Estimation of losses and parameters for induction motor

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Induction motors are the most popular motors in industrial area because they do not need commutator and brush, and it leads to their cheap cost and simple maintenance. Recently, induction motors are applied to many various speed applications, and the information about the electrical and mechanical parameters of induction motor is required to operate them in various speeds. Moreover, mechanical loss as well as core loss and iron loss should be measured for the motor performance evaluation, and motor parameters are required to calculate the motor loss here. This paper presents the procedure to estimate the losses of induction motor by using no-load test and curve-fitting, and the method to identify the mechanical parameters of induction motor by using deceleration profile. Here, mechanical parameters such as moment of inertia, damping coefficient and friction torque are simply estimated through the inverse matrix calculation. The identified mechanical parameters are validated by comparing the velocity-torque profile under load condition between the one measured by torque meter and the one estimated by torque-acceleration.

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1. Introduction

Recently, induction motors are applied to many various speed applications, and the information about the electrical and mechanical parameters of induction motor is required to operate them in various speeds. Moreover, mechanical loss as well as core loss and iron loss should be measured for the motor performance evaluation, and motor parameters are required to calculate the motor loss here .In order to plot the torque-speed curve, a few mechanical parameters of induction motor should be measured first. This paper shows the procedure to estimate the mechanical parameters and torque-speed curve of induction motor by using dynamometer. The mechanical parameters are estimated by using the deceleration profile of rotor and the mechanical loss which was measured by no-load test. Finally, torque-speed curve could be measured by using the measured parameters.

2. Measurement of characteristics of induction motor

2.1 Measurement of mechanical parameters

Mechanical torque to supply to rotate the motor is calculated from eq. (1).

$$T = J\ddot{\theta} + B\dot{\theta} + T_f \tag{1}$$

Where, T is motor torque, J is inertia of rotor, B is viscosity coefficient, T_f is friction coefficient, $\ddot{\theta}$ and $\dot{\theta}$ is angular acceleration and speed of rotor. In order to measure the torque which need to increase the speed of rotor in induction motor, 3 constants of J, B, T_f and 2 variables of $\ddot{\theta}$, $\dot{\theta}$ are needed. Here, J, B, T_f could be estimated from the deceleration profile which could be measured during power-off. The experimental setup and deceleration profile of induction motor are shown in figure 1 and 2. The equation of motion of point A, B, C in the deceleration profile could be described as eq. (2), (3), (4) and (5)

Point A : constant speed area, $$T = B\dot{\theta}_A + T_f \tag{2}$$

From eq. (2), $$P_v = T\dot{\theta}_A = B\dot{\theta}_A^{\,2} + T_f\dot{\theta}_A \tag{3}$$

Point B : Mechanical torque is zero, $$J\ddot{\theta}_B + B\dot{\theta}_B + T_f = 0 \tag{4}$$

Point C : Mechanical torque & viscosity effect is zero, $$J\ddot{\theta}_c + T_f = 0 \tag{5}$$

Eq. (3), (4), (5) could be expressed by a matrix form such as eq. (6)

$$\begin{pmatrix} \ddot{\theta}_B & \dot{\theta}_B & 1 \\ \ddot{\theta}_C & 0 & 1 \\ 0 & \dot{\theta}_A^2 & \dot{\theta}_A \end{pmatrix} \begin{bmatrix} J \\ B \\ T_f \end{bmatrix} = \begin{pmatrix} 0 \\ 0 \\ P_v \end{pmatrix} \tag{6}$$

The mechanical loss, P_v can be calculaed from eq. (7) and P_{NL}, P_s and P_f were measured by power-meter from no-load test. P_v was calculated with 24.6W and J, B, T_f can be calculated from eq. (6) and J is 0.023kg·m^2, B is 0.009kg·m/sec and T_f is 0.25 N·m.

$$P_f = P_{NL} - P_s - P_v \tag{4}$$

Where, P_f is the iron loss of stator, P_{NL} is the no-load input power, P_s is the copper loss.

(a) Induction moter and dynamometer (b) Power meter (c) 3phase Slide-AC

Fig. 1 Configuration of experimental setup for deceleration test and load test

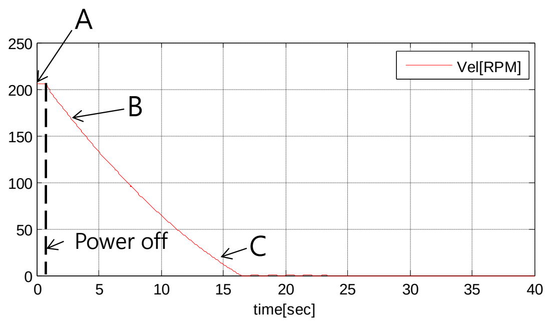

Fig. 2 Deceleration profile of induction motor

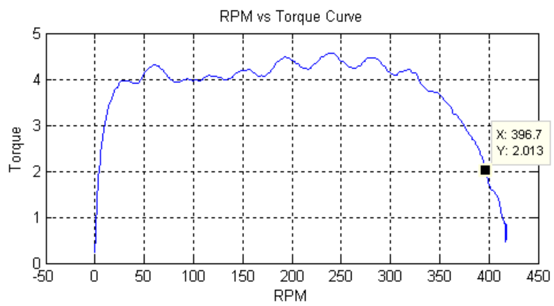

Fig. 3 Measured torque-speed curve

2.2 Measurement of torque-speed curve

Increasing the speed of induction motor, the speed and acceleration was measured by using the encoder which is equipped in the dynamometer. The torque could be calculated by using eq. (1) and torque-speed curve could be plotted as Figure. 3. To validated the measured torque-speed curve, load test for induction motor was accomplished. When 2 N·m load was exerted by using the dynamometer, the speed of induction motor was decreased to 387rpm which is similar to the value in Figure. 3.

3. Conclusions

Mechanical parameters such as moment of inertia, damping coefficient and friction torque are simply estimated through the inverse matrix calculation. The identified mechanical parameters are validated by comparing the velocity-torque profile under load condition between the one measured by torque meter and the one estimated by torque-acceleration.

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