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Proposed Model for a Water Based Room Heater

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***Abstract* – This paper presents the model and operating cost analysis of a water based room heater using a state-of-the-art micro-controller based Embedded Control Module (ECM). Water in the system is heated using an efficient instant gas heater. The ECM monitors the environment in the room using sensors located at different places, and heats selected areas by circulating hot water through radiators placed at appropriate locations. The ECM also keeps track of temperatures and water levels at different points in the system, and ensures efficient operation, so that the use of gas is minimized. A comparison of the cost of energy used by various existing heating methods and the proposed method is also presented.**

***Keywords* – Domestic Heating, Embedded Control Module, Water Based Heater, Renewable Energy, Modeling.**

I. INTRODUCTION

Heating is a basic requirement of human beings, especially in parts of the world where the temperatures are low. Existing small-scale heating systems are either expensive or not safe. This is particularly true for countries with low per capita annual income. A brief overview of heating systems used in different places is given below:

a) Coal based furnaces: These are expensive to operate, and are hazardous.
b) Kerosene oil based heaters: Not clean and hazardous; operating cost depends on the price of oil, which increases with time.
c) Oil based electric heaters: Expensive to operate. Typically use an average of 1.5 kW (either 1kW or 2kW element). Assuming a 10hour usage per day, this requires 15kWh per day. If the cost of electricity is Rs 15 per unit, this will result in an electricity bill of Rs 6750/= per month.
d) Electric Heaters with Coils and fans.
e) Gas Heaters:

The table given below summarizes the above discussion. The state-of-the-art in domestic heating is a water based heater used in large buildings with a boiler circulating water in different radiators placed at various locations in the building. The system is expensive, in its initial cost, as well as its operating cost. For single rooms and small spaces, a low-cost system is needed which is less expensive to operate. The proposed model is intended to satisfy precisely that requirement.

Table. I Summary of Operating Expenses for Existing Domestic Heaters

Heater Type	Operation Hours per day	Rupees per month (average)
Gas Heaters	10	4500
Electric Heaters	10	3600
Oil based Heaters	10	6750
Coal/Kerosene Based Heaters	10	varies

II. SYSTEM BLOCK DIAGRAM

The hardware block diagram of room heater fabricated by Electrical Engineering students at the National University of Computer and Emerging Sciences (FAST-NU), Lahore, Pakistan, is given in Figure 1. It consists of a radiator placed in the room. Hot water is passed through the radiator under the control of the actuator signal VR. This and other control signals, shown in Figure 2, are generated by the Electronic Control Module (ECM). Figure 2 also shows all the status signals associated with the ECM. The ECM operates under the instructions of a control program that works according to the flow chart given in Figure 3. It shows the functionality of the system. The microcontroller takes input from different sensors, and determines the set of valves that have to be opened. It also determines when to power ON the water pump, so that water can be heated only when needed. This results in considerable saving of natural gas. Figure 4 shows the prototype built by the students. The picture on the left-hand side shows the front view of the model, and the one on the right shows the rear view where the radiator is installed. A car radiator has been used to test the concept, and to make sure that all the sensors and actuators are working as expected.

