TELKOMNIKA Indonesian Journal of Electrical Engineering
Vol. 15, No. 1, July 2015, pp. 63 ~ 70
DOI: 10.11591/telkomnika.v15i1.8004

Induction Motor Characteristics Study using Laboratory Instrument Engineering Workbench

E.Ramprasath*, P.Manojkumar, P.Veena
K.S.Rangasamy College of Technology, Namakkal, Tamil Nadu, India
*Corresponding author, e-mail: ramprasath009@gmail.com

Abstract

Induction motor characteristics are complex to study, so in order to simplify its complexity modelling of induction motor will be useful. Proposed paper dealt with the simulation of induction motor based on the mathematical expression using the graphical user interface software. Laboratory Virtual Instrument Engineering Workbench (LabVIEW) software is used for modelling the induction motor and helps in analyzing the performance characteristics of a machine. After the invention of special electrical machine the research in induction motor starts to decreases but it is the widely used motor in industries. The study about induction motor characteristics became complex after the incorporation of power electronic switches such as thyristor, diodes, GTO, and MOSFET. Induction motor characteristics can be studied and modelled with the help of numerous softwares such as Finite Element Analysis and Laboratory Virtual Instrument Engineering Workbench.

Keywords*: induction motor, modelling, characteristics, simulation, LabVIEW.*

1. Introduction

Induction motor designing isderived based on the mathematical equation which is quite complex in nature, because equation whose terms are second order degree and more over it is a strongly coupled system. The input and output variable relationship is almost complex because there are multiple relationship between the parameters affecting them, find an appropriate parameter is difficult. Modelling the simulation of induction motor physically is hard due to factor of inbound relationship affecting them. Most common software employed for modelling and analysis are PSpice, Finite Element Analysis commonly are known as FEM analysis which analysis the flux revolving around the motor and to find out the un equal distribution of fluxes in induction motor, Matrix Laboratory and Laboratory Virtual Instrument Engineering Workbench are the software which are completly based on the graphical programming languages. software rather than is, are created based on the text lines such as C & C++.

LabVIEW software is fully based on the graphical programming environment. LabVIEW software has a dynamic nature which contributes to this real time tracking or processing the data. The changes in this parameter can be can be observed continuously without any run time interruption. Dynamic analyzing is established based on both the mathematical and physical model. Normally equivalent circuit of transformer resembles the equivalent circuit of induction motor based on the construction equalities, where the airgap between the stator and rotor in the induction motor differentiate from the transformer. LabVIEW software of following qualities such as multi-dimensional plots, xy graphs, report generation in excel, word makes this software accessible and has a unique feature, which simplifies the simulation process.

Induction motor are analysed using the dynamic and steady state analysis are normally difficult to compute so modelling a induction motor using mathematical model helps to eliminate the further consequences.The real time engine in LabVIEW helps to simulate a induction motor with the real time capability To simulate a motor like a real time motor the both should share the identical parameters.So the determination of parameters must be accurate for carrying out induction motor characteristics analysis. Machine performance changes according to the coupled system inertia, so a small negligible changes contributes to the change in the load torque. Motor constancy changes rapidly, if the motor inertia and load torque of that motor changes rapidly. Identifying faults in electric motor using LabVIEW is growing research area

Received March 26, 2015; Revised May 5, 2015; Accepted May 22, 2015

where many researchers contributing their value knowledge to find out faults in various electric motor.

2. Preliminary Equivalent Circuit & Mathematical Expression

The variety of sensors are implemented to get the results from the motor and they are estimated using the LabVIEW software. In industries three phase induction motors are employed widely. Hence it's significant to verify the voltage variation effect. In general induction motor are contrived to work under the balanced three phase condition, owing to a negative sequence there will be a minimum amount of voltage unbalance occurs which causes a instability during the motor operation. In common there will be a minimum unbalance which is merely negligible. The parameter identification is done by solving the following mathematical equations.

