Heating Efficiency by Electric Kettle

CAUTION: - THE EXPERIMENT WORKS ON 230V AC VOLTAGE SO BE CAREFULL, DO NOT TOUCH ANY NACKED WIRE/SOCKET DURING OPERATION/EXPERIMENT

Object. To study the heating efficiency of an electric kettle using VARIAC.

Apparatus. Electric kettle with a hole on top cover for inserting a thermometer, VARIAC of input 230V and output 0-270V at 4 Amp, AC voltmeter, Thermometer, connection leads.

Theory: If *m* kg of water, taken in an electric kettle (which consists of an insulated container and an immersion heater with its filament of resistance R ohm) is heated at a voltage *V* volt for time *t* second, and the temperature of the water rises by Δθ°C, then assuming that the heat capacity of container is negligible and there is no loss of heat, by the conservation of energy we have,

Electrical energy supplied to the heater = Heat energy gained by the water

*Power supplied to the heater * time = m * s * ∆θ*

$$\frac{V^2}{R}t = m * s * \Delta\theta$$

where, *s* is the specific heat of water,

$\Delta\theta$ is the difference in the initial and final temperature of water.

Formula.

Since the kettle not a perfect insulator, some of the electrical energy supplied to the kettle goes into heating the kettle and the surrounding air. Therefore, the heating efficiency of the electric kettle is given by:

$$\textit{Heating Efficiency of kettle } (\eta) = \frac{Output\ Heat\ energy}{Input\ Electrical\ Energy} * 100\%$$

$$= \frac{Heat\ gained\ by\ the\ water}{Input\ Electrical\ Energy} * 100\%$$

$$= \frac{m * s * \Delta\theta}{Power * time} * 100\%$$

Procedure: (Not to be written in copy)

1. Take water (500 ml) in the electrical kettle.
2. Connect leads of the kettle with VARIAC output sockets and connect an AC Voltmeter of 300V across VARIAC output sockets as shown in fig. 1.
3. Insert a thermometer into electrical kettle & ensure that its tip should be in contact with water (filled in kettle).
4. Insert VARIAC leads into mains sockets having 230V ± 10% at 50 Hz and switch it ON.
5. Now slowly increase the VARIAC knob in the intervals of 10V to note down the temperature of the water. After setting up the desired value of

voltage across the VARIAC, wait for 2 minutes and then note down the value of temperature with the help of thermometer.

6. Repeat the step 6, until the temperature of the water rises to 90-95^{o}C.

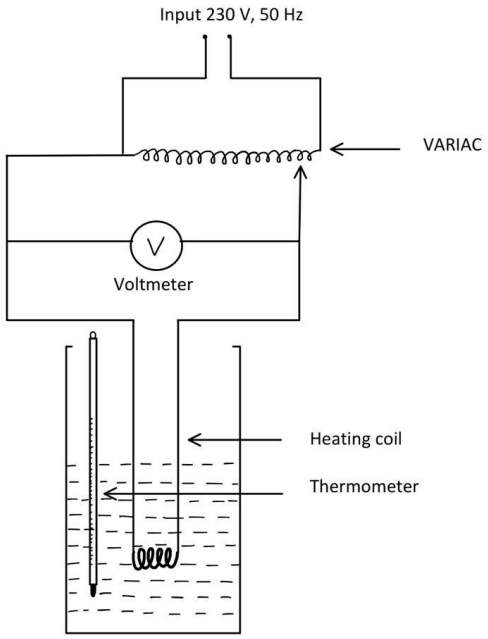

Fig.1 *Circuit diagram*

Observations.

1. Power of electric kettle = 1500 W
2. Specific heat of water s = 4.2 * 10 ^{3} J/Kg^{o}C
3. Mass of the water m = 500 gm
4. **Temperature of water vs voltage supplied**:

   Least count of AC voltmeter = ……

   Least count of Thermometer = ……

S.No.	**Voltage (V)**	**Temperature (^{o}C)**
1.		
2.		
3.		
4.		
5.		

6.		
7.		
8.		
9.		
10.		

5. Total time $\Delta\theta$ = 2 * n * 60 seconds (where n is the total number of readings)

   = …… sec

Calculations.

The input electrical energy is given by the following relation:

*Power supplied to the heater * time* = Power of the electric kettle * Total time

= …… J

The output heat energy is given by the following relation:

$m * s * \Delta\theta$ = …… J

Result.

The heating efficiency of the electric kettle = …….. J

Precautions.

1. Be clear on how to switch off the power in case of an emergency.
2. Be careful while using mains electricity.

3. Measure the amount of water correctly.
4. Record the holding time with precision.
5. Do not use exposed wires to connect a circuit.
6. Use the voltmeter and the VARIAC of correct range.

Viva - Voce

Q. What is your experiment?

Ans. To study the heating efficiency of an electric kettle with varying voltages.

Q. What do you mean by the heating efficiency of an electric kettle with varying voltages?

Ans. To find the dependence of rise in temperature of a given mass of water in a given time interval on the voltage at which the electric kettle works.

Q. What assumptions have you made above?

Ans. 1. The resistance of filament of kettle is assumed to remain constant, although it will increase with increase in temperature. Since the increase in temperature is not very large and the temperature coefficient of resistance of nichrome of which filament of kettle is made of, is very low, its resistance can be assumed to be constant over the range of temperature in which the experiment is performed.

2. There is no loss of heat by conduction and convection.

Q. How does the rise in temperature of water depend on the voltage at which the kettle works?

Ans. Rise in temperature is directly proportional to the square of voltage (if the mass of water and time of heating are kept same) at the normal working voltage of the kettle. But at low voltages, the rise in temperature is very low.

Q. How do you minimise the loss of heat by conduction and convection in your experiment?

Ans. By taking the container made up of thermocol provided with a lid.

Q. Why do you stir water before reading its temperature?

Ans. So that the temperature of entire water becomes uniform.

Q. The electric heater (or kettle) in your experiment is rated as 350 W, 220 V. What does it mean? What information does it convey?

Ans. It means that if the kettle (or heater) is operated at 220 V, it will consume power equal to 350 W.

Q. If the kettle is operated at 100 V, will it consume same power equal to 350 W?

Ans. No. Then it will consume nearly 70 W power.