# Parameters Calculation of 5 HP AC Induction Motor

I. Daut, K. Anayet, M. Irwanto, N. Gomesh, M. Muzhar, M. Asri, Syatirah
Power Electronics and Electrical Machine Design Research Cluster
School of Electrical Systems Engineering
Universiti Malaysia Perlis (UniMAP)
***** Email: anayet@unimap.edu.my, gomz_84@yahoo.com

***Abstract*-This paper presents the parameters calculation of 5hp three phase induction motor, the data obtained will assist to the FEM designer to design the complete model of AC induction motor. In this paper assume the efficiency of an induction motor is 84% and power factor is 0.80. The motor parameters such as the stator resistance, rotor resistance, rotor current, induction motor losses are presented in this paper.**

***Keywords*-Parameter calculation of induction motor, losses, power factor, efficiency etc**

## I. INTRODUCTION

Industrial sectors are the biggest consumer in the electric power generated in Malaysia for about 51.9% of the total electricity consumption, i.e. 27211.17 GWh [21]. World energy consumption is expected to increase 40% to 50% by the year 2010, and the global mix of fuels is projected to remain substantially the same as today. Three phase induction motors are the motors most frequently encountered in industry. It is simple, rugged and easy to maintain construction has enabled them to be widely used in industry in almost all applications. These motors are also called workhorses of the industry. The induction motors are used widely in the industry as well as the home appliances.

## II. MECHANICAL DESIGN PERSPECTIVES OF INDUCTION MOTOR

The stator and rotor magnetic cores are made of thin silicon steel laminations with non grain-to reduce hysteresis and eddy current losses. The stator and rotor laminations are packed into a single stack which is shown in Fig 1 or in a multiple stack shown in Fig 2.The latter has radial channels (5-15 mm wide) between elementary stacks (50 to 150 mm long) for radial ventilation. Single stacks are adequate for axial ventilation. Single-stack induction motors have been traditionally used below 100 kW but recently have been introduced up to 2 MW as axial ventilation has been improved drastically. The multistack concept is necessary for large power (torque) with long stacks. The multiple stacks lead to additional winding losses, up to 10%, in the stator and in the rotor as the coils (bars) lead through the radial channels without producing torque. Also, the electromagnetic field energy produced by the coils (bar) currents in the channels translates into additional leakage inductances which tend to reduce the breakdown torque and the power factor. They also reduce the starting current and torque. Typical multistack Induction motor are shown in For induction motors of fundamental frequency up to

300 Hz, 0.5 mm thick silicon steel laminations lead to reasonable core losses 2 to 4 W/Kg at 1T and 50 Hz. For higher fundamental frequency, thinner laminations are required. Alternatively, anisotropic magnetic powder materials may be used to cut down the core losses at high fundamental frequencies, above 500 Hz.

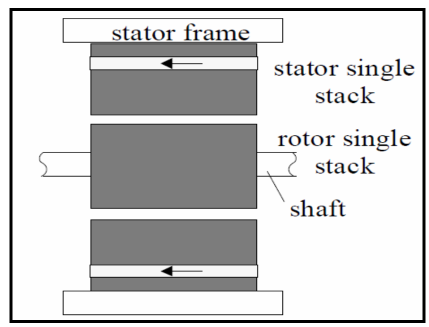


Fig 1. Single stack magnetic core

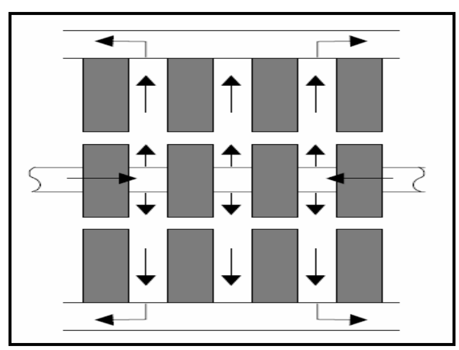

Fig 2. Multiple stacks induction motor

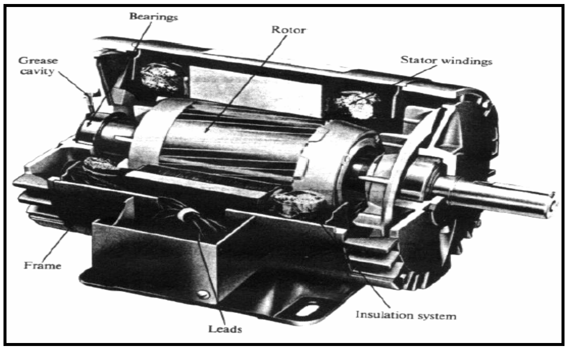


Fig 3. Induction motor wound three-phase stator winding with cage rotor

## III. INDUCTION MOTOR PARAMETERS CALCULATION

Induction motor having 4 pole whose synchronous speed 1500 rpm and measured speed is 1420 rpm, it is star connected. Let's say efficiency that required by consumer is 84% and the rms three phase voltage to the induction motor is 415V, rated current 7.9A and power factor 0.80 [10].

