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Improving Compressor Efficiency for Air Conditioners Using Temperature Control

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Abstract: **More than 3 million units of Air conditioners are being sold every year in India and sales are expected to grow further. The annual electricity consumption by air conditioners is rapidly increasing in India. The total potential energy savings from room AC efficiency improvement in India using the best available technology will reach over 118 TWhr by 2030. Out of the total power consumed by the ACs, around 65% is being consumed by the compressor alone. The compressor pumps the liquid from the evaporator into a condenser and expansion valve, and then back to the evaporator using a motor. In most commercially available ACs, this motor turns off when the required temperature is reached and turns back on as the temperature rises. This happens around 5-6 times every hour. As the starting current of an induction motor is very high, it draws a large amount of power from the supply. Also, the motor always runs at rated speed, which consumes more power than is actually required for effective cooling. The compressor efficiency can be improved by maintaining continuous operation at low speeds. This is achieved by varying the speed of the induction motor (in the compressor) based on the temperature difference between the set temperature and outdoor temperature. The energy savings were found to be 13.75% by employing this system.**

Keywords: **compressor, single-phase induction motor, temperature based speed control, energy efficiency, continuous cycle operation.**

I. INTRODUCTION

Room air conditioners transport heat from inside a room to the outside, with a refrigeration cycle. The most important components of an air conditioner are evaporator, condenser with fans and compressor. The focus of this paper is on the power consumed by compressors. The shaft of an induction motor is connected to a compressor and the fan. The pumping ratio of the refrigerant can be varied by varying the speed of this induction motor. Normally, the compressor operates at full speed, pumping the entire volume of refrigerant until the desired temperature is reached, and then turns off. This continuous switching on and off of the compressor consumes more energy compared to when the compressor is running at different speeds providing variable refrigerant flow. Hence in this paper, a microcontroller based motor controller with heat sensor is proposed. In this system, the speed of the single phase induction motor is varied with respect to the ambient temperature providing an environmentally friendly and efficient solution.

II. BLOCK DIAGRAM

The block diagram below shows the main components used for controlling compressor based on temperature:

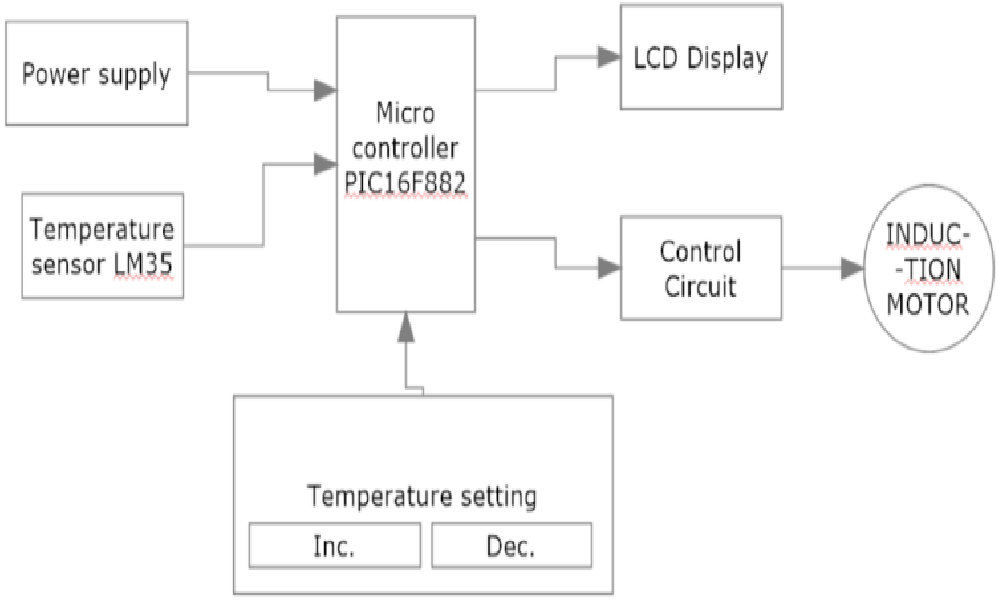

Fig.1: Shows the basic block diagram used in our system.