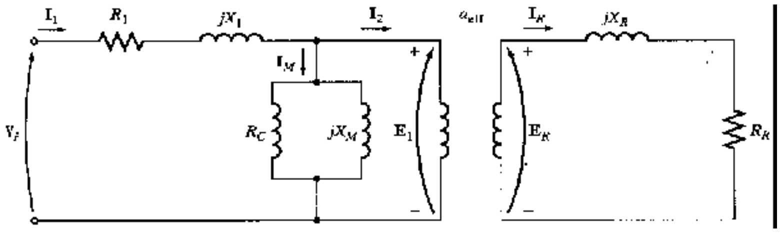

Figure 1. Equivalent Circuit Parameters of an Induction Motor

Slip is defined as the ratio of the difference between the synchronous speed and the actual motor speed to the ratio of the synchronous speed.

$$s = \frac{n_s - n_m}{n_s}$$

In general induction motor the torque is directly proportional to the product of the rotor current and flux per stator pole. The electromagnetic torque in synchronous watt can be expressed as:

$$T = \frac{3}{2\pi n_s} * \frac{sE_2^2 R_2}{R_2^2 + (sX_2)^2}$$

Stator copper loss occurs during energizing the stator windingat the induction motor:

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

Rotor copper loss occurs at the induction motor during the no load and half load losses:

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

Input power required by the induction motor to operate effectively:

$$P_{in} = \sqrt{3} V_L I_L \cos\theta = 3 V_{ph} I_{ph} \cos\theta$$

Air gap power between the rotor and stator of the induction motor:

$$P_{AG} = P_{in} - (P_{SCL} + P_{Core})$$

Core loss in the induction motor:

$$P_{core} = P_{AG} - P_{RCL}$$

Output power of the induction motor:

$$P_{out} = P_{core} - \left(P_{f+W} + P_{stary}\right)$$

Torque induced due to the interaction between the stator and rotor flux opposition.

$$\tau_{ind} = \frac{P_{conv}}{\omega_m}$$

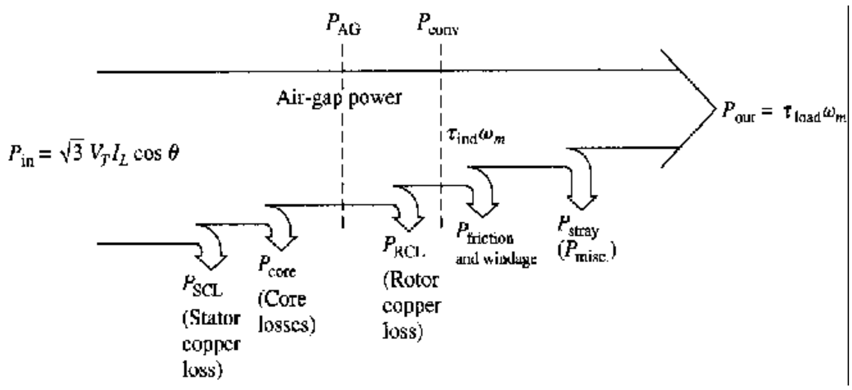

Figure 2. Power flow diagram of the induction motor

Table 1. Motor internal parameter

Parameters	Symbols	Input values
Rotor Resistance	R_1	8.6
Rotor Reactance	R_2	0.332
Stator Resistance	S_1	1.106
Stator Reactance	S_2	0.464
Magnetizing Reactance	X_m	26.3

Motor internal parameter are choosen from the parameters which are highly trained using the repetitive algorithms which follows a logical sequence. If there is any error in the following logical sequence, the error will be shown and the program return to a default state. The trained logical sequences give out a successful identification of parameter which are used to model the complete structure of induction motor. For a particular operating load condition these values are made constant thought the simulation running time. Parameters can be changed before simulating for different load condition. They corresponding characteristics curve can be drawn.

Table 2. Motor input teminal

Parameters	Symbols	Input values
Phase voltage	V_{ph}	220
Frequency	H_Z	50
Number of poles	P	4

Values are fixed throughout the simulation because small changes in these input values may deviate characteristics of the motor. So the above parameters should be fixed throughout the process of simulation.

