Project Report: Determination of Heat of Combustion Using a Bomb Calorimeter

Course: Heat transfer

Instructor: Dr. Sourav Sarkar Department of Mechanical Engineering Jadavpur University

Students: 1) Ratul Chakraborty Department of Mechanical Engineering Jadavpur University

Students: 2) Shaswata Ghosh Department of Mechanical Engineering NIT Durgapur

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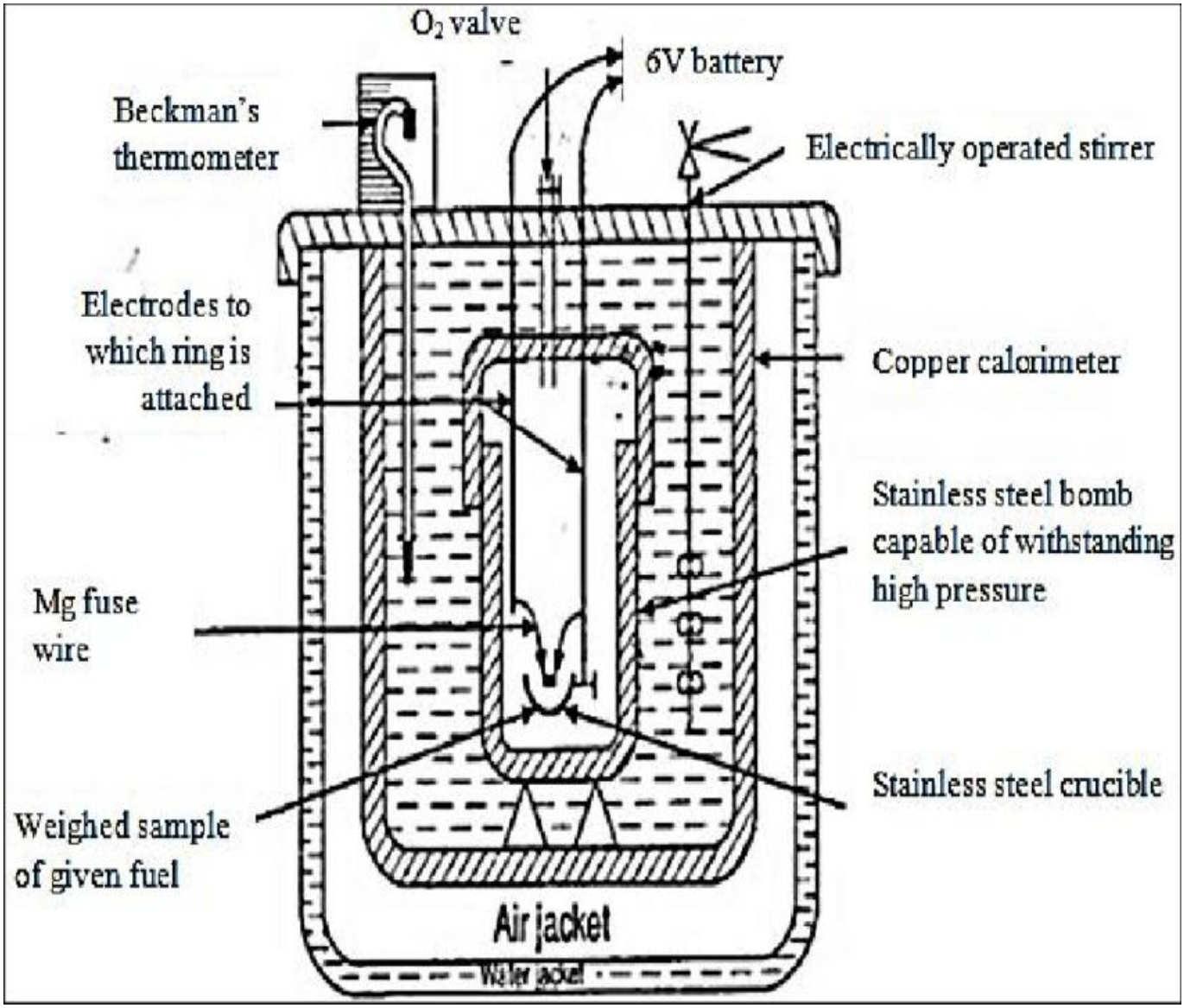
O_2 valve
6V battery
Beckman's thermometer
Electrically operated stirrer
Electrodes to which ring is attached
Copper calorimeter
Stainless steel bomb capable of withstanding high pressure
Mg fuse wire
Stainless steel crucible
Weighed sample of given fuel
Air jacket
Water jacket

Title:

Determination of Calorific Value of a Fuel Using Bomb Calorimeter

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Objective:

To determine the **gross calorific value (GCV)** of a given fuel sample using a **bomb calorimeter** and understand the energy content available in the fuel.

Theory:

A **Bomb Calorimeter** is a device used to measure the heat of combustion of a substance. When a known mass of fuel is burned in an oxygen-rich environment inside the bomb, the heat released is absorbed by the surrounding water and calorimeter parts. The temperature change in water is used to calculate the energy content.

Calorific Value is defined as:

"The amount of heat produced by the complete combustion of a unit mass of fuel."

