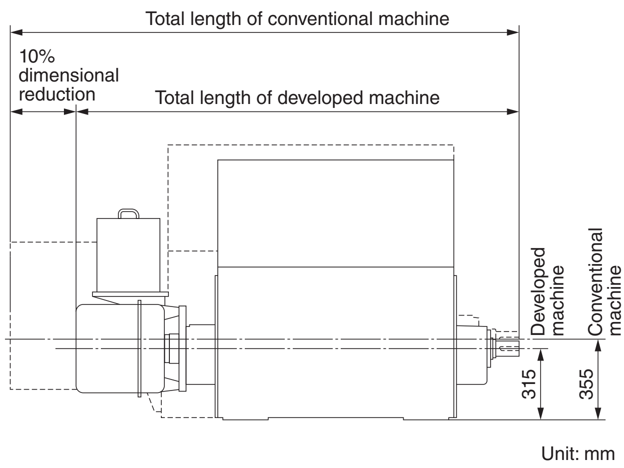

Fig. 1 **Implementation Case of Body Size Reduction from Frame No. 355 to Frame No. 315**

The reduced sizes from conventional Frame No. 355 to Frame No. 315 are shown. Model machine ratings: 240 kW-2 P-6000 V-50 Hz.

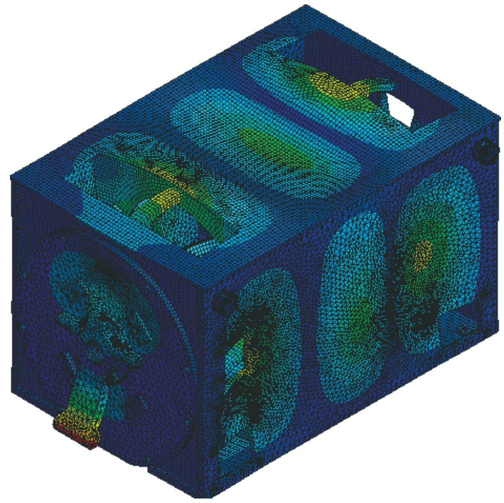

Fig. 2 **Example of Simulation for Eigenvalue Analysis**

The result of eigenvalue analysis for Frame No. 315 is shown.

output range, we have conventionally set two Basic Dimension (BD) No., BD No. 315 and BD No. 355, as motor BD numbers. The BD for the standardization of the assembly dimensions of electric motors refers to the height from the base to the shaft end center. BD No. 315 is 315 mm in the height size and BD No. 355 is 355 mm in the height size. It was made into a series with 3 types of frames (round frame, square, frame or deformed frame) and 5 types of shape designs (including the size differences 〈long (L), short (S) middle (M)〉 in the longitudinal direction of the electric motor).

In this body size reduction, we scrutinized between test data of the actual machine and the design data. We made the optimized design on the cooling structure using the characteristics simulation work. In the new model series, the output has been increased by 6 to 7% compared to the conventional model. Fig. 1 shows the implementation case of the body size reduction from frame No. 355 to frame No. 315. Due to the body size reduction, we realized 30% reduction by mass ratio and 10% smaller total length, a smaller footprint, and improved on transportation and the ease of work during installation.

4 Lighter Frame Design for Aeration Blower Motors

Among motor components, with exception of the cores, the motor frame is the heaviest part, so we realized a lighter design of the motor frame. The frame construction was reviewed and the plate thickness was optimized by making eigenvalue analysis. Consequently, a new frame was developed, meeting the specifications for both vibration and noise factors. Fig. 2 shows an example of simulation for eigenvalue analysis. For a machine of Frame No. 315, the frame mass is reduced by approximately 20%. Similarly, as for the case of a more compact design, this achievement leads to the improvement of workability and on-site installation conditions.

