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Efficiency Analysis of Rewinding Induction Motor with DTC-SVM Control Technique

Shikha Yadav
M.Tech. Research Scholar
Takshshila Institute of Engineering & Technology
Jabalpur (M.P.), [INDIA]
Email:

Pramod Dubey
Assistant Professor
Department of Electrical & Electronics Engineering
Takshshila Institute of Engineering & Technology
Jabalpur (M.P.), [INDIA]
Email: pramoddubey@takshshila.org

Abstract**—***Electrical drives play a significant role in the field of energy efficiency. Modern power electronic drives give good opportunities to control the energy flows efficiently. Use of electrical drives in industrial and other processes is increasing continuously as a result of the global concern over the change in climate condition. According to the present realizing, the reduction of carbon dioxide emissions is one of the most crucial targets in the future. Among other emerges, this can be achieved by minimizing the amount of energy consumed. Electric motors are used in all sectors from households to the industry and commercial sector. So it acts as the most important type of electric load. Electric motors are utilized in a large range of applications, such as pumps, fans, mills, compressors, elevators and transports. So it is essential to utilize electric energy as efficiently as possible in electric motor drives. Because in developed countries, electric motors use over half of all electricity consumed.*

Keywords:**—** *Quadrature Magnetizing, Stator, Rotor, Motor Efficiency, windage*

1. INTRODUCTION

Electric motor drives are found to be an attractive objective for energy efficiency improvements, as electric motor drives are used widely in various sectors. The extensive use of drive systems gives a better opportunity for significant energy savings. Even small improvements in efficiency would produce extensive energy savings globally. However, the problem is that electric drives are slowly replaced by new drives when the period of life of a properly designed drive reaches 30 years. The cost of the electrical energy that is consumed by a motor over its lifespan is multiple times the motor purchase price. For any industry, the cost savings are the most important consideration to moving on to more energy efficient solutions.

In addition to the new machines purchased and installed by the industry every year, nearly the same number of motors is repaired and reemployed. Consequently, how effectively these failed machines can be recovered is always an issue for both the end users and repairers. For a long time, the motor repairs have been thought to cause an efficiency loss and performance deterioration. Based on the industrial processes one may arrive at different savings potentials, but the key disputes to the improved efficiency in systems that driven by electrical machines lie down in the following three points:

1) To increase the efficiency of the electrical drive,

2) To efficiently control the drive, extend the application areas of

variable-speed electric drives using power electronics and

3) To incorporate the drive and the driven load to maximize the efficiency of the system.

The induction motor is the most common electric motor in most applications of all the sectors. Induction motors fail due to many reasons, and many are rewound two or more times during their lifespan. It is assumed generally that efficiency of a rewound motor is not same as the original motor. Exact estimation of efficiency of a refurbished motor or any existing motor is essential in industries for energy auditing, savings and management.

In most cases, the efficiency improvements can be obtained by the improved system efficiency, which very often, but not always, can be achieved with a variable -speed drive. The main function of a variable speed drive (VSD) is to control the power flow from the mains to the load. The combination of an electric motor with power electronic converter leads to the establishment of variable speed drives. The efficiency of the entire system can be optimized by introducing variable speed to the driven load, and so in this area that the greatest efficiency gains are possible.

An optimal control of the energy flow provides yet another way to reduce the losses in a motor drive. In frequency-converter-fed induction motor drives, there is also the option to reduce the drive losses by adjusting the motor magnetization level according to the motor load. This iron loss saving method is a well-known technique, which is applied to various kinds of electrical machines and which is implemented in different control algorithms. The whole drive system must be carefully dimensioned to obtain low losses. By adopting well-known, proven concepts, it is possible to increase the efficiency of systems driven by electrical machines and reduce the total electricity consumption.

In most of the industrial applications, it is frequently needed to control the inverter output voltage for the constant voltage to frequency ratio control of the induction machine. In the literature, pulse width modulation (PWM) techniques have been hinted to control the inverter output voltage waveform. The features of PWM technique depend on the applied control strategy. In present years, the direct torque control (DTC) of induction motor drive is extensively used in a drive system with high performance, because of its effective benefits like very simple, high efficiency, good power factor, extremely rugged construction. In recent years, the need for adjustable speed drives in industries is very high.