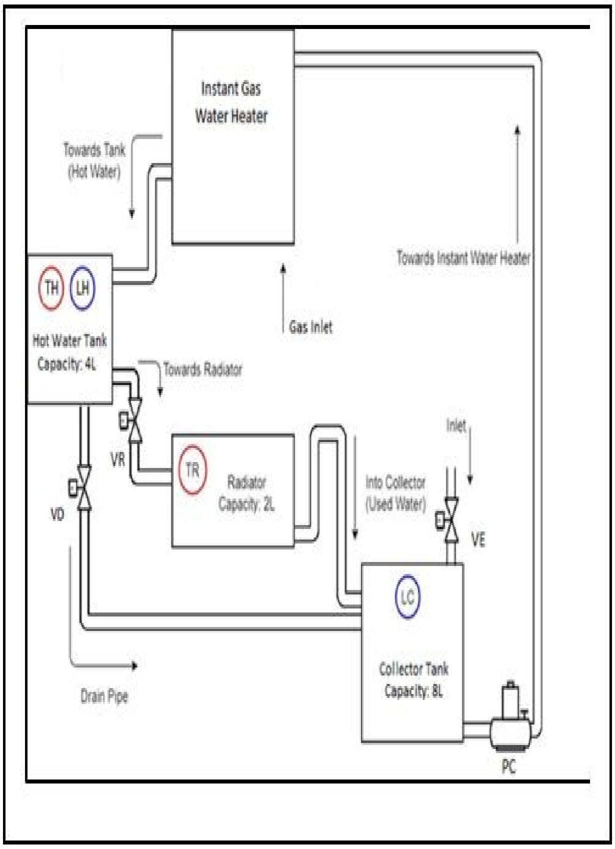

Fig. 1. Overall Block Diagram

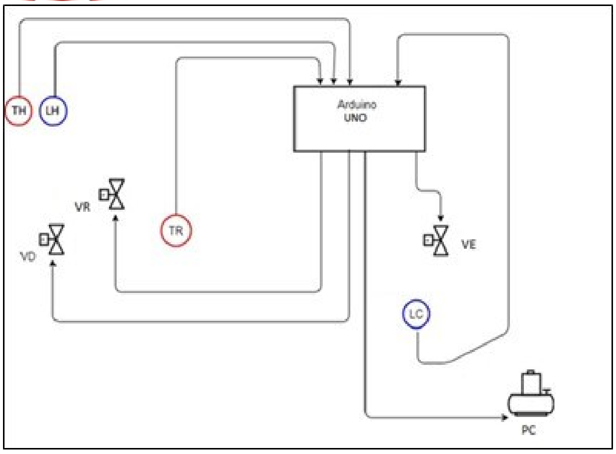

Fig. 2. Block Diagram of the ECM

Table II. Status and Control Signals associated with the ECM

Symbol	Name of Signal
PC	Pump Control Signal
VE	Electric Valve for Inlet to Collector Tank
VD	Electric Valve to Drain hot water tank
VR	Electric Valve for Radiator inlet
LH	Level sensor for Hot water tank
LC	Level sensor for Collector
TA	Ambient Temperature
TH	Temperature sensor for Hot water tank
TR	Temperature sensor for Radiator

