EVALUATING EFFICIENCY OF ELECTRIC DRIVES

Dheeraj Mishra[1], Pradeep Sharma[2], Neeru Goyal[3], Prashant Kumar Tayal[4]

[1,2]Faculty,Department of Mechanical Engg.,Dr.K.N.Modi University,NEWAI, TONK (Raj)India

[3]Faculty,Department of Electrical Engg.,Govt.Polytecnic College, SRIGANGANAGAR (Raj),India

[4]Faculty,Department of Electrical Engineering.,Dr.K.N.Modi University ,NEWAI, TONK (Raj),India

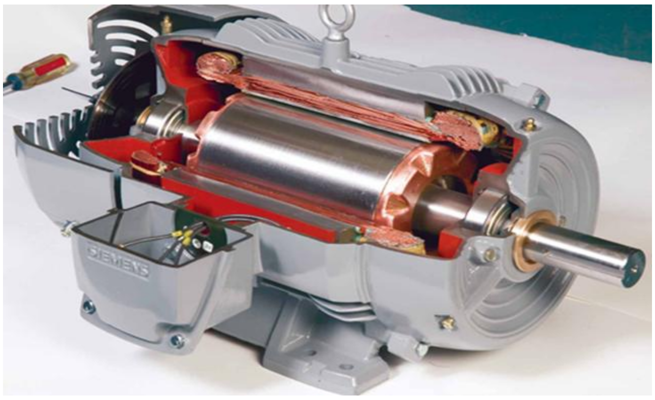
ABSTRACT

Electrical drives consume about 60% of all electricity used in industry. There is great potential for improved efficiencies in such drives. Consider the lifetime of an electric motor, the costs associated with the consumption of electricity account for up to 96% of the total cost. Therefore, when purchasing a motor, it is important to bear in mind its expected electricity consumption as this is a considerably greater factor than the initial purchase cost. Great savings potential in electrical drive systems lies in the use of energy – saving motors. These energy –optimized motors convert electrical into mechanical energy with the fewest possible losses whilst maintaining the required technical properties. At first glance, simply replacing an old motor with an energy efficient motor is the simplest way to improve energy efficiency. However, when assessing the economic efficiency of an electrical drive, it is not primarily.The motor that determines the optimal efficiency but rather the way in which the motor or machine speed is controlled. The savings potential of electronic speed control is four to five times greater than that of energy efficient motors. Electronic speed control can save between 20% and 70% of the energy costs of conventional mechanical methods such as throttle valves.

Keywords: Electrical Drives, Energy –Optimized Motors, Throttle Valves etc.

I. INTRODUCTION

The efficiency of any machine is the simple ratio of output to input. The precise measurement of these quantities will be difficult when efficiency goes above 90%.Variety of test methods have been developed and recommended by various authorities/Standards, depending upon motor sizes, equipment available and capability of system installed. When efficiency of different motors is being compared for selection purpose it is desirable that the efficiency should be arrived at by the same methods mentioned in the standard.



I.METHOD USED FOR EVALUATING EFFICIENCY

The different methods recommended by IS-Indian Standard/IEC-international electro-mechanical Commission/IEEE-American Standard/JEC-Japanese Standard and BS-British Standard for measurement of efficiency of electric motors are:

- Direct input/output method
- Calibrated machine method or use of duplicate machine
- Summation of losses method
- Indirect method or equivalent Circuit calculated method
- Graphical method(circle diagram)

It must be remembered that precision becomes more difficult as the input and output values get closer to each other. The more precise efficiency will be obtained from a direct measurement of losses and the efficiency calculated as input minus losses divided by input.

Accuracy of efficiency measurement also depends upon the accuracy of measuring instruments and person using it. The different test procedure given by different standards also give misleading picture of high efficiency declared by the manufacturers.

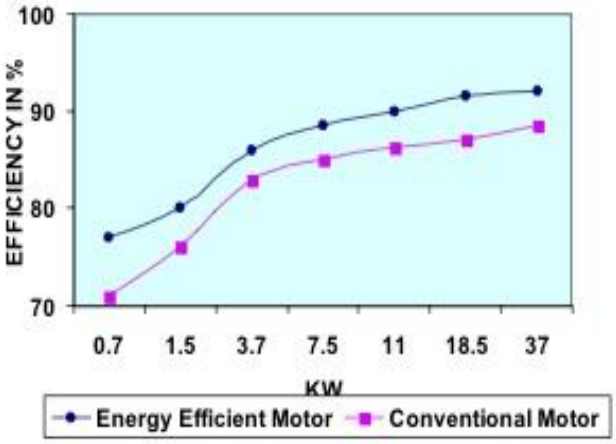
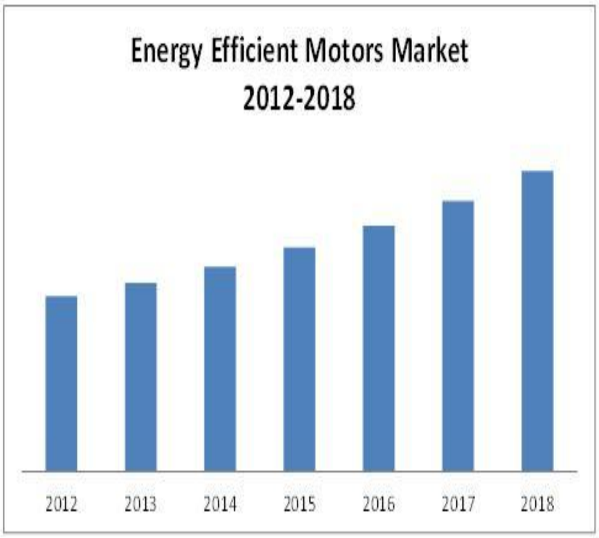