III. WORKING

A. Power Supply:

The power supply consists of a transformer, rectifier and a filter. A 230/12V transformer is used to step down the voltage from the supply and it is rectified using a diode. A voltage regulator is used to ensure a constant output of 5V to protect the components of the circuit from voltage variations.

B. Temperature Sensor:

The LM35 temperature sensor is used to detect changes in the present temperature. Its output is in degree Celsius and its output voltage is linearly proportional to temperature. For each degree rise in temperature, the output of them sensor increases by 10mV. For example, if the present temperature is 23 deg. Celsius, the output voltage of LM35 will be 230mV. An LCD display is used to display the present temperature and also the required temperature. The required temperature is set using two keys, one for increment and one for decrement.

C. Microcontroller:

The PIC16F882 microcontroller is used in this system for control. It is a 28 pin, 8 bit microcontroller with high performance RISC CPU. It has a built in A/D converter with 10-bit resolution. The output of the temperature sensor is given to the microcontroller. When there is a 1 degree Celsius increase in the temperature, the LM35 output increases by 10mV. By using the 10-bit ADC of the microcontroller, 5mV is required to increase the register value by 1. Therefore, the 10mV output of LM35 is divided by 2 to get the ambient temperature. The microcontroller computes the difference between the present temperature and set temperature and accordingly controls the speed of the motor.

D. Control Circuit:

The control circuit consists of optocouplers, pots, a diac and a traic. The output of the microcontroller is given to 5 optocouplers. When the temperature difference is 0 degree Celsius, optocoupler 1 is activated and when the difference is 1 degree Celsius, optocoupler 2 is activated and so on. Each optocoupler is connected to its respective pot (470k). By varying the resistance of each pot, the required speed of the motor is set. The optocoupler is connected to the traic (BT136) through a diac to control its gate signal. A snubber circuit **is** placed across the power switches to suppress voltage spikes and damp the ringing caused by circuit inductance. The output of the snubber circuit is connected to an induction motor. This motor controls the refrigerant flow from the compressor. By varying the speed of the induction motor, required amount of refrigerant is pumped into the room. Thus, by preventing the continuous switching of compressor, its efficiency is improved.

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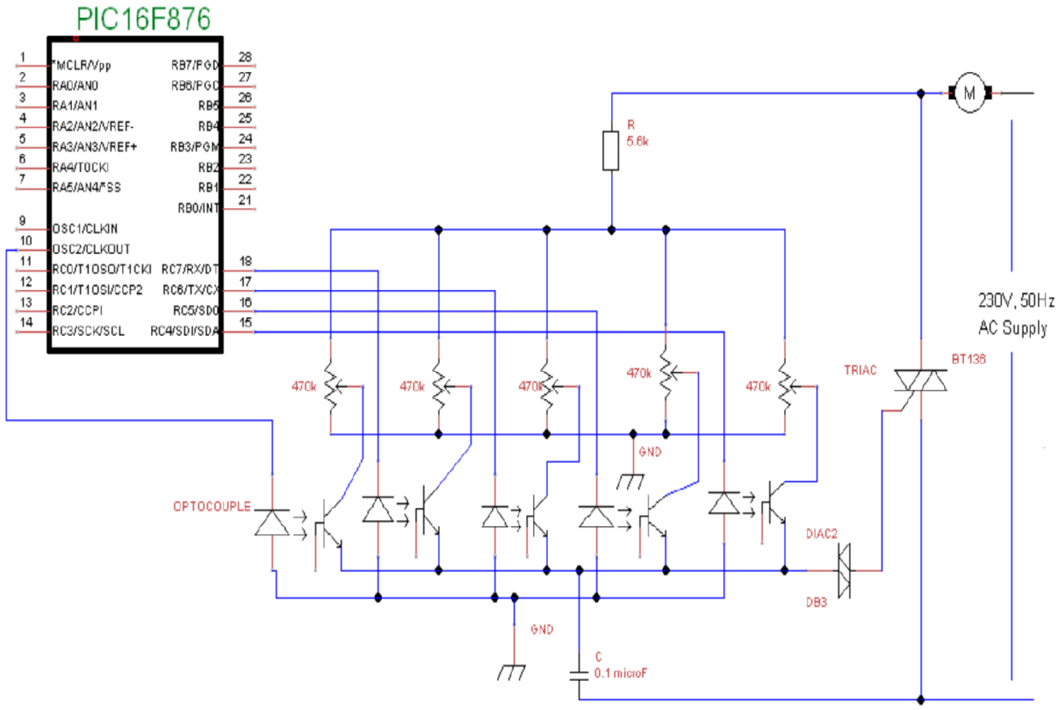