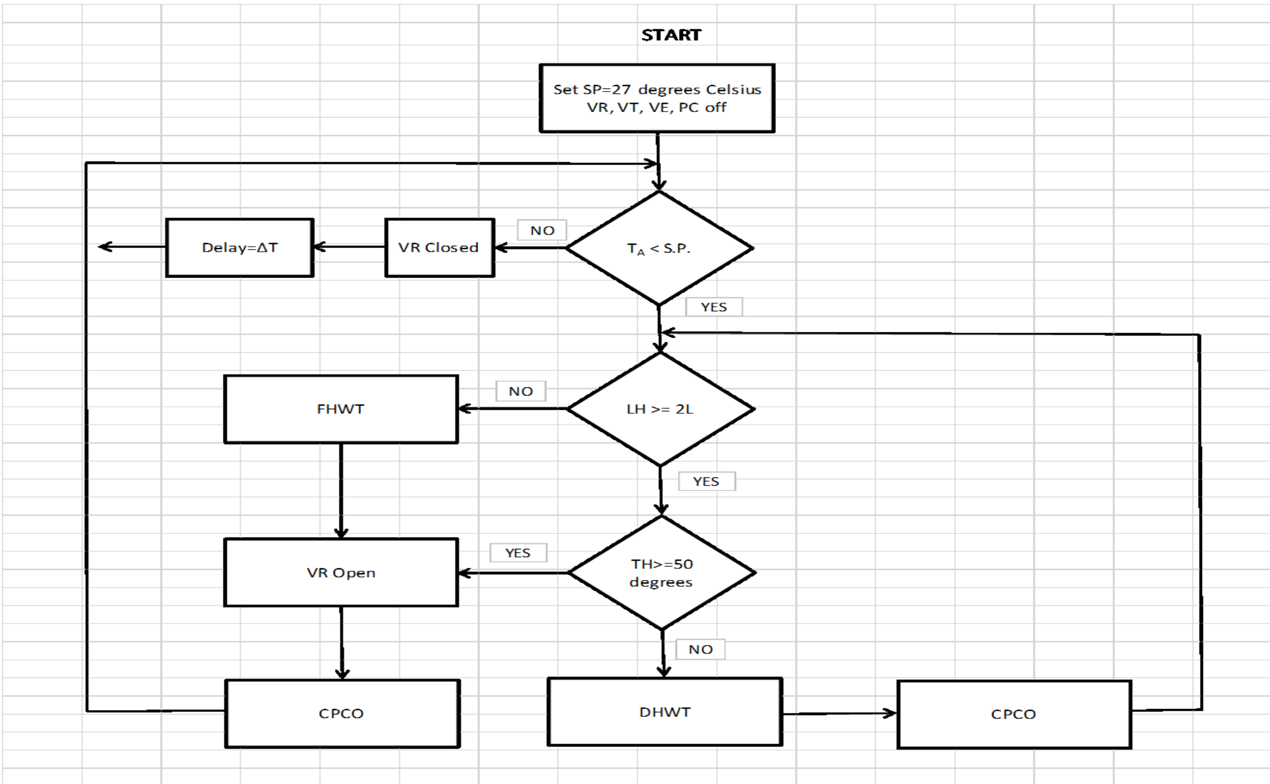

Fig. 3: Flowchart of the Control Algorithm managing the Room Heater


Fig. 4. Prototype model of the Room Heater

III. Cost Of Ecm and Other Mechanical Parts

Item	Pieces Required	Cost of 1 piece (PKR)	Total Cost (PKR)
Horizontal Water Level Sensor Float Switch for Tank	1	900	900
12V DC, 200/220V AC, 2W Solenoid Valve	3	700	2100
Locally Available Water Pump	1	500	500
12V Input/220-40V Output, 8A Relay	4	200	800
Waterproof Temperature Sensing Probe	3	150	450
Lm35 Temperature Sensor	4	80	320
Ultrasonic Sensors	2	400	400
Bluetooth Slave Wireless Serial Module with PCB JY-MCU	1	600	600
Arduino Uno Development Board	1	1000	1000
Total Cost of ECM			**7070**

Item	Pieces Required	Cost of 1 piece (PKR)	Total Cost (PKR)
Instant Gas Water Heater	1	7500	7500
Insulated Water Tank	1	2000 approx	2000
Stainless Steel Tank for Collector	1	3000 approx	3000
Radiator	1	1200	1200
Pipes and Fittings	May Vary	Depends on Quantity	Depends on Quantity
Total Cost of DHS			**13700 approx.**

It can be seen from the above analysis that the overall system cost is Rupees 21,000/= approximately. Operating cost based on a 10 hour per day usage is given below: Compare this with available systems, as shown in Table I.

Electricity consumption	750 watts
Usage per day	10 hours
Energy consumed per month	225 kWh
Gas consumption per month	Rs 400
Operating cost per month	Rs 3775

IV. Results and Discussion

It can be seen from the above discussion that if properly fabricated, the water based room heater will cost much less compared to existing heating systems, and will be cheaper to operate. In addition, it will provide a safe and clean environment. The prototype shown in Figure 4 was installed in the final year project lab of the electrical engineering department at the National University of Computer and Emerging Sciences, Lahore. The control algorithm was tested for different conditions, and the results were as expected.

V. Conclusion

A model for a water based room heater has been presented in this paper. It consists of radiators placed at appropriate locations in the room. Hot water is circulated in the radiators under the control of an Embedded Control Module (ECM), which keeps track of water levels and temperatures at various points in the system. The overall result is a reduced initial cost and low operating expenses.

VI. Future Directions

- Use of renewable energy for heating the water.
- Humidity control can be added.
- Installation in an actual building and study of performance.
- Integration with other forms of energy.
- Design of better algorithms for the ECM.
- Adaptation to local environment for better performance.
- Use of better materials for the radiators for efficient heat transfer and to minimize losses.

Acknowledgements

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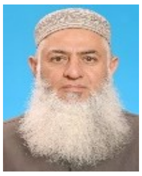
Authors' Profiles



Dr. Anjum Ali completed his Ph.D. degree in August 1988 from the University of Alabama, Huntsville, Alabama, U.S.A. He has been teaching Electrical and Computer Engineering subjects since March 1978. His first teaching appointment, as a lecturer of Electrical Engineering, was at the University of Engineering and Technology (UET), Lahore, Pakistan, after winning gold medals in each of the last three years of his undergraduate engineering education.

His teaching experience includes twelve years at Mercer University, Macon, Georgia, USA, and about nine years at three different universities in Saudi Arabia. He has also worked, as an associate professor, at the Lahore University of Management Sciences (LUMS), Lahore, Pakistan, from 1996 to 1998. He served as the chairman of the Electronics Engineering and Instrumentation Department at the Hail Community College (now University of Hail), Hail, Saudi Arabia, from February 2000 to June 2002. During his stay there, he developed a four year degree program in Electrical Engineering for the University of Hail.

Dr. Anjum Ali returned to Pakistan in July 2002, and joined Al-Khawarizmi Institute of Computer Science (KICS) at the University of Engineering and Technology, Lahore, as a professor in December 2002. During his stay at KICS, he initiated many research and development projects and won research grants. He has been a professor of Electrical Engineering at the National University of Computer and Emerging Sciences, (FAST-NU), Lahore, since May 2005.

Dr. Anjum Ali has taught many EE, CE and CS courses and supervised numerous graduate as well as undergraduate students during his 40 years of teaching career. He has over 30 conference and journal publications. He is also the founding editor of the FAST-NU Research Journal. His areas of current research interest include embedded control systems and computer architecture.

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