RESEARCH ON ENERGY SAVINGS ACHIEVED BY IKI HEATERS IN COMMUNALLY-USED SAUNAS

This research was initiated by IKI-Kiuas Ltd. after receiving positive feedback from housing cooperatives using their heaters. The electricity bills had decreased when old heaters had been replaced by IKI-heaters. The research initiative examined whether the reduced energy consumption could be caused by the use of the new heaters and what different aspects contributed to the reduction in energy consumption.

The energy consumption of IKI heaters, which are characterized by a large amount of stones, and regular heaters are first compared to each other by theoretical calculations and then by practical testing. The investigation of energy consumption is divided into three phases: heating a sauna, sauna-bathing and the time between sauna-going shifts. The consumption of energy is dependent on different aspects in these three phases, which is why they are each examined separately.

THEORETICAL CALCULATIONS

The energy consumption of different heaters is examined by considering an example sauna the size of 9 cubic metres with the inner surface of the covering measuring 24 square metres and with a 0.2 $W/m^{2o}C$ average coefficient of heat transfer of structures. The air in the sauna changes 4 times in one hour.

Compared to a regular heater, IKI heater is a heat-storing heater and it contains 100 kilos more stones, which take an hour longer to heat. During the heating the temperature of the stones rises to $100^{o}C$ and the air temperature comes up to $50^{o}C$.

Heating the example sauna using a heat-storing heater consumes 9.541 kJ of energy, which is approximately 2.63 kWh more than the regular heater consumes. 2.2 kWh of this is consumed by the larger stone mass. The energy stored in the stones does not leave the sauna room and can therefore be utilized during bathing or in drying the sauna room. The remaining 0.43 kWh is lost through ventilation as well as through the energy flow that traverses the covering.

Supposing that all the energy stored in the stones can be utilized during sauna-bathing or in drying the sauna room. If we can verify that the IKI heater's total energy consumption after heating is 0.43

kWh less than the reference heater's, then the same amount of energy escapes the sauna using either one of the heaters. The overall energy consumption entails the energy used by the heater's resistors as well as energy transferred from stones to air and water.

Because of the large stone mass, IKI heater gives out a moist steam in lower temperatures than the heaters with a smaller stone mass. This means the required output capacity is smaller, which results in smaller energy consumption. In the time falling between sauna-going shifts, in the example sauna the required heating capacity diminishes 17.1 W per/degree Celsius when the temperature drops. When the temperature is dropped by 10 degree Celsius, the required output capacity is then 171 W lower. This would mean that 0.17 kWh of energy is saved in one hour. The 0.43 kWh of energy flow lost while heating the sauna is then saved in 2 1/2 hours under these circumstances. After this time, the same amount of energy would have been released to the surroundings of the sauna using either the large stone mass heater or a regular heater. If the sauna was used for a longer period of time, the IKI heater's energy consumption would be smaller than the reference heater's.

If the consumption of water is the same despite the type of heater used, it does not affect the energy consumption in any way. However, the water poured on the heater vaporizes more efficiently when using a heater with a large stone mass. This adds to the comfort of bathing, but used incorrectly can also add to the consumption of energy. If there is an increase in the amount of water poured on the heater, it eats up the conservation of energy achieved by bathing in a lower temperature.

When changing an old heater to a heat-storing IKI heater some users may increase the amount of water they use without noticing it, because the water vaporizes and does not drain through the heater to the floor. The same amount of water should be poured on the heater, but a larger amount of it will vaporize. The energy-saving potential offered by IKI heaters during actual sauna-bathing is small.

PRACTICAL TESTING

Theoretical calculations cannot be considered a substitute for practical testing. In order to support the calculations, practical tests were carried out during 18–19 May 2009 in the communal sauna facilities at Tehtaankatu 13. The housing cooperative has two identical sauna spaces, which are equal in size to the example sauna used in the theoretical calculations. For the testing, one of the sauna rooms had an unused 7.5 kW IKI electric heater installed in it. The reference sauna room had a Helo 8 kW electric heater installed in it, which was also unused.

The reference heater has a nominal output of 8 kW, because there were no other 7.5 kW heaters on the market apart from the IKI heater. The difference in the nominal output should not have a great effect, because the tests were focused on output averages. The larger resistors are switched on for a shorter time if the energy consumption is equal.

On Tuesday 19 May 2009 the heaters were on for approximately 6 hours in total in different temperatures. During this time, the IKI heater consumed a total of 17.8 kWh of energy and the Helo heater consumed 20.8 kWh. This means that during that day the IKI heater consumed 3 kWh less energy than the reference heater.