All the loss estimation of 5hp induction motor has summarized in Table 1 and all the calculated value for induction motor parameters has summarized in Table 2. Formula used in this paper

Input Power:

$$P_{in} = \sqrt{3}V_L I_L Cos\theta = \sqrt{3} * 415 * 7.9 * 0.8 = 4542.80W$$

The input power of the induction motor is 4542.8W

Efficiency calculation:

$$\eta = (1 - \frac{P_{losses}}{P_{in}}) * 100\%$$

Losses calculation:

$$P_{losses} = P_{SCL} + P_{RCL} + P_{core} + P_{F+W} + P_{Stray}$$

Stator copper loss:

$$P_{SCL} = 3I_1^{\ 2} R_1$$

Rotor copper loss:

$$P_{RCL} = 3I_2^{\ 2} R_2$$

The Shaft Load Torque:

$$\tau_{Load} = \frac{P_{Out}}{\omega_m} = \frac{3730}{1420 * 2\pi(1\min/60s)} = \frac{3730}{148.75} = 25.08N.m$$

Air gap power:

$$P_{AG} = 3I_2^2 \frac{R_2}{s}$$

Per-Phase Stator Core Loss Resistance:

$$R_c = \frac{V_{L-L}/\sqrt{3}}{I_c}$$

Per-Phase Stator Magnetizing Inductor:

$$L_m = \frac{V_{L-L}/\sqrt{3}}{2\pi f_s I_m}$$

Based on IEEE 112-B standard Pstray, Value at 1 kW is 2.5% of the full-load input power, dropping at 10kWto 2%, at 100kWto 1.5%, at 1000kW to 1%, and at 10 MW to 0.5% [12].

Therefore,

$$P_{Stray(IEEE)} = 4542.8 * 2.5\% = 113.57W \quad (1)$$

In the IEC 34-2 standard, these losses are not measured and are arbitrarily estimated to be equal to 0.5% of the full-load input power [12].

Therefore,

$$P_{Stray(IEEE)} = 4542.8 * 0.5\% = 22.7W \quad (2)$$

In Ontario Hydro's simplified segregated loss method suggests that one way around this obstacle is to assume a value for a combined windage, friction and core losses [11]. The study recommends that these combined losses be set to 3.5% of the input rated power

So, $P_{Rot} = 3.5\% * P_{in}$

Therefore, obtained rotational loses:

$$P_{Rot} = 3.5\% * 4542.8 = 158.99W$$

Factors to be consider: I1 > I2, I1 must be bigger than I2 value because $I_1 = I_2 + I_\theta$ see Fig 4. The lower the horse power of the motor that increases the total resistance

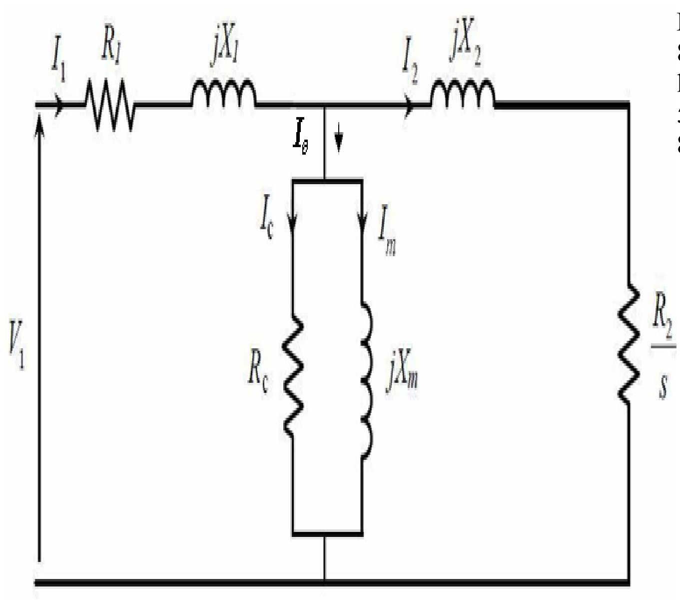


Fig 4. Equivalent Circuit of the AC Induction Motor

## IV. INDUCTION MOTOR LOSSES SEGREGATION

TABLE I: Loss Segregation Obtained from Calculation

| Losses Segregation | Calculated Value (W) |
|---|---|
| Input Power (Pin) | 4542.8 |
| Stator Copper loss | 363.36 |
| Rotor Copper loss | 91.1 |
| Core loss + Friction and windage losses | 158.99 |
| Stray losses ($P_{strayIEEE\text{-}12B\ standard}$) | 113.57 |
| Stray losses ($P_{stray\ IEC\text{-}34}$) | 22.7 |
| Total Losses (Watts) | 749.72 |
| **Output Power(Pout)** | **3730** |