Table 3. Motor core loss

Parameters	Symbols	Input values
Core Loss	L	300

Core loss are made constant throughout the running time of the motor. Because they won't change for a motor throughout its lifetime or may be known as fixed loss with respect to the real time construction of the motor. So it's made as constant in this simulation.

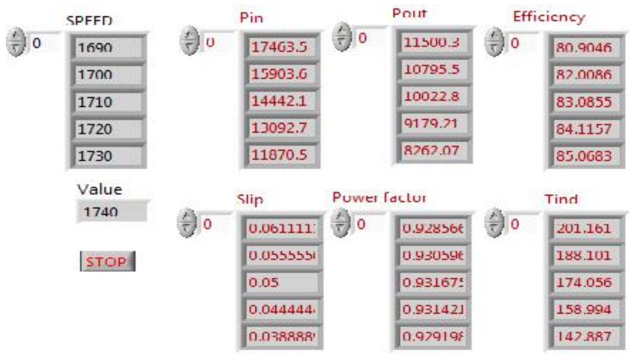

Figure 3. Output parameter of induction Motor

During the load test, if the loading of the motor changes there will be a change in parameter such as the input power, power factor, output power, slip, efficiency and torque induced. The changes in this parameter are displayed in the Figure 3. LabVIEW helps to compute quickly so that there will be a quick response to the change in the loading values.Mechanical characteristics of induction motor are to be analyse in that torque vs speed characteristics plays a major role in analyses of induction motor. In this simulation the torque vs speed characteristics are analysed for the study of an induction motor which are modelled by the mathematical calculation.

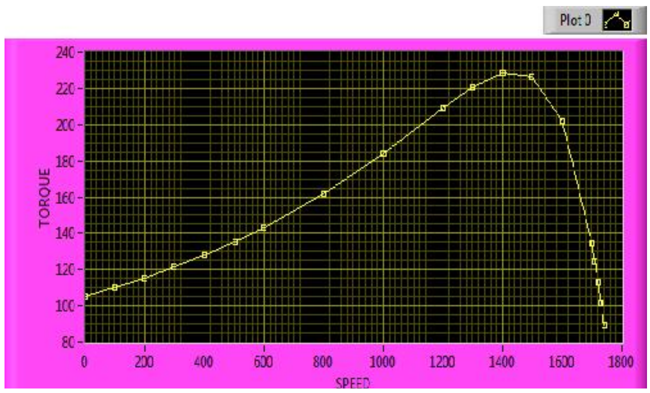

Figure 3. Torque vs Speed characteristics of induction motor

Torque vs speed characteristics of an induction motor shown which shows the single quadrant operation of the motor.

Characteristic curve shown here resembles the National Electrical Manufacture Association Design A in theoretical it will have low resistance and reactance owing to that it produce very small starting torque and have high breakdown torque when comparing it whether other NEMA Designs. Starting torque of an induction motor is merely known as stalled rotor toque.In NEMA designs there nearly classified into four variety of designs are achieved according to thetorque characteristics of a motor. NEMA acronym of National Electrical Manufacture Association is the association of electrical equipment and medical imaging manufacturers in the United States.

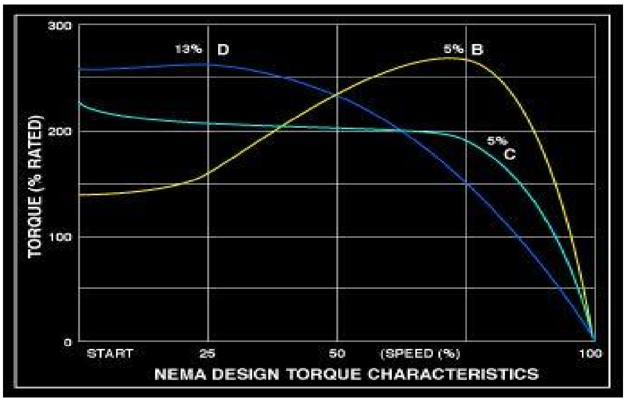

Figure 4. NEMA design Characteristics

The NEMA designs are classified into NEMA A, NEMA B, NEMA C and NEMA D. NEMA designs are classified according to the NEMA A design types Sector.

