UCR College of Engineering- Center for Environmental Research & Technology

Evaluation of Energy Efficient HVAC Electrical Motor Systems

First Independent Motor Testing Facility in California

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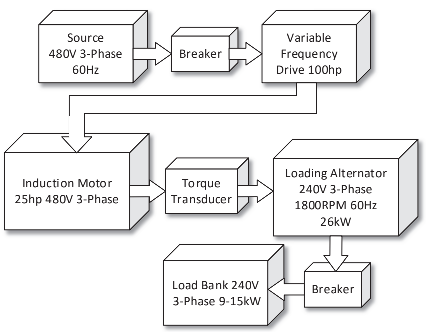
Introduction

Electric motors in HCAC systems typically last for many years. In many office buildings located in relatively cleaner environment it is not unusual for HVAC motors to last 10-20 years. Any inefficiencies due to oversized and/or poorer quality motors can add up to large energy loss over the life of the motor. For many practical reasons HVAC motor oversizing occurs frequently. For example, when a HVAC motor breaks down during a hot and humid day, the maintenance manager is under pressure to bring it back to operation as soon as possible. If a local motor dealer does not have a similar sized motor in stock a higher sized motor may be installed due to its availability. Nobody ever goes back and reinstalls the proper sized motor after this temporary fix is achieved and this oversized solution becomes permanent. The only way to find out HVAC motor oversizing and inefficient operation is to perform on-site motor testing. But on-site testing is challenging due to the location of HVAC motors in building attics and basements coupled with the risks associated with high voltage and current prevalent in motor controllers and breakers. Another challenge is the lack of availability of professionals and consultants capable of performing safe on-site testing of HVAC motors.

Motor Efficiency Test Bench: Block Diagram



Motor Efficiency Test Bench

Image of entire system as well as connected heaters used as load bank

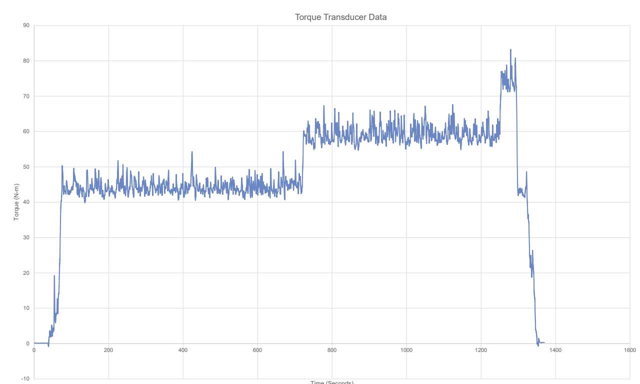
Purpose

To verify independently efficiency of an electric motor, a testing facility was set up at CE-CERT of UC Riverside. Accurate measurement of both input and output powers is necessary to find operating efficiency of a motor. Input power measurement is relatively easy with electrical power/watt meters, but measurement of output power is complicated due to the output being mechanical, hydraulic, thermal, and various pumping systems. To isolate and measure actual motor output measurements at the shaft of the motor is needed. This is achieved by separating the load from the motor and inserting a torque transducer between them.

Close up of Torque Transducer

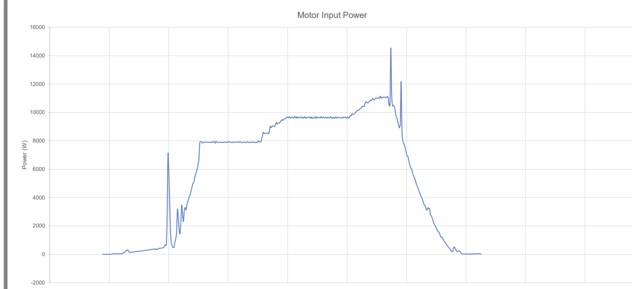
In this Picture the torque transducer is shown in the middle. The left coupling connects to the motor undergoing testing while the right coupling connects to a loading generator.

Motor Output Measured by Torque Transducer



The above figure shows the torque transducer output for three different loading conditions.

Motor Input Power Measured by Power Analyzer



The motor input power was measured using an accurate 3-phase power analyzer

The electric motor efficiency is given by the following equations:

$$Efficiency, \eta = \frac{P_{out}}{P_{in}} \times 100\% \qquad (4.1)$$

$$P_{out} = \omega\tau = \frac{2}{Poles} \times 2\pi f \qquad (4.2)$$

Where,

P_{out} = output power of the motor at the shaft calculated by equation 4.2

P_{in} = input power of the motor measured by power meters

ω = angular frequency in radians per second

τ = torque in newton-meter

Poles = number of electromagnetic poles of the motor

f = frequency of the electrical grid power

Results

	9 kW Load	12 kW Load	15 kW Load
Output Frequency (Hz)	59.7	60.0	59.5
Input Power (kW)	8.447	11.312	14.279
Output Torque (Nm)	43	57	72
Efficiency (%)	95.48	94.34	94.25

Results from Motor Efficiency Test Experiments

Conclusion

A testing facility was developed capable of efficiency and load testing of electric motors up to 25 hp capacity. This facility also has an ability to test efficiency of Adjustable Speed Drive (ASD) up to 100 hp. The facility can also measure electrical system harmonics. This is the first independent electric motor testing center in the state of California capable of providing unbiased evaluation of motor efficiency at various operating conditions. This facility is available for use by the industry professionals, academics and other stake holders.

Acknowledgement

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