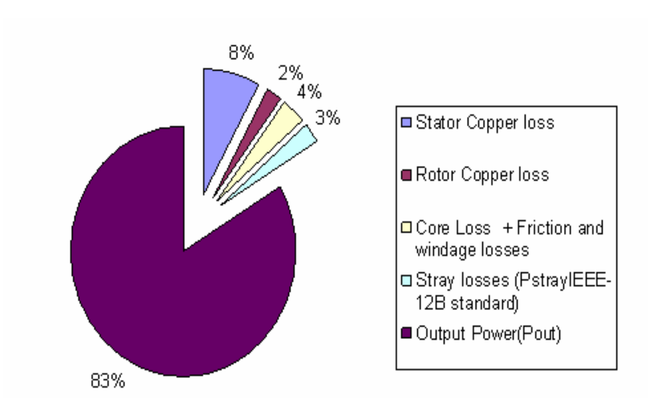


Fig 5. Percentage of Loss Segregation of 5hp Induction Motor

Based on Fig 5, it shows that the stator copper loss contribute 8% towards the losses followed by the core loss (4%). Stray loss (3%) and finally the rotor copper loss (2%).17% from the 5hp induction motor is dissipated as losses. and the balance 83% is the output power of the induction motor.

TABLE II: Induction Motor Parameters Obtained from Calculation

| 5HP Induction Motor Parameters | Calculated Value |
|---|---|
| Stator current (I1) | 7.9A |
| Rotor current (I2) | 3.95-4.0A |
| Stator resistance (R1) | 1.9 Ω -2.4Ω |
| Rotor resistance (R2) | 1.8 Ω -1.946Ω |
| Stator core loss current (Ic) | 6.356A |
| Magnetizing current (Im) | 4.74A |
| Excitation current (Iø) | 2.72A |
| Stator core loss resistance (Rc) | 37.72Ω |
| Stator magnetizing inductor (Lm) | 0.1542 H |
| Magnetizing reactance (Xm) | 48.44 Ω |
| Slip | 5.30% |
| Rotor frequency ($f_r$) | 2.65 Hz |
| Shaft load torque (T) | 25.08 N-m |

Table II summarizes the complete parameter of the 5hp induction motor; it shows that the stator resistance is nearly similar to that of the real stator resistance of the induction motor and may vary ±5 Ω.

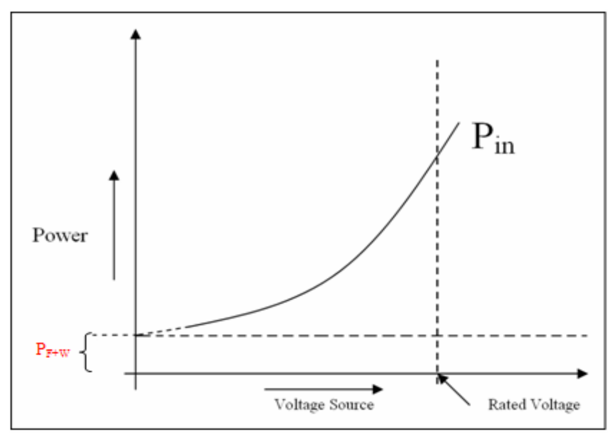


Fig 3. Friction and windage loss Segregation method for induction motor

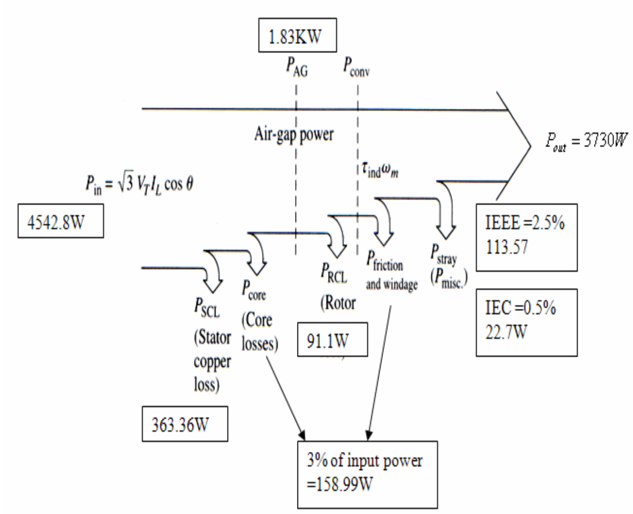


Fig 4. The Power flow diagram of an induction motor

## V. DISCUSSION

The 5 hp parameter calculation is called the backwards calculation method in which the efficiency is assume to the value that is in the present market, and the rated current and voltage is taken with data from average value of voltage and current use in the 5 hp induction motor based on literature review. The power factor is 0.80, although in the present market power factor goes up to 0.85 with the usage of power factor correction circuit. Based on the calculation the value of each parameters calculated is nearly the value of the manufacturer's data and others researchers obtained data thus making it possible to calculate the parameters for the induction motor to fulfill the need of the industry.

## CONCLUSION

The following conclusion could be made on this paper,

- A proper parameter calculation is needed to obtain the range of specification of the induction motor such as the total resistance, reactance, the losses estimation, stator current, rotor current, etc.
- It is noted that if the horse power rating of the induction motors increases the value of resistance decreases.
- All the data that calculated can be used for FEM designer to design the complete model of AC induction motor
- Proper rating should be set in order to obtain the exact efficiency of the Induction Motor.

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