Figure 5. Output power vs Efficiency characteristics of induction motor

During the loading of the motor, efficiency tends to increases with the corresponding loading of the machine. The linearly decreases with the output power, the reading are noted for the first few readings. When the machine reaches nearer to the full load, the efficiency of the motor will be maximized.

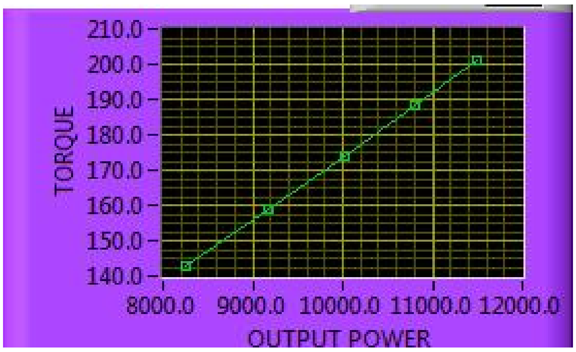

Figure 6. Output power vs Torque characteristics of induction motor

Torque vs output power characteristics is linear in nature. When the torque increase the corresponding output power also tend to increase, where the increase in torque is directly proportional to the output power of the motor to maintain the stability. If there is a sudden disruption, then this will cause the instability in nature. Torque is normally measured in terms of N/m^2. Here the graph is drawn between the percentages of torque to the output power of the motor.

Figure 7. Output power vs Current characteristics of induction motor

Current vs output power characteristics is linear in increase in nature. When the output power increase the current, which is directly proportional to each other and also tend to increase the stability of the induction motor. If there is a loading of the motor current will change according to the loading of the motor. Torque is directly proportional to the current, the current increase the output power also increases. There are other various characteristics are also represented in the graphical representation. Normal rating of the current slightly increases over a period of the time. For every increase in speed there a increase in the current at the rate of 2 amps per given speed. If the torque value decreases the simultaneously current values are also decreased.

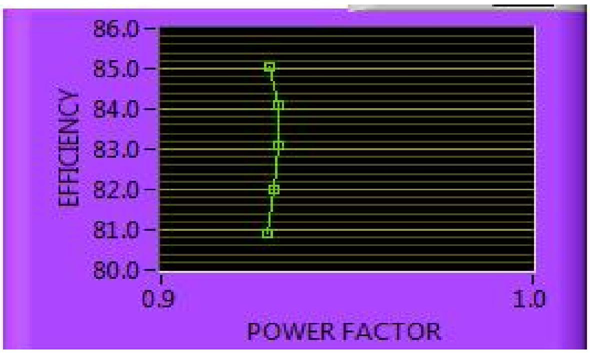

Figure 8. Power factor vs Efficiency characteristics of induction motor

Power factor vs efficiency characteristics show when the motor gets loaded to the rated loaded condition then there is increase in the power factor of the motor. The power factor of the induction motor when load to its rated value it is nearer to the unity power factor value. The power factor of the squirrel cage induction motor also gets improved if the motor is loaded is nearer to the rated speed, but in most of the industries they're loaded optimally and not to the full range. The slip ring induction motor is less efficient than the squirrel cage induction motor.

Figure 9. Speed vs Efficiency characteristics of inducton motor

Efficiency increases with the speed of the motor if the motor is loaded to the rated speed then the efficiency will be maximized if the motor is loaded above the rated speed both the efficiency and the power factor will be decreased.

4. Conclusion

The analysis of this simulation model shows that induction motor model here can be compared with the real time evolution machine model. The simulation model is built with the LabVIEW software. It can be used to model and simulate the working process of induction motor by which induction motor performance is analysed, which is set to compare with the real time operating condition of the induction motor for the optimal operation of machines. The creation of the induction motor model can be bundled into a sub-Virtual Instrumentation, for further experimental studies.

This type of work can be further proceeded to the other machines such as special electrical machine and direct current motor. It helps the manufacturer to study the motor performance before manufacturing it or it helps the manufacturer to invent a new machine on the above said consideration. They are less time consuming parameters and can be analysed quickly without any interruption in the following simulations.