Fig. 2: shows the control circuit for the efficient compression system

IV. RESULTS

The above experiment was practically tested on a 20W motor which is used in a scroll type compressor. The following results were experimentally obtained

TABLE 1: VARIATION OF POWER CONSUMED WITH SPEED

Temp. Diff. (deg.C)	Speed (RPM)	Current (A)	Voltage (V)	Power (watt)
0	512	0.1	52.3	4.707
1	968	0.12	76.5	8.262
2	1162	0.16	136.9	19.714
3	1924	0.18	179	28.998
4	2386	0.2	232.1	41.778

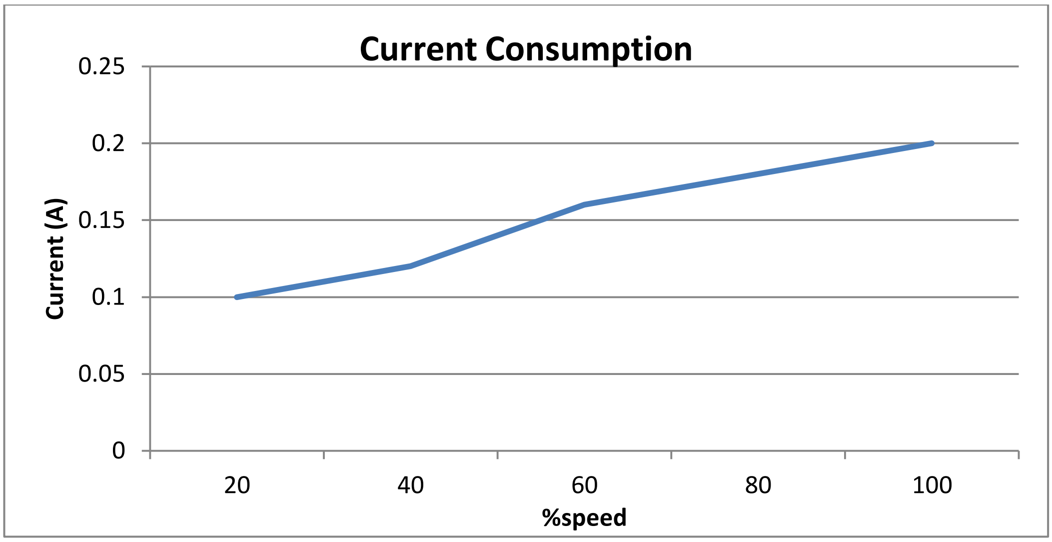

Fig.3: shows the current consumed at various speeds

From table 1, it can be seen that the power consumes reduces as the motor is made to run at different speeds. Energy savings upto 13.75% were obtained by implementing the above system.

V. CONCLUSION

The use of the above system for speed control application offers an energy efficient and environmental friendly solution. The efficient compression system will offer new low cost solutions for light, commercial and consumer applications. The current consumption for the constructed circuit varies between 0.16A and 0.2A for the 20W, 50Hz single phase AC motor. This system is suitable for applications in places where the temperature is moderate.

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