GE ECM™ Evaporator Fan Motor Energy Monitoring

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Evaporator Fan Motor Energy Monitoring

Background

Evaporator units are integral components of commercial walk-in refrigerators and freezers. The small fans housed within these units continuously move air across the evaporator coils and circulate it throughout the cooled space. Most come equipped with fans that are driven by relatively low efficiency, shaded-pole (SP) or permanent split capacitor (PSC) induction-type electric fan motors. Individually, these small induction-type fan motors may seemingly not consume a great deal of energy, but the energy consumption and operating cost of multiple evaporator fans combined and running continuously can accumulate to substantial amounts. Utilization of a more efficient motor alternative would be beneficial.

The ECM (Electronically Commutated Motor) combines the inherent efficiency of a DC motor design with an electronic drive control in a package small enough to easily fit inside a typical evaporator unit. In evaporator fan applications, ECMs have the potential to dramatically reduce the energy consumption over that of lower efficiency shaded-pole and permanent split capacitor motor equivalents.

Researchers at the FSTC (Food Service Technology Center) installed and monitored two GE ECM™ motors in a walk-in freezer to document the energy savings potential.

ECM Description

An ECM utilizes a permanent magnet, three-phase, brushless DC motor combined with a built-in, sophisticated electronic AC inverter that is used to drive it. The GE ECM™ can be factory programmed to maintain either constant speed or constant torque, and in some cases constant airflow.

The particular version tested (shown in Figure 1) is the GE ECM™ 84 Series, 208-240 volt, model number 5SME84BM1027, which is tailored for evaporator fan use and programmed to maintain constant speed (1550 rpm). It comes equipped with a wiring harness that readily adapts to the evaporator's existing two-prong connector. It has a maximum shaft output power of 90 watts and can replace a wide range of SP or PSC motors rated up to 1/8 horsepower. The rated life span is 15 years.

Figure 1.
GE ECM™ 84 Series

Test Procedure and Equipment

The FSTC's laboratory walk-in freezer evaporator unit originally came equipped with two shaded-pole 1/15 hp fan motors; for this test, the evaporator was retrofitted with two GE ECM™ motors. Before the retrofit was performed, the existing shaded-pole motor power was measured for one day, and the rotational speed and airflow were also measured and recorded. They were then removed and replaced with the new ECMs while retaining the original fan blades. Upon replacement, the fan speed and airflow were measured and confirmed to be the same as in the original SP motor configuration. The combined energy consumption of both ECM fans was then monitored for two weeks. Evaporator exit air temperature across the motors and the bulk internal air temperature were also recorded.

The fans' rotational speeds were measured with an electronic stroboscope, and airflow measurements were done with a vane anemometer. Energy data recording was performed with the use of a Dent Instruments ElitePro data logger with a Magnelab 5A current transformer to record voltage, current, power and cumulative energy at 15-minute intervals. For temperature monitoring, a Hobo H8 temperature data logger, with a remote temperature probe placed directly in front of an evaporator fan guard, was used to record the evaporator air exit temperature. The walk-in freezer wall-mounted thermometer was used to monitor the bulk air temperature.

Results

The initial measurement of the original SP motor fans' input power was 271 watts (two fans combined). Following the retrofit, the average measured input power for the ECM fans throughout the two-week monitoring period was 88 watts (two fans combined). The average supply voltage throughout the test period was 207.4 V. The freezer maintained an average bulk air temperature of 0°F, and the average evaporator exit temperature was –5.1°F.

Based on the as-tested FSTC freezer data, the daily energy consumption and estimated annual energy cost and cost savings were determined. The ECM equipped fans used 67 % less energy and would yield an annual operating cost savings of $104 per fan. The results are summarized in Table 1. Figure 2 shows a graph of a five-day period of the combined power of the ECM fans and also the evaporator exit air temperature.