2. METHODOLOGY

Achieving overall aim of the study comprised following tasks. First information about the efficiency of the induction motor is evaluated and rewinding effects on induction motor efficiency is analyzed based on losses that are employed in the induction motor operation. There are different control techniques that can directly or indirectly control these losses and aid to achieve efficiency enhancement. In this research torque and flux are controlled by direct torque control method and this control method is employed with space vector modulation technique to provide better control over the normal PWM technique. This control is implemented with fuzzy logic based intelligent control method and energy efficiency of new and rewound motor is examined after subjecting to the control method.

Induction Motor and its Efficiency

The AC induction motor is one of the most efficient motors in existence for high horsepower applications such as 500 HP and higher, where efficiency ratings of 97% or higher are possible. However, under light load conditions, the quadrature magnetizing current required to produce the rotor flux represents a large portion of the stator current, which results in reduced efficiency and poor Power Factor operation.

The fundamental learning about the constructional feature for an induction motor is required to comprehend the principle of three phase induction motor in a better way. This Motor comprises of two fundamental parts:

***Stator*:** Stator of three phase induction motor is comprised of a number of slots to develop a 3 phase winding circuit which is associated with 3 phase AC source. The three phase winding are arranged in such a way in the slots that they deliver a rotating magnetic field after AC is given to them.

***Rotor*:** Three phase induction motor rotor comprises of a cylindrical laminated core with parallel slots that can convey conductors. These conductors are comprised of substantial copper or aluminum bars which fit in every slot and they are short-circuited by the end rings. The slots are not precisely made a parallel to the hub of the shaft, however, are slotted somewhat skewed in light of the fact that this course of action diminishes magnetic humming commotion and can abstain stalling of a motor.

3. MOTOR EFFICIENCY

Two vital credits identifying with the efficiency of power use by A.C. Induction motors are efficiency (η), defined as the proportion of the mechanical energy produced at the rotating shaft to the electrical energy input at its terminals, and power factor (PF). Motors, as other inductive loads, are portrayed by power factor considers less than one. Thus, the aggregate current attracts expected to deliver the same real power is higher than for a load described by a higher PF. An imperative impact of operating with a PF under one is that resistance losses in wiring upstream of the motor will be higher since these are relative to the square of the current. Hence, both a high value for η and a PF near solidarity are wanted for proficient general operation in a plant.

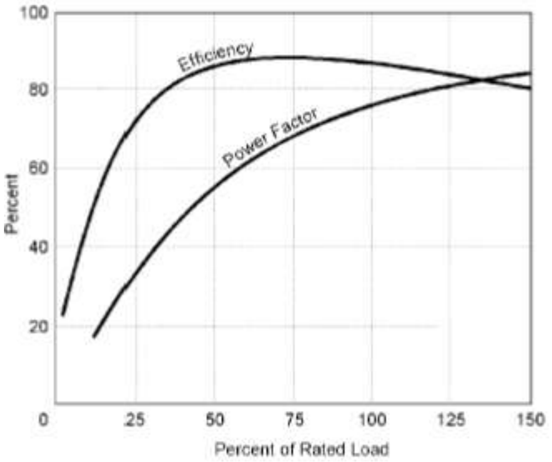

Figure. Efficiency/ Power factor VS Load (for 3-phase IM)

Fig. demonstrates the impact of load on power factor and efficiency. It can be seen that power factor drops powerfully at part loads. Squirrel cage motors are generally more effective than slip-ring motors, and higher-speed motors are generally more efficient than lower-speed motors. Efficiency is additionally a component of motor temperature. Completely encased, fan-cooled motors are more efficient than screen protected drip-proof motors. Additionally, as with most equipment, motor efficiency increments with the rated capacity limit.

