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# Experimental Study of Calcium Carbide as an Alternative Fuel Using in Water Heater

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**Abstract**

So far, we are utilizing material 's like coal, wood or any other petroleum products to generate heat. This operation is more expensive and time consuming. In this study, we have proposed a chemical phenomenon through which we can get heat straightforwardly and rapidly. The notion is to add Calcium carbide [$CaC_2$], and Water [$H_2O$], Ice [frozen $H_2o$], or Saline water [$NaCL+H_2O$], with or without the use of air pump to obtain Acetylene for heat generation. From this experiment we had identified different variable parameters suggesting the different range of temperature with the aid of simple apparatus. This straightforward setup can be used comfortably where there is enormous snow, in the ship, tramping to the forest or desert for heat generation and its subsequent application for heating of any liquid, desalination of water, etc. The conclusions would be precious for future investigation.

***Keywords****: Calcium carbide, Acetylene, Air pump, Water heater, Alternative fuel, Experimental setup*

## 1. INTRODUCTION

In present scenario, there is not a single water heater which is both portable and don't use electricity, liquified petroleum gas or piped natural gas. So, globetrotter and people living in high range areas cannot use water heater when they need because of lack of resources. So, our experimental study is to make a water heater which can be used anywhere in the world regardless of how high or low the temperature of place would be with great ease. The water heater uses a mixture of calcium carbide and any source of water as a fuel. As both these things are economical and easily accessible, as water is a ubiquitous resource, so it is available anywhere in the world. If in case water is not available in direct liquid form, snow or saline water can be used efficiently. This would be very helpful for army personnel posted in such low temperature places, also for the sea travellers and last but not least for all the common people in any condition due to its portability.

### 1.1 Main Objective of the Experiment: -

- Provide a water heater with any form of $H_2O$ (water) and calcium carbide as fuel mixture.
- To make the water heater portable, so that it can be taken off to any places with at most comfort.
- To produce the water heater at minimal cost, so that everyone can purchase it without any money crunch.

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- To produce the main fuel (acetylene gas) at the time of requirement of heating the water, so that there is no extra cost of storing and transporting the gas.

**Table 1**

Comparison with Other Fuels [9]

| Properties | Acetylene | LPG | Natural gas |
|---|---|---|---|
| Composition | $C_2H_2$ | $C_3H_8$:48%; $C_4H_{10}$:50%; $C_5H_{12}$ :02% | $CH_4$:>85%; $C_2H_6$: 38%; $C_3H_8$: 1-2% |
| Density kg/m3 (At 1 atm & $0^0$C) | 1.097 | 0.537 | 0.777 |
| Auto ignition temperature($^0$C) | 305 | 470 | 760 |
| Stoichiometric air fuel ratio (kg/kg) | 13.2 | 15.67 | 17.19 |
| Flammability limits (volume %) | 2.5-81 | 1.81-8.86 | 5.0-15.6 |
| Flammability limits (Equivalent ratio) | 0.3-9.6 | 0.53-2.48 | ---------- |
| Lower calorific value (kj/kg) | 49900 | 49300 | 52200 |
| Gross calorific value(kwh/kg) | 13.9 | 13.69 | 14.50 |
| Maximum deflagration speed (m/sec) | 1.5 | ---------- | ---------- |

1.2 Effects of other fuels

- In present days, world is confronted with twin crisis of fossil fuel depletion and environmental degradation. The fuel used till now for heating water are limited. Liquified petroleum gas and piped natural gas is a flammable mixture of hydrocarbon gases used as fuel in heating appliances, cooking equipment. Also, it is costly and in addition it has much toxicity when it is leaked, it can cause severe cold burns to the skin and can act as an asphyxiant at high concentration [11].

- Electricity is not readily available everywhere in the world and heaters which use it are not much economical in cost as well as require high maintenance. So, consumers have to bear these problems. If in case of electric current gets in contact with water used to heat, then it can cause severe explosion, water shock or even death of a person because electricity is always a good conductor of electricity, so it is always risky to use it when water is in contact.

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- **So, after studying this criterion the need for alternative fuel like calcium carbide take place due to its availability, environmentally friendly, cost-effective and techno-economically competitive.**

## 2. Overview

The project involves the production of acetylene gas through calcium carbide and water reaction in reaction tank.

$CaC_2$ + $2H_2O$ → $C_2H_2$ + $Ca(OH)_2$

Calcium Carbide | Water | Acetylene | Calcium Hydroxide

The reaction of calcium carbide and water produces acetylene and a chalky suspension of calcium hydroxide. Acetylene, consists of 2 carbon atoms and 2 hydrogen atoms joined by a triple bond. When a lit match or an automatic electric spark is brough near the acetylene gas then combustion of acetylene takes place in presence of oxygen to produce high temperature heat with carbon dioxide and water [12].

$2C_2H_2$ + $5\ O_2$ → $4CO_2$ + $2H_2O$

Acetylene | Oxygen | Carbon Dioxide | Water

In the proposed heater, the main container is to be filled with standard amount of calcium carbide and water/ice/saline water, which on reaction gives acetylene gas and residual calcium hydroxide. Acetylene gas thus produced is a synthetic gas but not an air gas, and is a colourless and highly combustible gas with pungent odour.[10]

This acetylene gas is then sparkedwhen it is flown through pipe with the help of automatic electric ignition system due to which high temperature heat is produced. The high temperature heat so produced heats up the water with the help of heat exchanger and residue gas is flown out to atmosphere after purification. In this way, the whole process of heating takes place.