Table 1.
Fan Energy Usage and Operating Cost

	Avg. Input Power (Watts)	Avg. Daily Energy (kWh)	Annual Operating Cost*
Shaded-Pole (per fan)	135.5	3.252	$154
ECM (per fan)	44.0	1.056	$50
Reduction (per fan)	91.5	2.198	$104
Reduction (2 fans)	183.0	4.396	$209
Percent Reduction	67%		

* Calculated using $0.13 per kWh

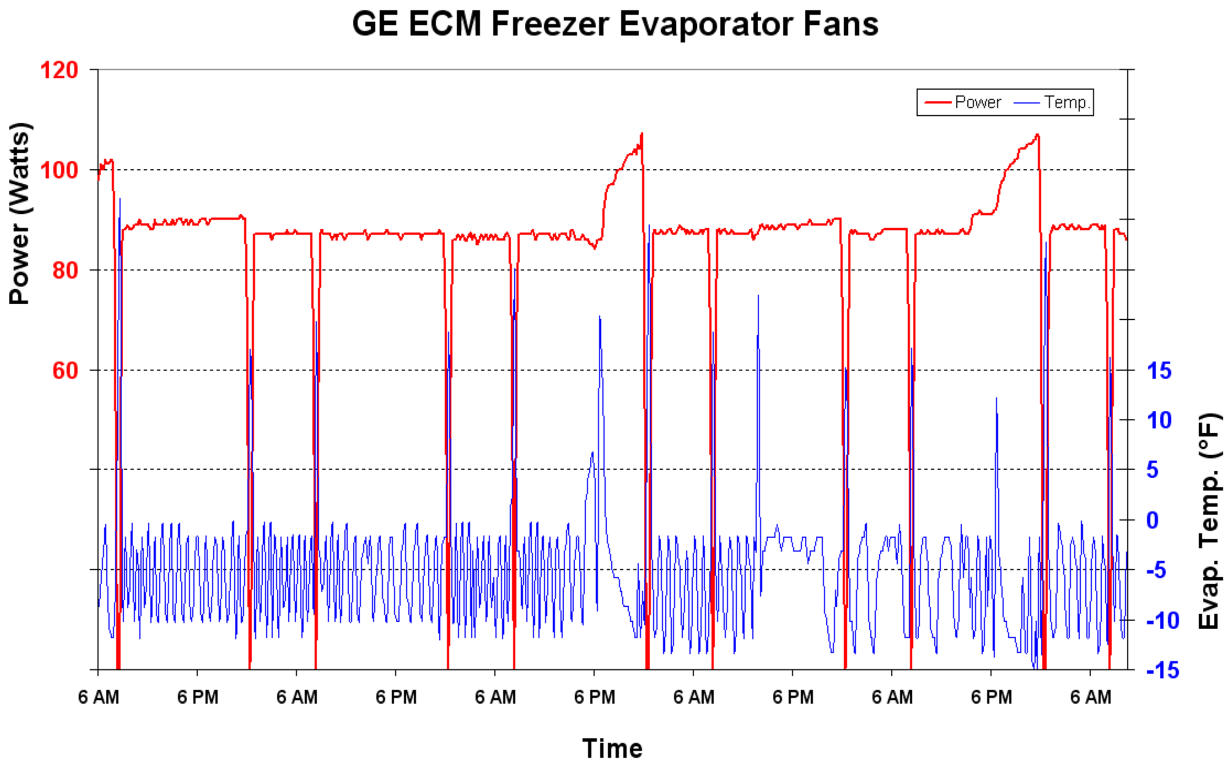

Figure 2. Power and Temperature

The zero-value power points shown on the graph signify the freezer defrost cycles when the fan motors were switched off and the defrost heating coils were energized. Because the timer-controlled defrost cycle frequency and duration can vary from one installation to another, these brief off periods were disregarded, and a duty cycle of 100% was used in the average power and energy calculations.

