Gcse investigation: exploring the efficiency of a kettle

To explore how the efficiency of a kettle changes with the volume of water that is used to heat it.

Prediction:

Through a kettle heat is lost through mainly three areas. Firstly, through radiation, this is when heat is thrown out of the kettle via the kettle wall out of the main body of water. The second way is by conduction, this is where heat passes through the main body of water via the kettle wall. And, also by convection, where some of the water particles carrying energy are lost through water vapour through the spout of the kettle. In all these ways of heat loss, everything revolves around the surface area, where all the heat is lost. The bigger the surface area of the volume of water, the more heat energy will be lost.

I have done some preliminary work, which proves that if the volume of the body of water doubles, the surface area is unproportional to the body of water even though you would expect it to double. I have looked at the effects of changing the volume of water and calculated its surface area through the expression 2 ? r(r+h). I am treating the kettle as a cylinder. As the kettle has a volume of 0. 5 litres of water, the surface area is 387 cm2, at 1. 0 litres of water, the surface area is 528 cm2, which demonstrates that doubling the volume does not actually double the surface area.

Preliminary Calculations

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Volume/Mass of water in a kettle

(Litres/Kilograms)

Depth of water

(cm)

Surface area of cylinder (cm2)

0. 5 l

500 kg

3. 6

387

0. 75 l

750 kg

5. 4

457

1. 0 l

1000 kg

7. 2

528

1. 25 l

1250 kg

9. 0

599

1. 5 l

1500 kg

10. 8

670

Method

Firstly, set up the equipment. In this experiment I am timing to see how long it takes to heat water of given temperatures. I will then fill the kettle up with 500ml of tap water, measuring the water accurately in a measuring cylinder. I will then put the temperature probe in to the kettle at approximately 1cm away from the heating element and ensure that in all my experiments I keep the probe the same distance away from the element because otherwise the temperature of the water will vary throughout the kettle. I will then plug the kettle in and then turn the kettle on and when the temperature reaches 20?C begin the stop clock. Then wait till the water reaches the desired temperature, when it does press the reset button which will give me a lap time, then record the time and again press the rest button which will continue on with the time. When it reaches the next given temperature, press the reset button again and record the lap time and once again press the same button to continue on with timing the heating process, and carrying on repeating this process till I have recorded all the times in my results table.

I will then repeat this experiment 4 more times but to keep the investigation fair, make sure that for every individual experiment………..

* I wash the kettle out thoroughly with cold water to cool the element down, as it will still be warm from the previous experiment.

* I change the water, from hot to cold, so the common starting point remains 20? C for every experiment.

* Use the same common starting point (temperature), because the water's temperature from the tap can vary slightly.

* I will use the same range of temperatures for each experiment.

In this experiment I am not heating the water to 100? C because it doesn't always reach this temperature of boiling.

When I have gathered my results, I will need to use some calculations to reach the aim of the experiment, to find out how efficient the kettle actually is.

To work out the efficiency, I can use the simple equation:

Efficiency = Useful energy

Supplied energy – which in my case is:

Efficiency = Heat absorbed by water

Electricity supplied

To calculate the top part of the equation ‘ Heat absorbed by water’, or basically the energy that was successfully used, we use the Specific Heat Capacity of Water, which is 4200J / kg / ? C. This means that for every 4200J of energy taken in by every kilogram of mass, by every temperature in crease of one degree.

An example of working out the ‘ Heat absorbed by the water’ for half a litre (or half a kilogram), heated up by 30?, I would do

4200 x 0. 5 x 30 = 6300

To calculate the bottom part of the equation, the ‘ Electricity supplied’, I will use the equation E = P x t, I know what the power (P) rating for a kettle is, 2200, and I will have worked out the time in our experiments.

I just have to divide the ‘ Heat absorbed by water’ by the

‘ Electricity supplied’ and this will give me the efficiency as a decimal, so just times it by 100 to get the percentage.

Results Tables:

For 500ml (0. 5kg) of water.

Temperature Change (? C)

Time (seconds)

Electricity supplied (J)

Energy absorbed

Efficiency (%)

20-35

42

92400

31500

34

20-50

64

140800

63000

45

20-65

77

169400

945000

56

20-80

82

180400

126000

70

20-95

90

195000

157500

80

For 750ml (0. 75kg) of water.

Temperature Change (? C)

Time (seconds)

Electricity supplied (J)

Energy absorbed

Efficiency (%)

20-35

26

57200

49250

82

20-50

49

107800

94500

88

20-65

74

162800

141750

87

20-80

98

215600

189000

88

20-95

125

275000

236250

86

For 1 litre (1kg) of water.

Temperature Change (? C)

Time (seconds)

Electricity supplied (J)

Energy absorbed

Efficiency (%)

20-35

33

72600

63000

87

20-50

64

140800

126000

89

20-65

97

213400

189000

89

20-80

129

283800

252000

89

20-95

162

356400

315000

89

For 1. 25 litres (1. 25kg) of water.

Temperature Change (? C)

Time (seconds)

Electricity supplied (J)

Energy absorbed

Efficiency (%)

20-35

38

83600

78750

94

20-50

77

169400

157500

93

20-65

117

257400

236250

92

20-80

180

352000

315000

89

20-95

199

437800

393750

90

For 1. 5 litres (1. 5kg) of water.

Temperature Change (? C)

Time (seconds)

Electricity supplied (J)

Energy absorbed

Efficiency (%)

20-35

35

121000

94500

78

20-50

101

222200

189000

85

20-65

149

327800

283500

86

20-80

196

431200

378000

88

20-95

244

536800

472500