5 Standardization of Aeration Blower Motors

In the past, the body shape design was selected according to the required specifications for each project. We produced submittal documents and drafted drawings and manufacturing drawings. In the new series of induction motors, in response to the required specifications (voltage, frequency, efficiency, power factor, noise, options, etc.), we organized the design into 40 design patterns, 2 types of frames, and an iron core shape design was integrated into 5 types. We also prepared documents and drawings to be submitted for each pattern.

The system allows the user to select the one that meets the required specifications from among the patterns. In doing so, we realized additional design-less workflow from the quotation offering

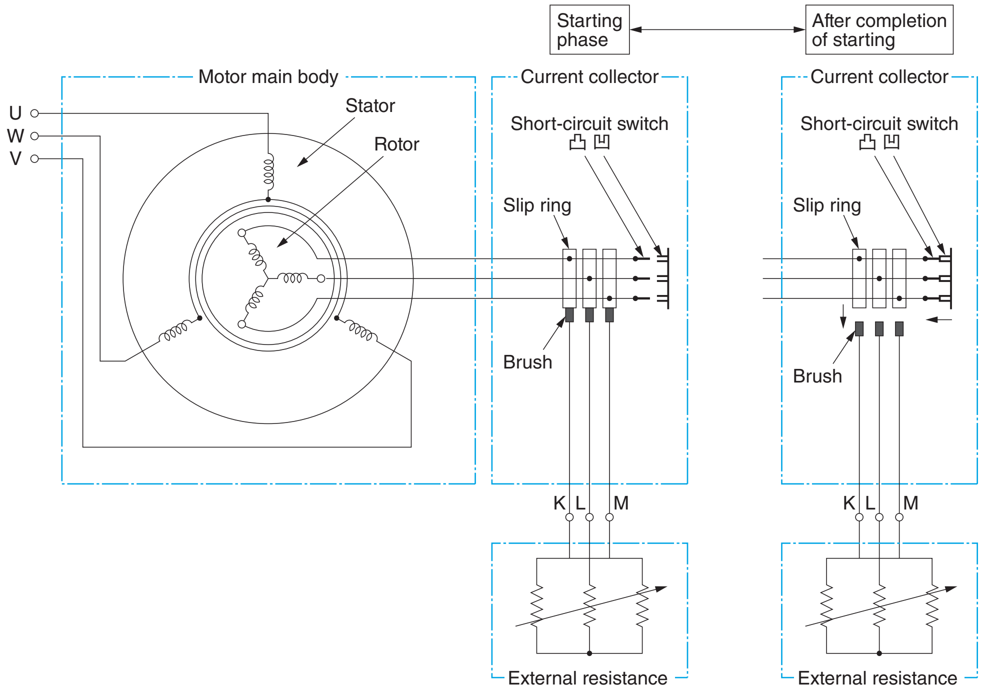

Fig. 3 **Configuration Drawing of Rotor Winding, Current Collector, and External Resistor**

A mechanical configuration is shown. The resistance is externally connected through the current collector.

stage to manufacturing design.

In the future, we will use this system to immediately output submittal documents and drawing according to specifications and respond quickly to customer requests.

6 Development of Brush Pulling Device

In a wound rotor type induction motor, an external resistance is connected to the rotor winding through the slip ring and brushes only during starting. The wound rotor type induction motor can achieve both high starting torque and low starting current. After starting is completed, external resistance is no longer necessary. Then, the rotor winding is short-circuited inside the motor and the brushes are pulled up to reduce brush wear.

Fig. 3 shows the configuration drawing of the rotor winding, current collector, and external resistor. During the starting, the brushes are brought into contact with the slip ring and the short-circuit switch (the short-circuit mechanism of the rotor winding) is opened to connect with the external resistor. After the start-up is completed, the brushes are pulled up from the slip ring and the short-circuit switch is turned on to short-circuit the rotor winding. The brush pulling device is electrically operated to raise and lower the brushes and is inter-linked to turn on and off the short-circuit switch.