The intermittent highest power values (above 95 W) are indicative of periods when the evaporator coil was operating under heavily frosted conditions. During peak operation periods when extended loading and/or frequent door openings would allow moist air to enter the freezer and cause frost. This would create airflow restriction across the evaporator, thereby slightly increasing the load on the fans until the next defrost cycle would commence and then clear the frost from the coil.

It should also be noted that the input power for any given fan motor can vary with different fan blade size and design, as well as operating conditions such as the pressure drop across the evaporator and the air density across the fan. In this example, where the installation was a freezer as opposed to a refrigerator, the colder, denser freezer air temperature resulted in a slightly higher load on the fan and a corresponding increase in input power.

Refrigeration Cost Comparison

An additional benefit of using an evaporator fan motor that consumes less electrical energy is the resultant internal heat load reduction within the refrigerated space. Since all of the electrical energy that the evaporator fan consumes is ultimately converted into heat, a reduction in fan energy will translate into an equal reduction in internal heat load. This ultimately results in less energy required by the system's condensing unit to maintain the same temperature within the space.

A common unit of reference used to indicate a refrigerator or freezer's overall efficiency is the COP (Coefficient of Performance). It represents the ratio of the amount of heat energy added to the cooled space divided by the amount of electrical energy that is required by the condensing unit to reject that heat. The particular COP and amount of energy used depends on whether the system is a freezer or a refrigerator and also on the system's specific design, size and operating conditions. Freezers can require anywhere between 50% to 100% more energy than refrigerators to remove the same amount of heat. For example, a small walk-in freezer can have a COP of 1.5, while a similarly placed and sized refrigerator can have a COP of 2.5 or 3.

For simplicity, a COP of 2 will be used for the example below. For every two watts of evaporator fan power reduction, there will be one additional watt of condenser unit power reduction, for a net reduction of three watts. The energy consumption and calculated annual operating costs factoring in the refrigeration power are summarized in Table 2.

Table 2.
Energy Usage and Cost Comparison w/ Heat Load Reduction Factor

	Avg. Input Power (Watts)	Refrigeration Power* (Watts)	Combined Power (Watts)	Combined Daily Energy (kWh)	Combined Annual Operating Cost**
Shaded-Pole (per fan)	135.5	67.8	203.3	4.878	$231
ECM (per fan)	44.0	22.0	66.0	1.584	$75
Reduction (per fan)	91.5	45.8	137.3	3.294	$156
Reduction (2 fans)	183	91.5	274.5	6.588	$313
Percent Reduction	67%				

* COP = 2 ** Calculated using $0.13 per kWh

Conclusions

The monitoring results of this study show a great opportunity for energy and operating cost savings through the use of ECMs. A 67% power reduction, for an overall reduction of 137 watts and 3.3 kWh/day per fan, resulted in a $156 per fan yearly savings. Initial purchase pricing, installation costs and any local utility company purchasing incentives or rebates need to be factored into the life cycle cost or return on investment calculations, but the annual energy cost reduction alone is a strong incentive for evaporator fan motor retrofitting.

Although the purchase cost of an ECM is generally higher than that of a replacement SP or PSC induction motor, the difference is largely dependent on the induction motor's size and type. I.e., larger PSC motors with output power that is at the higher end of this ECM's horsepower range would cost more (and would be priced comparably to the GE ECM™) than smaller SP motors with low output power.

In the example presented above, using an installed retrofit cost estimate of $250 and an annual operating cost reduction of $156 per fan, the simple payback period for this installation would be about nineteen months. In the event of an existing induction-type motor failure, replacement with ECMs would result in a more immediate savings benefit.

High efficiency combined with the added virtues of long life and the versatility of being able to replace a wide range of SP and PSC motor sizes all make the GE ECM™ an ideal choice for evaporator fan use.

References

Energy Solutions: EC Motors. http://www.plugloads.com/ecm.html

GE ECM™ 84 Series. http://www.geindustrial.com/cwc/products?id=ecm84&famid=23