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Energy Savings from Modified Air Circulation and Ventilation in Houses

By John Burrows

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Tests carried out at the Canadian Centre for Housing Technology showed that the use of energy-efficient furnace fan motors and add-on motor controllers can have a positive effect on energy consumption. This article reports on those tests.

Recent studies using the Canadian Centre for Housing Technology (CCHT) demonstrated the positive effects of using energy-efficient furnace fan motors and motor controllers. The two identical CCHT research houses, both R-2000, were used to compare the energy use of normal furnace operation (in one house) to that with modified air circulation (in the other house). At the start of each study, benchmarking using identical fan motors was carried out to verify the similar energy usage characteristics of the two houses.

The first study tested the use of brushless DC motors with integrated controls, which are significantly more efficient than permanent split capacitor (PSC) air circulation motors presently used in most residential furnaces. The efficiency improvement is especially good for heating scenarios that employ continuous fan operation and reduced circulating airflow rates.

Brushless DC motors were shown to reduce the electricity consumption by about 75% for continuous fan operation systems. This resulted in a reduction in total house electricity consumption during the heating season by up to 25%. For other times of the year, there was a similar reduction in electricity required for constant movement of air, and a further reduction in the electricity required for cooling by about 10%. Natural gas use for heating increased by up to 14% to make up for lower motor heat generation. The net effect was still a significant reduction in utility costs (electricity and natural gas), and, a significant net reduction in greenhouse gas emissions where electricity is generated from fossil fuels.

Although brushless DC and similar motors offer significant energy saving potential, their use is limited to new furnace applications because retrofitting existing furnaces with these motors is expensive and raises warranty and liability issues. For this reason, a second study was launched to determine whether low-cost, commercially available programmable timer devices, combined with existing furnaces equipped with conventional PSC type fan motors, could also provide energy benefits similar to those of energy-efficient fan motors. These programmable fan controllers ensure a minimum air flow at any given time by causing the furnace fan to run at circulation speed for a specified time or until there is another call for heating or cooling.

The programmable timers were tested during the heating and spring shoulder seasons in a fashion similar to the brushless DC motor testing studies, except that both furnaces had standard PSC-type blower motors. One of the CCHT houses was designated as the

control house, and its furnace fan was allowed to run continuously throughout the tests. The other house featured the fan controller, which was allowed to operate in four different circulation modes. This allowed for direct observation of the effects of the fan controller in terms of the amounts of electricity and natural gas used by the furnace, as well as the effects on temperature and carbon dioxide levels as measures of circulation adequacy. The furnace fan circulation modes evaluated were:

- Continuous Circulation: The fan was always running, either in heating or circulation speed.
- 30/30: The fan could be off for 30 minutes, then run in circulation speed for 30 minutes or until there was a demand for heat.
- 45/15: As above, up to 45 minutes off and up to 15 min on.
- Demand Circulation: The fan ran only when there was a demand for heat.

The air leakage of both research houses was artificially adjusted to replicate typical 1990s-era air infiltration rates and CO_2 was introduced and distributed to simulate occupancy by four people. During testing, the heat recovery ventilation system was turned off and the only mechanical ventilation came from the daily operation of the stove hood.

The results demonstrated that PSC blower motors controlled by programmable timers can achieve energy savings similar to those of brushless DC motors, but at a much low cost. For the 30/30, 45/15 and demand-circulation modes, the observed reductions in fan electricity were 49%, 59% and 86%, respectively. The corresponding increase in gas use was 11 or 12%. For the 30/30, 45/15 and demand- circulation modes, the modelled electricity reductions were 49%, 65% and 75%, respectively. The corresponding modelled seasonal increases in gas use were 7.6%, 10.1% and 11.6%, respectively.

A model was used to project the effects of a controller for an entire heating season, and for a shoulder season and mid-winter. Although approximate, the model indicates that changing from continuous circulation to 30/30 could save 1,117 kWh of electricity (49% of the electricity used by the furnace) while increasing furnace natural gas use by 130 m^3 (7.6% of furnace gas use). A change from continuous circulation to 45/15 could save around 1,488 kWh of electricity (65%) while using an additional 173 m^3 (10.1%).

For the majority of heating systems that operate in demand-circulation mode, installation of a programmable fan controller will provide the ability to run the circulation fan for longer periods of time. This will result in better air circulation, a slight increase in electricity consumption, and a decrease in natural gas use. The net effect will be a slight increase in total utility bills because electricity is more expensive than gas on an energy content basis. For heating systems that currently use continuous circulation, the installation of a fan controller can save electricity and be set to provide the optimum level of air circulation. The furnace will use less electricity and more gas, but still resulting in a net decrease in utility bills.

Electrically commutated motors can have a significant impact on air circulation and energy use for residential heating systems and are recommended for new home furnace installations. Programmable fan controllers are inexpensive, practical devices for providing variable amounts of air circulation to houses built since about 1990 that have conventional PSC fan motors. The same can also be stated for houses built to construction practices before 1990, which were commonly less airtight.

For more information, contact Mike Swinton, Research Manager, Canadian Centre for Housing Technology. Mike.swinton@nrc-cnrc.gc.ca

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John Burrows is an Ottawa-based consultant and technical writer.

CCHT is a partnership involving the National Research Council (Institute for Research in Construction), Natural Resources Canada and Canada Mortgage and Housing Corporation. It began operation in 1999 and is used to accelerate the development of new technologies and their acceptance in the marketplace.