The temperature in both sauna rooms before heating was approximately 23 degrees Celsius. The saunas were heated until the temperature reached 63 degrees Celsius in the room with the IKI heater and 70 degrees in the reference sauna. These are the upper limits of operating temperatures for each heater. In these average temperatures exhaust air temperature was 74 degrees Celsius in the IKI-heated sauna and 85 degrees Celsius in the reference sauna. The temperature on the upper benches in both saunas was approximately 55 degrees Celsius. In the IKI-heated sauna, the temperature was slightly more even from the beginning. The differences in temperature were evened out as the sauna-bathing went on for longer. The air ventilation was not switched off during the heating.

During heating the IKI heater consumed 10.8 kWh of energy, while the reference heater consumed 8.4 kWh. The difference is energy consumption was 2.4 kWh in favor of the reference heater. If the theoretical calculations are reliable, the IKI heater's additional 100 kilos of stones would explain 2.2 kWh difference in the energy consumption. As explained, the heat stored in the stones can be utilized later during bathing or drying the sauna. This means that the amount of energy that escapes through ventilation and energy flow through the coating is only 0.2 kWh greater when using the IKI heater.

During the time that falls between sauna-going shifts the average output for the IKI heater was 2.7 kWh and for the Helo 3.0 kWh. This means that the IKI heater has a 0.3 kWh smaller output while the sauna room temperature averages 7 degrees Celsius lower than that of the reference sauna. The lower temperature lessened the heater's required output approximately 0.04 kW/ ^{o}C.

The test results are so similar to the results of the theoretical calculations that they can be taken as describing the total energy consumption of the heaters. The energy stored in the larger stone mass of the IKI heater during heating did not escape into the air in significant amounts during the time between the sauna-going shifts. Therefore, under these conditions, the IKI heater would save the 0.2 kWh energy flow lost during heating in less than an hour.

On Tuesday both saunas were used for bathing three times. The average temperature during the sauna-going shifts was in the IKI heated sauna 68°C, 62°C and 59°C. The sauna with the reference heater averaged temperatures of 73°C, 64°C and 53°C. The energy consumption of the reference heater was 2.2 kWh during the first two shifts and 2.1 kWh during the last. The consumption of energy was measured between the first and last throws of water on the heater, which were approximately 18 minutes apart. The average output of the reference heater was 7.3 kWh, which is relatively close to its maximum output capacity. During the identical sauna-going shifts the IKI heater consumed 0.3 kWh, 0.7 kWh and 0 kWh of energy. During the last shift the resistors were not switched on at all. However, during the last shift the temperature in the reference sauna was lower than in the IKI-heated sauna. According to the calculations, the reference sauna should have been consuming less energy, as well. Also, during the middle sauna-going shifts the energy consumption should have been the same in both saunas.

Additionally, during all the sauna-going shifts, a significant amount of water drained through the reference heater on to the floor, while the IKI heater vaporized almost all the water that was poured on it. Therefore vaporization consumed more energy in the IKI-heated sauna than in the reference sauna. This confirms the assumption that the energy stored in the stones during heating can be utilized efficiently during bathing.

CONCLUSIONS

The measurements support the theoretical calculations, which showed that heating a sauna with an IKI heater consumes more energy than heating a sauna with a heater with less stones in it. The larger consumption of energy during heating is caused by the amount of energy stored in the IKI heater's larger stone mass, which can be utilized later during bathing and is therefore not lost. Only a fraction of the larger energy consumption escapes into the surrounding through ventilation and energy flow through the covering.

Because of the larger stone mass in the IKI heater the water poured on the heater vaporizes efficiently even at lower temperatures. This is why it can be used for bathing at slightly lower temperatures. To maintain a lower temperature requires less output capacity from the heater, which means that energy is saved during sauna-bathing and specifically during the time between the sauna-going shifts.

IKI heaters save energy specifically when the difference between the energy consumption during bathing in favour of IKI is greater than the difference of the energy saved during heating is in favour of the other heater.

Energy-savings during the use of a sauna depends on the room’s features and on how long the sauna is in use after it has been heated. The results from the tests show that in housing cooperatives’ saunas, which are used for many hours a day, the IKI heater should use less energy than heaters that have smaller stone capacity.

The example sauna used in the calculations was a typical communal-use sauna in an apartment building and it showed that energy savings were achieved using an IKI heater even with under three hours’ daily usage. The daily usage includes heating, sauna-going shifts as well as the time between the shifts.