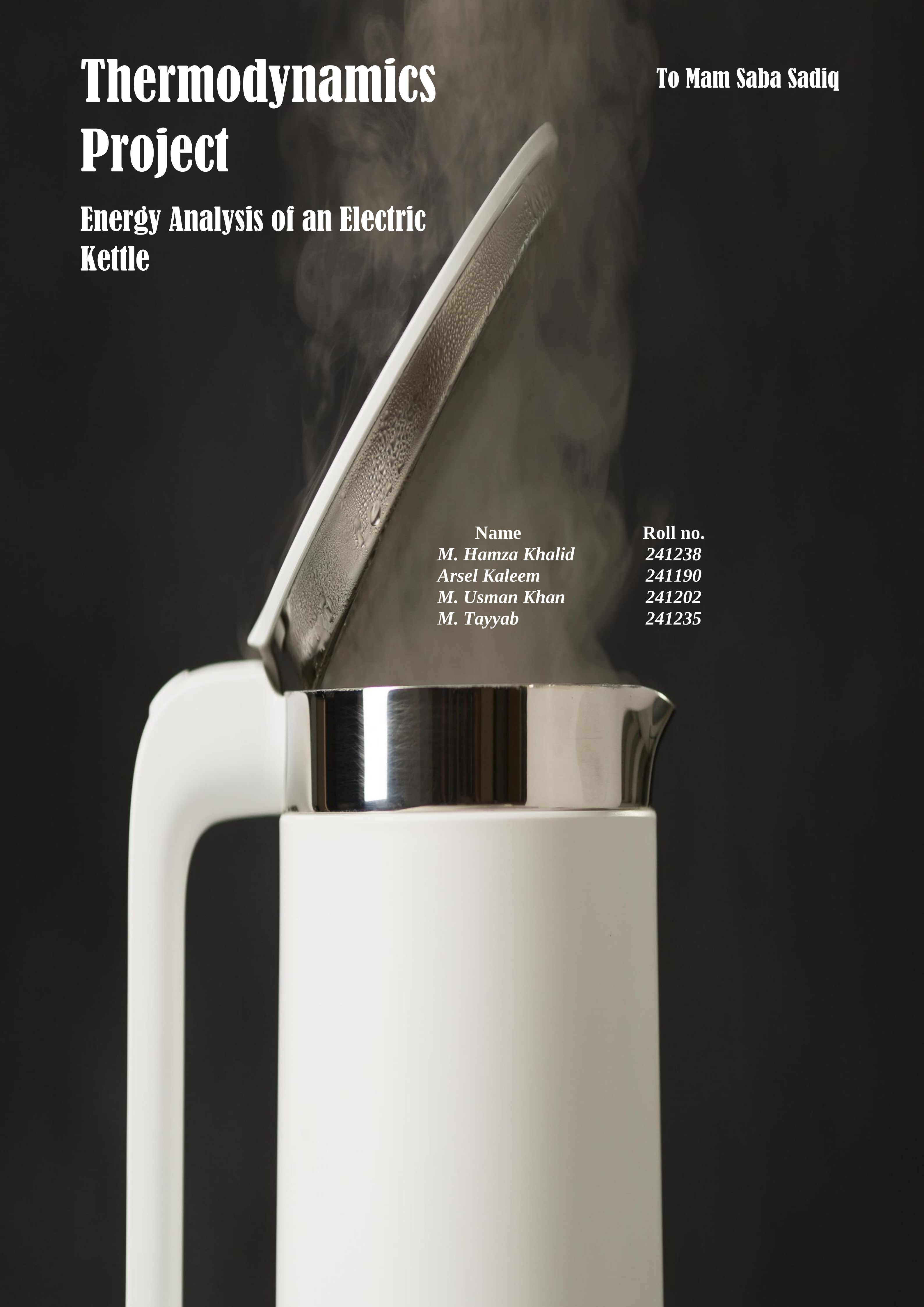

Thermodynamics Project

To Mam Saba Sadiq

Energy Analysis of an Electric Kettle

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1. Introduction

Electric kettles are commonly used household appliances designed to rapidly heat water using electrical energy. Despite their widespread use, the thermodynamic performance of electric kettles often goes unnoticed. This project aims to analyze the energy efficiency and heat transfer characteristics of a typical electric kettle using fundamental thermodynamic principles.

2. Model of kettle

We used **KENWOOD** electric kettle 2.2 liters .it is made of stainless steel .with power of 1500 watt and 220 volts voltage and 9.1 ampere current.