Fig 1: Efficiency Comparison



LOSSES IN ELECTRIC MOTORS

Losses in the induction motors can be divided in two parts, No-load losses (Constant losses) and load dependent losses (variable losses).

NO-LOAD LOSSES

- Windage and frictional losses are mechanical losses. It is due to the bearing friction in rolling of motor and air windage by fan for the ventilation/cooling of machine.
- Core (iron) losses constitute of hystrasis and eddy losses in the iron part.
- Brush friction losses. When brushes do not having lifting device in slip ring (wound rotor) motor.
- Additional iron losses due to non-sinusoidal waveform due to the VFD supply.

LOAD DEPENDED LOSSES

* Stator copper losses are the losses in the stator winding due to flow of current and resistance of copper material.

* Rotor copper losses (Slip losses) are the losses due to current flow in rotor cage bars and short circuiting ring (rotor winding in case of wound rotor motor).

STRAY LOAD LOSSES

Stray load losses are additional fundamental and high frequency losses in iron, circuiting current in the stator winding, and harmonic losses in rotor conductor under load. These losses are proportional to rotor current square. Stray losses are most difficult losses to measure and perhaps one of the most variable losses between the motors of identical designs. There are direct and indirect methods given in different standards for determining stray load losses. Some of the standard like JEC ignore these losses because it is smaller in quantity than the other.

Approximate Average Motor Efficiency		
H.P.	1/2 Load	Full Load
½	60%	69%
1	75%	76%
5	80%	82%
15	84%	88%
100	89%	91%
250	91%	93%

Test for Evaluating Efficiency of Induction Motor

II. DIRECT MEASUREMENT OF OUTPUT/INPUT

Output can be measured in terms of mechanical or electrical output depending upon the type of device used for measurements ,either it is brake, dynamometer or DC-machine. The dynamometer provides a flexible tool to motor designer for evaluating motor performance at various operating condition and it is preferred to measure motor efficiency for rating 1HP to 125 HP. It can be also used for much larger rating motors as well. It provides controlled load for temperature rise testing. It can be also used for measuring torque and current for entire speed range for plotting torque-speed and current –speed characteristics of motor.

The Dynamometer is mechanical device. It has ware and tare. If it is not properly maintain and calibrated, then it provides great source of error in output measurement. The dynamometer is available to an accuracy of 0.5% of full scale. So measurement of output at lower scale will be erroneous, means many dynamometer are required for wide range of output, which will be of high investment in the testing. To minimise these effect of dynamometer error the test motor full load torque rating should be within 1/3 to the full rated load of dynamometer.

III.CALIBRATED MACHINE OR DUPLICATE MACHINE

It is called pump back (feedback) test method because power is taken from the line and it is return again to same system except for the losses in the test motor and generator and losses in the supply unit.

In this test method, the motor operates at line frequency and is coupled to an identical unit that operate as an asynchronous generator, pumping back into an adjustable frequency MG set which operate below rated frequency. This test is inherently more accurate than dynamometer test because all power measurements are made on electrical quantity. The electrical instruments are more accurate than the Dynamometer and the range can be adjusted during the test.

However feedback testing is not as versatile as Dynamometer testing and is usually restricted to efficiency determination of machines larger than 300 H.P.

Two machines of similar design are required and duplicate machines are not always available. Also this test is more difficult to perform than Dynamometer, since two-power supply, two sets of measuring instruments and more test personnel required.

IV. SUMMATION OF LOSSES METHOD

The efficiency can be calculated from the total losses, which are assumed to be the summation of losses without output measurement.

The data of stator winding resistance, no-load current, no-load losses, power input, line current, terminal voltage and rotor slip are to be measured to evaluate losses in the machine.

Stator and rotor copper losses are the multiplication of Current Square and resistance of the winding. The winding resistance is depends on temperature of winding during the test. The temperature rises of all the machines of similar rating and size is not same, so reference temperature of machine will be considered (as shown in table 1), shall be used for determining the I^2R losses in the stator and rotor winding at all load. If the rated temperature rise is specified as that of a lower class of insulation system, then the reference temperature for resistance correction shall be that of the lower class of insulation.