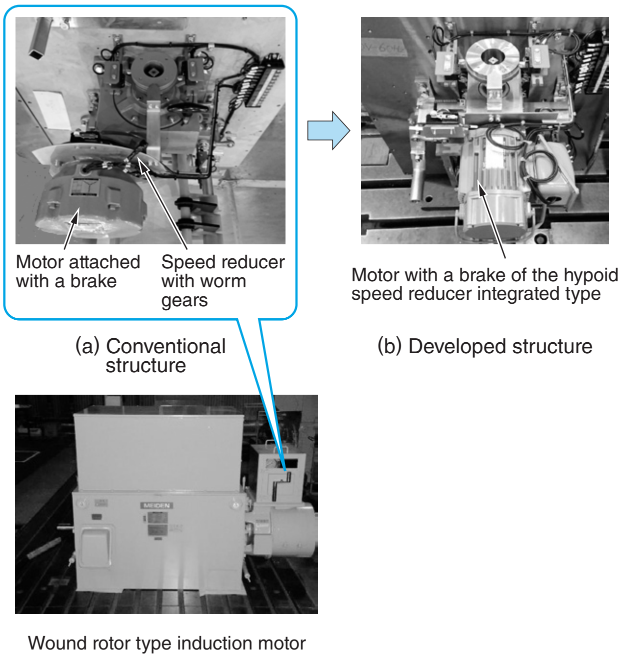

Fig. 4 **Conventional and Developed Structures of Brush Pulling Device**

Combining our original speed reducer with worm gears and motor attached with a brake conventional structure and development structure of motor with a brake of the hypoid speed reducer integrated type is shown.

The conventional brush pulling device used an electric motor with a brake via our original worm gear reducer to drive the pulling device and short-circuit switch. It has, however, a large number of parts and requires time for assembly and maintenance. The number of parts was large, and assembly and maintenance took time. The developed brush pulling device uses a general-purpose hypoid reducer-integrated electric motor with a brake to reduce the number of parts and improves assembly and maintenance, and increase gear efficiency. Compared to the conventional motor, the motor output was halved.

Fig. 4 shows the conventional and developed structures of the brush pulling device. We conducted a durability test at twice the level of an ordinary design standard requirement and we confirmed there is no problem in the developed brush pull-up device.

7 Efforts to Reduce Body Size of Large Machines

Regarding the body size reduction of electric motors, the larger the size of an electric motor, the greater the impact on product price, installation conditions, and installation work. This is an issue that should be addressed. **Fig. 5** shows a large size vertical shaft-wound rotor type induction motor. The body size is determined mainly by the temperature rise of the stator and rotor windings and the required specifications (power factor, efficiency, maximum torque, and noise). The power factor, efficiency, and noise have a particularly large effect on the large, low-speed machines for pump applications. It is, therefore, necessary to reduce the size of the machine. Improvement of power factor, efficiency, noise and design accuracy are necessary to reduce the size of the machine. The noise is evaluated by synthesizing the response simulation and ventilation noise using the stator core as a model. We are working on the optimization of the structure and improvement of design accuracy by full model analysis including components.

Fig. 5 **Large Size Vertical Shaft-Wound Rotor Type Induction Motor**

An example of large size vertical shaft-wound rotor type induction motor is shown.

8 Postscript

The demand for wound rotor type induction motors, which are capable of both suppressing voltage drop during start-up and achieving high starting torque characteristics, is expected to continue to grow, especially for the demand of facility renovation. The demand for replacing old cage type induction motors is also steady. For the cage type induction motor, the same effect as that of the wound rotor type motor can be expected if an inverter drive is used.

The introduction of a new drive system requires careful consideration of the installation location, product life, operation method, and other factors for the planning.

In addition to the recent model change of the wound rotor type induction motor conducted, we will work on the eco-design in response to the anticipated material changes in the future. We will also work on the reduction of the body size and overall performance improvement of wound rotor type induction motor.