References

[1] RK Rajput. Electrical Machines. First edition. New York: McGraw-Hill. 1993: 352-353.

[2] Krishnan R. Electric Motor Drives Modeling, Analysis and Control. First edition. New Jersey: Prentice-Hall International. 2001.

[3] Gunabalan R, Immanuel Prabakaran S, Reegan J, Ganesh S. Simulation of inverter fed induction motor drive with LabVIEW. *International Journal of Electrical, Robotics Electronics and Communications Engineering*. 2014; 8(1): 91-95.

[4] Gentian dume. Synchronous Generator Model based on LabVIEW Software. *WSEAS Transactions on Advances in Engineering Education.* 2014; 10: 101-112.

[5] RA Jabbar, Azah Mohamed, MA Hannan, Muhammad Junaid, M Mansoor, A Latif, H Noor. *Simulation of electrical machines laboratory using LabVIEW*. International Conference on Computer, Electrical, and Systems Science, and Engineering, World Academy of Science Engineering and Technology. 2010: 29-31.

[6] Abdenour Soualhi, Guy Clerc, Hubert Razik. Detection and diagnosis of faults in induction motor using an improved artificial ANT clustering technique. *IEEE Transactions on Industrial Electronics.* 2013; 60: 4053-4062.

[7] M Aderiano da Silva, J Richard Povinelli, AO Nabeel Demerdash. Rotor bar fault monitoring method based on analysis of air-gap torques of induction motors. *IEEE Transactions on Industrial Informatics.* 2013; 9: 2274-2283.

[8] Bogdan Virlan, Seifeddine Benelghali, Alecsandru Simion, Leonard Livadaru, Rachid Outbib, Adrian Munteanu. Induction motor with outer rotor and ring stator winding for multispeed applications. *IEEE Transactions on Energy Conversion.* 2013; 28: 999-1007.

[9] L Daniel Ransom. Randy Hamilton. Extending motor life with updated thermal model overload protection. *IEEE Transactions on Industry Applications*. 2013; 49: 2471-2477.

[10] Gianmario Pellegrino, Alfredo Vagati, Barbara Boazzo, Paolo Guglielmi. Comparison of induction and pm synchronous motor drives for ev application including design examples. *IEEE Transactions on Industry Applications.* 2012; 48: 2322-2332.
[11] N Konstantinos Gyftakis, V Dionysios Spyropoulos, C Joya Kappatou, D Epaminondas Mitronikas. A novel approach for broken bar fault diagnosis in induction motors through torque monitoring. *IEEE Transactions on Energy Conversion*. 2013; 28: 267-277.
[12] Lu´ıs Alberto Pereira, C´esar Cataldo Scharlau, Lu´ıs Fernando Alves Pereira, S´ergio Haffner. Influence of saturation on the airgap induction waveform of five-phase induction machines. *IEEE Transactions on energy Conversion.* 2012; 27: 29-41.
[13] Pinjia Zhang, Yi Du, G Thomas Habetler, Bin Lu. A nonintrusive winding heating method for induction motor using soft starter for preventing moisture condensation. *IEEE Transactions on Industry Applications.* 2012; 48: 117-123.
[14] Sungho Lee, Jongman Hong, Sang Bin Lee, J Ernesto Wiedenbrug, Mike Teska, Heedong Kim. Evaluation of the influence of rotor axial air ducts on condition monitoring of induction motors. *IEEE Transactions on Industry Applications.* 2013; 49: 2024-2033.
[15] Woosuk Sung, Jincheol Shin, Yu-seok Jeong. Energy-efficient and robust control for high-performance induction motor drive with an application in electric vehicles. *IEEE Transactions on Vehicular Technology.* 2012; 61: 3394-3405.
[16] E Ramprasath, P Manojkumar, P Veena. *Induction Motor Analysis Using LabVIEW.* In Proceeding on International Conference on Electrical Engineering and Technology. 2015; 2(5): 498.
[17] E Ramprasath, P Manojkumar. Modelling and Analysis of Induction Motor using LabVIEW. *International Journal of Power Electronics and Drive System (IJPEDS)*. 2015; 5(3): 344-354.