Figure 1 (Electric cattle)

3. Objective

The objective of this project is to:

1. Estimate the energy required to heat a known volume of water in an electric kettle.
2. Compare the estimated thermal energy requirement with the actual electrical input
3. Calculate the efficiency of the kettle.
4. Identify and analyzing heat losses to the surroundings.

4. Methodology

The procedure followed for the thermodynamic analysis includes:

1. Measuring the mass of water to be heated.
2. Recording the initial and final temperatures of the water.
3. Using a stopwatch to measure the time taken for the heating process.
4. Calculating the energy required by using energy analysis equation

5. calculating the electrical energy
6. Calculating efficiency and estimating heat loss.

5. Collected Data

Mass of water (m) → 1 lite = 1 kg
Initial temperature (T1) → Room temperature =25°C
Final temperature (T2) → Boiling =100°C
Time taken (t) → 3 minutes =180 seconds
Power rating of kettle (P) → 2000 watt

6. Assumptions

1. No phase change occurs (heating only up to 100°C)
2. All heat goes into water (ideal case, no losses)
3. Atmospheric pressure is 1 atm
4. Electrical input = Power × Time (constant power)

7. Thermodynamic Analysis

To get heat out we will use

Method 1

Q-W=m(u₂-u₁)

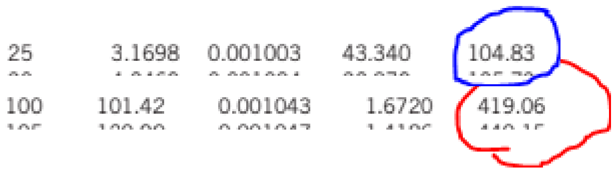
Using stem table A-4

@T= 25 degree

U_1=104.83 kJ/kg

@T= 100 degree

U_2=419.06



25	3.1698	0.001003	43.340	104.83
100	101.42	0.001043	1.6720	419.06

Electrical input = Power × Time

W$_{in}$= 2000 × 180 = 360,000 J = 360 kJ

So Q=1(419.06-104.83)+(-360)

Q=-44.77 kJ ∴ **This is heat loss that's why it is negative**

Method 2

Thermal Energy Required:

Q = m×c×(T2-T1)

Specific heat (c) of water = 4.184 kJ/kg·°C

Q = 1.0 × 4.184 × (100 - 25) = 314 kJ

Electrical Energy Input:

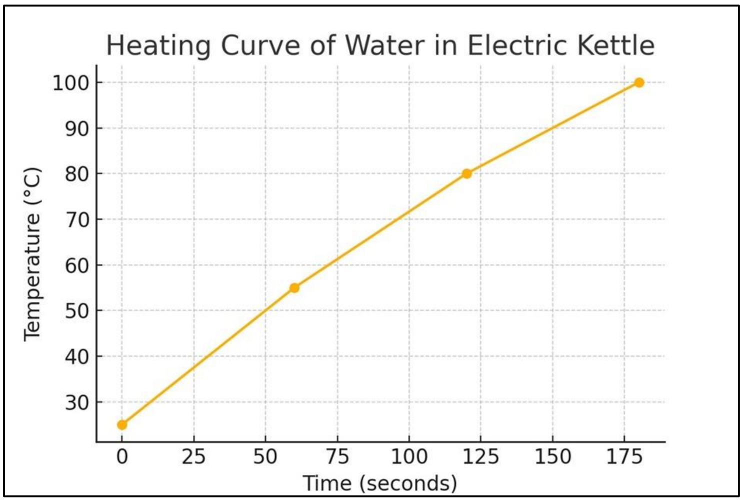
E = P × t = 2000 × 180 = 360,000 J = 360 kJ

Efficiency:

Efficiency (η) = (Q / E) × 100 = (314 / 360) × 100 ≈ 87.2%

Heat loss = E - Q = 360 - 314 =46 kJ≈ 44.77 kJ

Heating Curve of Water in Electric Kettle



8. Conclusions

The thermodynamic analysis of the electric kettle reveals an efficiency of approximately 87.2%, indicating that most of the electrical energy is effectively used to heat the water. However, around 12.8% of the input energy is lost to the surroundings, likely due to heat dissipation through the kettle's surface and lid. Improving insulation and reducing heat loss paths can further enhance the efficiency of such devices.

9. References

1. Thermodynamics-an-engineering-approach-5th-edition
2. Steam tables from **thermodynamics-an-engineering-approach-5th-edition**
3. Manufacturer datasheet of electric kettle (Model **KENWOOD** electric kettle 2.2-2000)

10. Tools & Resources

1. Steam tables
2. Thermodynamics textbook
3. Stopwatch/timer
4. Internet for data sheets and virtual observations
5. Calculator for calculations