Induction motor efficiency and losses

Study on electric drive system efficiency is all set to raise the capacity and cleverness of an electric motor and its controller, to change electrical energy into mechanical energy; that is, kilowatts of electric power are supplied to the motor at its electrical terminals, and the HP of mechanical energy is taken out of the motor at the pivoting shaft. Accordingly, the main power consumed by the electric motor is the losses brought about by making the change from electrical to mechanical energy. Along these lines, the direct estimation strategy for motor efficiency can be stated as:

$$Efficiency = \frac{Mechanical\ out\ put}{Electrical\ input} \times 100\%$$

But, Mechanical energy out = Electrical energy in – Motor losses or

Electrical energy in = Mechanical energy out + Motor losses

Clearly, to raise the mechanical energy out for a given electrical energy in, the motor losses must be diminished and therefore, the electric drive system efficiency is improved. Hence, regularly, the efficiency can likewise be controlled by first estimating the losses and utilizing either the input power or the output power to compute the efficiency. This is called indirect technique or loss isolation strategy. Indirect technique efficiency count required the facts of SCIM losses.

Rewinding Effects on Energy Efficiency

It is common practice in the industry to rewind burnt-out motors. The population of rewound motors in some industries exceeds 50 % of the total population. Careful rewinding can sometimes maintain motor efficiency at previous levels, but in most cases, losses in efficiency result. Rewinding can affect a number of factors that contribute to deteriorated motor efficiency: winding and slot design, winding material, insulation performance, and operating temperature. For example, a common problem occurs when heat is applied to strip old windings: the insulation between laminations can be damaged, thereby increasing eddy current losses.

A change in the air gap may affect power factor and output torque. However, if proper measures are taken, motor efficiency can be maintained, and in some cases increased, after rewinding. Efficiency can be improved by changing the winding design though the power factor could be affected in the process. Using wires of the greater cross-section, slot size permitting, would reduce stator losses thereby increasing efficiency. However, it is generally recommended that the original design of the motor be preserved during the rewind unless there are specific, load-related reasons for a redesign. The impact of rewinding on motor efficiency and power factor can be easily assessed if the no-load losses of a motor are known before and after rewinding. Maintaining documentation of no-load losses and no-load speed from the time of purchase of each motor can facilitate assessing this impact.

For example, comparison of no load current and stator resistance per phase of a rewound motor with the original no-load current and stator resistance at the same voltage can be one of the indicators to assess the efficacy of rewinding.

To the designer who re-evaluates the motor design, the following information is valuable:

1) Type of failure
2) Length of time in service (time since the last outage or installation)
3) Total number of starts and some indication of the intervals between starts
4) Speed torque curve
5) Expected future service.

Careful control of the stator winding design while keeping the same number of effective turns will produce a lower stator-conductor loss and this will offset any slight increase in the core, windage, and friction losses. Even the repeated rewinds do not cause the appreciable change to the motor efficiency on average. However, this is only achieved by strictly following the good repair practice in the rewinding procedure, improving the winding design and bearing lubrication. Rewinding the machine and reducing the stator conductor loss may increase the full-load efficiency after rewinding, but it will also alter the shape of the efficiency load curve. This will cause a change to the load, at which the maximum efficiency point occurs. If the rewind company has the necessary skills, there is an opportunity to alter the winning design by changing the number of effective turns or winding patterns. This would enable the maximum efficiency point to be moved closer to the actual load point in service of the motor being rewound.

Experimental Results of Efficiency

The exploration and improvement of the study of the standards found that efficiency is the first and most important parameter since efficiency will create a holistic environment which combines and balance the motor efficiency, cost and performance. The IEEE Standard provides several methods and procedures for the efficiency measurements in accordance with the type and sizes of the machine, with the wanted accuracy, etc. These methods can be subdivided into two categories: the direct method in which the absorbed and provided power at the motor shaft is directly measured, and the indirect method in which the motor losses are measured by suitable tests and the efficiency is measured by measuring the motor absorbed power. The method also provides guidelines for efficiency measurement for the motor operating under the condition of partial-load, temperature changes and voltage variation.

Based on the calculation methods given in chapter 3 the losses and efficiency values are estimated for the considered parameters and from the output values of control methods.

The parameters rating of the induction motor is given in table.5. The losses and efficiency output for a new and rewind induction motor is compared in table.6.