Class A, E	75^0C
Class B	75^0C *
Class F,H	115^0C
*Latest revision	is 95^0C

TABLE 1

No load losses that are independent of load current are measured by running motor under no-loads at rated supply condition and minus the stator I^2R losses in no-load condition.

Rotor I^2R losses are taken to be equal to the product of the slip and total power transmitted to the rotor winding.

Stray load losses is most controversial losses and it is very difficult to measure directly. So different standard specify different methods or constant to measure this loss.

IS standards specify that the stray load losses vary as the square of the primary current and total value at full load is equal to 0.5% of the rated output.

As per IEEE standard-112, the stray load losses is different directly by the reverse rotation test, while standard ‘ANSI’ specifying that the unless and otherwise stated the stray load loss for motor below 2500 HP should be 1.2% of the rated output and 0.9% of the rated output for motors rated 2500 H.P. and above.

JEC standard do not account for stray load losses in the efficiency evaluation by the summation of loss method. Latest revision of IEC specify graph of % losses versus rating of motor.

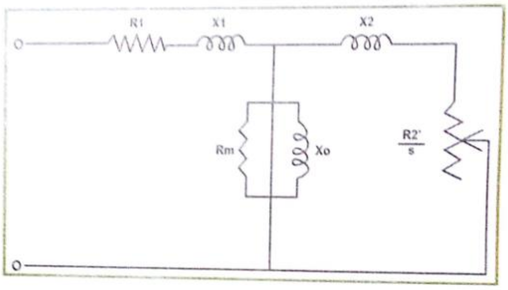
V. EQUIVALENT CIRCUIT METHOD

In many cases it may not be practical to test the machine under load as specially in large motor above 1000 kW, in such instance, the expected efficiency versus load is determined by the equivalent circuit method as shown in figure.

The equivalent circuit parameters are calculated from no-load and locked rotor impendence test data’s. These motor parameters are not linear, but are current, frequency and temperature dependent. Accordingly proper care and adequate knowledge of the motor design is often necessary to obtain accurate result.

VI. GRAPHICAL METHOD (CIRCLE DIAGRAM)

This is graphical method and highly inaccurate method for evaluating output of the machine. Many modification has been done in latest revision of IS to improve accuracy of this method.



VII.SUMMARY

*Accurate evaluations of motor efficiency depend upon standard and the method of test follows for measurement and calculation of efficiency of motor. The different standard follows different norms like.

*IS, IEC and JEC37 followed 75^0C as reference temperature for class B insulation system, while IEEE specify 95^0 C.

*IS, IEC and JEC37 standard does not define temperature correction for rotor resistance r 2

*JEC standard 37 has no direct provision for including stray load loss in the efficiency determination.

*IEEE 112 specific about method to be used for determination of efficiency, based on size and rating of machine.

*The standardised value of stray load losses proposed by IS/IEC is not realistic value.

*The maximum confidence level efficiency, determination should be based on an actual load test. Stray load test should be measured directly or indirectly.

*Based on experience it is recommended to use Dynamometer method or summation of losses method for efficiency calculation of motor up to 500 HP and above 500 HP the duplicate machine or equivalent circuit method may be used.

VIII. CONCLUSION

IEEE standard 112 test methods are more vigorous then IS/IEC or JEC standard. So evaluation of efficiency by IEEE standard will be lower than the efficiency evaluated by IS, IEC and JEC.

The efficiency evaluated by JEC 37 standard will be higher by 0.5 to 2%, which is quite significant when evaluating two similar machines on basis of efficiency.

REFRENCES

[1]. Almeida, A.T.; Ferreira, F.; Fong, J.; Fonseca, P. (2008): EUP Lot 11 Motors, Preparatory study for the Energy Using Products (EuP) Directive, Coimbra.

[2]. Boteler, R. (2009): USA Motor Update 2009: Proceedings EEMEDS 2009 - Energy Efficiency in Motor Driven Systems.

ISBN: 978-93-86171-35-1

[3]. Boteler, R.; Brunner, C.; de Almeida, A.; Doppelbauer, M.; Hoyt, W. (2009): Electric Motor MEPS Guide, Zurich.

[4]. Brunner, C.; Borg, N.; (2009): From voluntary to mandatory: policy developments in electric motors between 2005 and 2009: Beitrag auf der eceee 2009.

[5]. Almeida, E. (1998): Energy efficiency and the limits of market forces: The example of the electric motor market in France. In: Energy Policy, 26 (8), pp. 643-653.

[6]. De Keulenaer H.; Belmans R.; Blaustein E.; Chapman D.; De Almeida A.; De Wachter.

[7]. B.Radgen P. (2004): Energy Efficient Motor Driven Systems ... can save Europe 200 billion kWh of electricity consumption.