CHAPTER 3

INDUCTION MOTOR MODEL

3.1 Introduction

In order to study induction motor characteristic, an induction motor must be modelled in suitable form. In this chapter, induction motor model is presented in detail. A method for aggregating a group of induction motors into one equivalent model is also described.

It is well known that induction machines are widely used in many applications. Industrial plants may consist of several large induction machines, even in household induction machines appliances are widely used e.g. air-conditioners, refrigerators, etc..

As mentioned above, it can be seen that most power system loads contain a substantial proportion of induction motors which are well known to have an influence on the dynamic response of power system. Therefore, it appears necessary to model induction motor loads in a reasonable way for stability studies of power systems.

There are many methods for representing the behavior of induction motors due to change in applied voltage and frequency i.e. constant impedance, approximate steady state behavior. The methods depend on the degree of accuracy desired in the representation.

Methods proposed here for modelling induction motor loads are discussed in the following section.

3.2 Steady State Model

Steady state characteristic of induction motor is represented by consumed active and reactive power as function of voltage.

Induction motor is modelled by the standard equivalent circuit shown in Fig. 3.1 .

The steady state characteristic is predicted by the following equation :

$$T_e = \frac{\frac{\omega_e}{\omega_b} X_M^2 r_r s |V_s|^2}{\left[r_s r_r + s\left(\frac{\omega_e}{\omega_b}\right)^2 (X_M^2 - X_{ss} X_{rr}) \right]^2 + \left(\frac{\omega_e}{\omega_b}\right)^2 (r_r X_{ss} + s r_s X_{rr})^2} \quad \ldots\ldots (3.1)$$

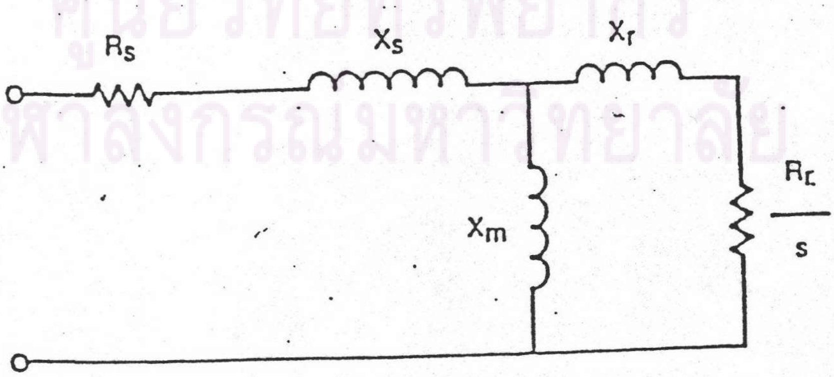

Fig. 3.1 Induction Motor Equivalent Circuit

This equation is solved in order to obtain induction motor slip at steady state condition by iteratively adjusting it until the electrical torque is equal to the mechanical load torque. The active and reactive power drawn by the motor are calculated by the following equation :

$$P = Re[(v^2/Z^*)] \qquad ..... (3.2)$$

$$Q = Im[(v^2/Z^*)] \qquad ..... (3.3)$$

The parameters of equivalent circuit can be determined by two types of test :

- No-Load test
- Short-Circuit or Rotor-Blocked test

In this thesis, all motor test data are submitted by Thai Food International Co.,Ltd.

3.3 Dynamic Model

To predict dynamic behaior of a induction motor, the innertia constant and load torque characteristic should be taken into account because these parameters have great effect on dynamic characteristic of induction motor.

$$H = 0.5*J*(w_s)^2/P_B \qquad ..... (3.4)$$

where

J is moment of inertia

w_s is synchronous speed

P_B is base power

3.4 Aggregated Induction Motor Model

When load at a given bus include several induction motors, it is not convenient to model each motor individually. Thus, and aggregate motor model is necessary.

Several techniques for grouping induction motors into an aggregation model have been proposed. Note that all aggregation methods are approximate in nature, therefore it is not necessary to use complex method. Instead, the method should be as simple as possible.

In this thesis, the following motor aggregation technique is used. The method is based on motor rating weighted average. For this method, each parameter of aggregate model is derived as the weighted average value of the respective parameter of individual motor in the group.

The equations used for this purpose are :

$$P_{mag} = \sum_{i=1}^{k} R_i * P_{mi} / R_{ag} \qquad ..... (3.5)$$

$$R_{ag} = \sum_{i=1}^{k} R_i \qquad ..... (3.6)$$

where

P_m is each parameter of the induction motor model in per unit

R is the motor rating

Motor parameters are those of the equivalent circuit shown in Fig. 3.1 including the inertia constant. The parameters mention above are listed below :

R_s is stator resistance

X_s is stator reactance

R_r is rotor resistance

X_r is roror reactance

X_m is magnetizing reactance

H is innertia constant