Table 5. Parameters ratings of induction motor

Parameters	**Values**
Voltage	400V
Current	10.8A
Speed	1466rpm
Frequency	50Hz
No. of poles	4

Table 6. Losses and efficiency of new and rewind motor

	New motor	**Rewind motor**
Stator I^2R loss	411.2	365.6
Rotor I^2R loss	212.9	177.9
Core loss	131.5	153.5
Friction and windage loss	22.5	69.2
Stray load loss	72.8	53.7
Efficiency	86.7	86.9

The results show a slight drop in the stator conductor loss, rotor conductor loss, and stray loss, but an increase in core and WF losses. Primarily, the increased loss is caused by an inadequate bearing fitting and greasing. The results show motor efficiency can actually be improved during rewind in some cases. It is the stator conductors which are replaced during rewinding. The number of turns must not be changed but sometimes enough extra space is in the slots to use a larger size wire. This larger size wire reduces the losses and thereby increases efficiency. Some older motors have very thick ground insulation in the slots which can be replaced with a thinner insulation but with a higher dielectric and mechanical strength than the original to provide more slot space for copper. Another way to reduce stator I^2R losses without changing turns is to wind with much shorter end turns. Also, any motor that was originally wound with aluminum wire can be greatly improved by a change to copper wire.

As can be seen, with the proposed scheme gives better tracking speed with less ripple in torque and with current slightly lower than in the traditional one, so that this ensures that the machine consumes less power and increases efficiency. Where else the control task is fully met as it retains both the speed tracking, as the torque regulation with low operating currents, even at full load, that is the a condition which has been developed these tests.

However, the efficiency of rewind motor cannot be improved in all the cases as discussed in the previous chapter. Multiple rewinds also reduce the efficiency in some percentage compared to the new motor. Proper care while rewinding procedure can provide better efficiency results than new method.

REFERENCES:

[1] Toliyat, H. A., Lipo, T. A., & White, J. C. (1991). Analysis of a concentrated winding induction machine for adjustable speed drive applications. II. Motor design and performance. *Energy Conversion, IEEE Transactions on*, *6*(4), 684-692.

[2] Takahashi, I., & Noguchi, T. (1986). A new quick-response and high-efficiency control strategy of an induction motor. *Industry Applications, IEEE Transactions on*, (5), 820-827.

[3] Bonnett, A. H., & Yung, C. (2008). Increased efficiency versus increased reliability. *Industry Applications Magazine, IEEE*, *14*(1), 29-36.

[4] Razali, R., Abdalla, A. N., Ghoni, R., & Venkataseshaiah, C. (2012). Improving squirrel cage induction motor efficiency: Technical review. *International Journal of Physical Sciences*, *7*(8), 1129-1140.

[5] Bazzi, A. M. (2010). *Designing* better induction motor drive systems from efficiency, reliability, and power electronics perspectives (Doctoral dissertation, University of Illinois at Urbana-Champaign).

[6] Bonnett, A. H. (1980). Understanding efficiency in squirrel-cage induction motors. *IEEE Transactions on Industry Applications*, *4*(IA-16), 476-483.

[7] Bortoni, E. C., Haddad, J., Santos, A. H. M., De Azevedo, E. M., & Yamachita, R. A. (2007). Analysis of repairs on three-phase squirrel-cage induction motors performance. *IEEE Transactions on Energy Conversion,2* (22), 383-388.

[8] Brethauer, D. M., Doughty, R. L., & Puckett, R. J. (1994). The impact of efficiency on the economics of new motor purchase, motor repair, and motor replacement. *IEEE transactions on industry applications*, *30*(6), 1525-1537.

[9] Calzada-Lara, G., Pazos-Flores, F., & Alvarez-Salas, R. (2010, August). A new Direct Torque Control for a better efficiency of the induction motor. In *Power Electronics Congress (CIEP), 2010 12th International* (pp. 78-83). IEEE.

[10] Cao, W., & Bradley, K. J. (2005, May). Assessing the impacts of rewind and repeated rewinds on induction motors: is an opportunity for re-designing the machine being wasted?. In *Electric Machines and Drives, 2005 IEEE International Conference on* (pp. 278-285). IEEE.