Formula Used:

Heat released (Q)=(W+w)×ΔT

Where:

- W = Mass of water (g)
- w = Water equivalent of calorimeter (g)
- ΔT = Rise in temperature (°C)

Calorific Value (CV)= $\frac{(W+w)\Delta T}{m}$

Where:

- m = Mass of fuel burnt (g)

Apparatus Required:

- Bomb calorimeter setup

- Fuel sample (e.g., benzoic acid, kerosene, or coal)
- Oxygen cylinder
- Thermometer or temperature sensor
- Water
- Fuse wire
- Weighing balance

Equipment	Description
Arduino Uno	Microcontroller board for processing signals
MAX6675 Module	Thermocouple amplifier with digital output
K-Type Thermocouple	For measuring temperature up to 1100°C
USB Cable	For Arduino connection
Laptop with Arduino IDE	For coding and serial monitoring
Stopwatch	For manual time tracking
Bomb Calorimeter setup	For combustion energy measurement
Transient Heat Block or Rod	For transient heat conduction experiment

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diff


K-Type Thermocouple → MAX6675 Amplifier → Arduino Uno


MAX6675 to Arduino:
- VCC → 5V
- GND → GND
- SCK → Pin 13
- CS → Pin 10
- SO → Pin 12
```

```ino
#include <max6675.h>

// Define pins for MAX6675
int thermoSO = 8;
int thermoCS = 9;
int thermoCLK = 10;

MAX6675 thermocouple(thermoCLK, thermoCS, thermoSO);

void setup() {
  Serial.begin(9600);
  delay(500); // Allow sensor to settle

  // PLX-DAQ header (optional but helps)
  Serial.println("CLEARDATA");
  Serial.println("LABEL,Time,Temp_C,Temp_F");
}

void loop() {
  float tempC = thermocouple.readCelsius();
  float tempF = thermocouple.readFahrenheit();

  // Send data to PLX-DAQ: TIME is built-in
  Serial.print(tempC);        // CH1 = Temp_C
  Serial.print(",");
  Serial.println(tempF);      // CH2 = Temp_F

  delay(1000); // every 1 sec
}
```

Experimental Procedure:

1. Weigh a known quantity of the fuel sample (~1g) and place it in the crucible inside the bomb.
2. Attach the fuse wire and add a few drops of water inside the bomb to absorb acid gases.
3. Fill the bomb with pure oxygen to about 20–30 pound.
4. Place the bomb in the calorimeter filled with a known quantity of water.
5. Note the initial temperature of water.
6. Ignite the fuel using an ignition circuit.
7. Stir continuously and record the final temperature after combustion stabilizes.
8. Calculate the temperature rise and apply the calorific value formula.

Observation Table:

S. No	Parameter	Value
1	Mass of fuel (m)	1.00 g
2	Mass of water (W)	2000 g
3	Water equivalent of calorimeter (w)	500 g
4	Initial Temperature (T_1)	41.5 c
5	Final Temperature (T_2)	52.75 c
6	Temperature Rise (ΔT)	11.25 c

Calculations:

Given:

- W=2000g
- ΔT=11.25 °C
- m=1.00m = 1.00m=1.00 g
- gcv= 22973 kj/kg

Result:

The **calorific value of the given fuel** was found to be:

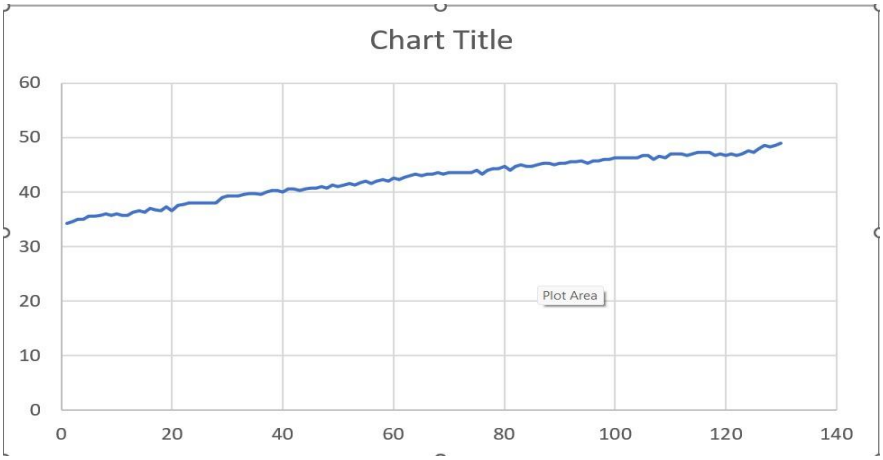
22793 kJ/kg

Graph:

A simple **Temperature vs Time** graph can be plotted.

Y-Axis: Temperature (°C)

X-Axis: Time (minutes)



The temperature rises sharply during combustion and then levels off.

Conclusion:

- The bomb calorimeter efficiently measured the **gross calorific value** of the fuel.
- The obtained calorific value (36.61 kJ/g) indicates that the fuel has **high energy content**, suitable for industrial or domestic use.
- The experiment emphasizes the importance of precise measurements and insulated conditions to minimize heat loss.

Precautions:

- Ensure the bomb is sealed properly before filling with oxygen.
- Handle oxygen cylinder with care.

- Stir water continuously for even heat distribution.
- Use accurate weighing balance and calibrated thermometer.