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FINAL TECHNICAL REPORT

"Natural Gas Conservation Through Throttling --
A Demonstration Study"

D.O.E. Grant No. DE-FG44-81R410404

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Summary

A total of 12 homes in Lexington, Kentucky participated in a demonstration project to investigate the possible energy savings associated with a gas throttling technique applied to residential gas furnaces. In a prior study, two homes utilized the throttling technique during the winter of 1980-81 and indicated an average savings of 9% attributable to gas throttling. Results from the current demonstration project, conducted during the winter of 1981-82, showed an average savings of 7.2% resulting from the use of throttling. It is therefore indicated that, on average, use of this simple technique can increase residential gas furnace efficiencies by approximately 8% without any sacrifice in indoor comfort, i.e. without a change in indoor temperature.

Methods

The basic hypothesis of this study was that, because residential furnaces are usually "oversized", their operation might be made more efficient by throttling (reducing) the input gas flow rate. It was thought that this reduced flow rate of fuel consumption would result in less net heat being lost through the flue (the interested reader is referred to the final report for the prior study, D.O.E. Grant # DE-FG44-80R410250, in which this concept is discussed and developed).

Twelve homes were selected in Lexington, Kentucky that had forced-air, gas fired residential furnaces and owners that were willing to participate in the study. Homes were not allowed to have any other heating sources, e.g. fireplaces, other stoves, heaters, etc. The homes selected were:

I. V. Currrens	298 Lafayette Parkway
II. E. Dillender	362 Sheridan Drive
III. K. Dillender	554 Stonehaven Drive
IV. S. Eades	205 Mandalay Road
V. J. Feebish	319 Carlisle Avenue
VI. C. Harmon	289 Zandale Drive
VIII. B. Kelley	109 Chelan Court
IX. K. Marefat	2025 Winona Way
X. C. Mattingly	3329 Crown Crest Road
XI. S. Smith	3042 Montavesta Road
XII. B. Stevens	296 Lafayette Parkway

The owners each agreed to leave their furnace thermostat unchanged during the heating season, and a thermograph was placed at a central location in each home to provide a continuous record of indoor temperature to assure that this was maintained at a near constant value. In addition to a thermograph for each home (Bacharach Model 14-7030), a pressure regulator as illustrated in

Figure 1, and a timer, also shown in Figure 1, were installed in each home. The pressure regulator, installed by a licensed plumber, permitted the required throttling of gas input flow rate to the furnace, and the timer unit monitored the burner and blower "on time" as well as the number of burner cycles. The development of this timer unit was fully described in the previous report (D.O.E. Grant # DE-FG44-80R410250). Twelve custom built timer units were fabricated and ^{ONE} installed at each home (see Figure 2 for the electrical schematic of the timers).

Each homeowner was provided a "log-book" into which was recorded on a weekly basis the data from the timer unit. The pressure regulator setting was changed approximately monthly from either a full flow to a throttled flow (75-85% of full flow), or from a throttled flow to a full flow condition. Each time the investigators changed the flow condition, a calibration was established for the gas flow rate (in cubic feet per minute) by observing the time required for two cubic feet of gas to be consumed by the furnace (established by watching the utility gas meter while only the furnace was in operation, i.e. all other gas appliances were off during this calibration period). With this calibration, only the "on time" of the furnace burner (from the timer) was required to calculate the amount of gas consumed in a given period. The electrical current consumed by the furnace blower was measured for each furnace, and since the voltage was a constant the power (current times voltage) consumptions were established. The "on time" for each blower was recorded by the timer unit (see Figure 1), and therefore by multiplying this "on time" by the power the energy consumed by the blower could be determined for each period. Each home furnace was operated for approximately two one month periods at a full rated flow condition, and for two one month periods at a throttled flow condition. Calibration data and flow rates were also carefully entered in the log-books for each home. At any given time during the study approximately half the furnaces were operated at their full rated gas flow rate while the other half were operated at a throttled condition (75-85% of rated flow). This was done to minimize any nonlinear effects attributable to outdoor temperature or weather conditions.

Conditions developed during the course of the study that rendered the data from homes V and XI unusable. A gas leak was detected toward the end of the study in a gas line to a clothes dryer in home V, and since it was uncertain as to the effect of this leak on the calibration data, this home was dropped from the study. Also, it was determined that the furnace in home XI was preset at a flow rate of only 85% of it's rated flow. Therefore it was impossible to establish for this furnace the data at full-rated flow. Home XI was therefore eliminated from the study. Ten homes therefore satisfactorily completed the study.

A custom-built timing device featuring a circular dial with a needle and several electronic components, including a timer and a counter, mounted on a metal frame. Wires connect the device to a burner and blower system.

BURNER & BLOWER TIMERS &
BURNER CYCLES COUNTER

A gas pressure regulating valve, a complex mechanical device with multiple pipes, fittings, and a central control knob, used for regulating gas pressure in a furnace system.

PRESSURE
REGULATOR

Figure 1. (TOP) Custom Built Timing Device to Record Furnace Burner Time, Blower Time, and Burner Cycles.

(BOTTOM) Gas Pressure Regulating Valve.

Figure 2. Electrical Schematic of Custom-Built Timing Device.

Results

Figure 3 contains the results from the present study. Shown for each of the 10 homes completing the study is the average energy in BTU's per degree day consumed by the furnace operating at both rated (full) and throttled flow rates. These values represent the total furnace energy, i.e. the sum of the natural gas and electricity used by the furnace. Also shown in Figure 3 for each furnace is the net savings resulting from application of the throttling technique. These ranged from a high of +22.8% to a low of -4.1%, with an average net savings of +7.2%. At full rated flow the 10 furnaces averaged consuming 17,877 BTU per degree day, but when throttled the average dropped to 16,665 BTU per degree day, and thus the +7.2% average net savings attributable to the throttling technique.

Conclusions & Recommendations

From the data of both the present and the previous studies it can be concluded that reducing by 15 to 25% the average input gas flow rate to a forced air residential furnace can be expected to produce an approximate 8% net savings. It should also be realized that this 8% increase in efficiency is attainable without any sacrifice in indoor comfort, i.e. without any decrease in indoor temperature. The saving is attributable solely to less heat being lost through the flue.

It is recommended that a device be developed to permit any homeowner to take advantage of this energy savings. The investigators are presently attempting to develop such a prototype, and hope to interest a company in manufacturing and marketing the device.

If the results from these two studies can be applied nationwide, a net savings of approximately 8% can be achieved in a vital natural resource.

FIGURE 3

Total* Average Energy Used
By Furnaces (BTU/Degree Day)

FURNACE	Gas Flow Rate At Rated*	Throttled	Net Savings
IV	21,970	17,880	+22.8%
I	21,100	18,180	+16.1%
III	21,270	19,250	+10.5%
VIII	14,860	13,630	+ 9.0%
XII	13,530	12,410	+ 9.0%
X	18,610	17,380	+ 7.1%
II	17,560	16,560	+ 6.0%
VI	17,380	17,680	- 1.7%
IX	14,550	14,970	- 2.8%
VII	17,940	18,710	- 4.1%
GRAND AVERAGE	17,877	16,665	+ 7.2%

* Natural Gas Plus Electricity Consumed by Furnace.