## 3. Calcium Carbide Manufacturing

Heating of lime and carbon mixture to $2000^0$C and $2100^0$Cin an electric arc furnace produced calcium carbide. [10-11]

Lime is reduced by carbon to calcium carbide and carbon monoxide by given reaction: -

CaO + 3C → $CaC_2$ + CO

Calcium Oxide | Carbon | Calcium Carbide | Carbon Monoxide

Lime for reaction is usually made by calcium limestone in a kiln at plant site. The source of carbon for reaction are petroleum coke, metallurgical coke and anthracite coal due to impurities in furnace charge remains in calcium carbide product, the lime should contain no more than 0.5% each magnesium oxide, aluminium oxide, iron oxide and 0.004% phosphorous.Also, coke charge should be minimal in ash and sulphur.About 991 kilograms (2.185 pounds) of lime, 683 kg (1506 lb) of coke and 17 to 20 kg (37 to 44 lb) of electrode paste are required to produce 1 mega gram (2205 lb) of calcium carbide.

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## 4. Literature Referred

[1] Described the design parameters of electric arc furnace for one ton per day calcium carbide production. The furnace designed was a small type and hence about 43% efficiency is only obtained. Thermal efficiency can be increased by implementing the off-gas utilization incorporating computer or microprocessor controlled operating mechanism employing improved refractories and adopting strict raw material control and better operating procedures.

[2] Provided the design of electric water heater which includes polymeric body having an elongated hollow inlet and outlet opening, in communication with the hollow barrel for flowing water to pass there through. An electric resistance water having a heating element of a material exhibiting a positive temperature coefficient of resistance is disposed in hollow of polymeric body and in heat transfer communication with water flowing through hollow barrel. An electric source supplies electric power to heating element to generate heat. A controller senses current flow through heating element and determines a resistance related valve such as current or resistance of heating element.

[3] Describes a new plasma spout-fluid bed process for the synthesis of calcium carbide. Calcium carbide was produced in a granular form by solid phase reaction of carbon and calcium oxide spout. Fluid bed reactor was found to have different zones: a high temperature plasma reaction zone and a well isothermal bed zone. The experimental results showed that reaction took place in reaction zone and conversion to calcium carbide increased linearly with reaction time. Microscopic analysis of solid product showed that calcium carbide was formed around both graphite and calcium oxide particles, indicating that carbon-calcium vapour reaction took place at the surface of both free carbon and the carbon diffused into the oxide.

[4] Describes the explosion of an acetylene gas cylinder, which occurred in 1993 in Sydney. The failure caused severe fragmentation of the cylinder that resulted in a fatality and property damage. He examined the nature of the explosion which occurred and sough an explanation of the event. He gave more information to prevent accidents. Regarding while using acetylene and reaction take place in combustion and safety precautions.

[5] Disclosed gas fired water heater/boiler apparatus with a unique burner assembly that provides high level of BTU/hr input making it suitable for commercial installation. The gas burner includes a pair of superimposed tubes, each having evenly distributed performance of a different uniform size, that are rolled flush together and provide a thick-walled burner with greatly increased strength and resistance to premature failure while furnishing an optimum flame pattern. The gas burner projects into the interior of a vertical cylinder array of finned heat exchanger tubes through which fluid to be heated in circulated. The water and heater boiler apparatus are compact and thermally insulated by a pressurized forehearth and may be insulated on combustible floors or in closets with zero clearance.

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[6] Describes the process for production of acetylene and synthesis gas by partial oxidation of hydro- carbons with oxygen, wherein gaseous reactants are separately preheated intimately mixed in a mixing zone, reacted after passing a burner block and rapidly quenched with an aqueous quench medium after reaction and further characterized in that aqueous quench medium is recirculated in closed system. Preferable the ratio of gaseous reactants is selected in such a way that acetylene and soot produced in reaction are obtained in a weight ratio of 50 to 500.

[7] Outlines the method and apparatus for storage of acetylene by providing an acetylene storage device which has an interior volume. A carbonaceous adsorbed is disposed in the interior volume of storage device, and acetylene is introduced into the storage device to be reversibly adsorbedby carbonaceous adsorbent. A pressure of less than 2 bar is maintained in the storage device.

[8] Provides calcium carbide/ water acetylene gas generator which comprises of inner and outer nested chamber in which inner chamber has plurality of trays inserted therein, with a grid located above each tray. Water is provided to the inner chamber and is disposed throughout the inner chamber by the grides to the tray containing calcium carbide or like material. Space between inner and outer chamber is used to provide liquid cooling of the inner chamber.

## 5. Experimental Detailing

The main aim of the experiment was to make a miniature scale model of water heater with calcium carbide & water/ice/saline water as a fuel and to conduct experiments to evaluate its efficiency and complications that will arise if it is transferred to a larger scale model.

### 5.1 The experimental setup was constructed with following apparatus and substances: -

1) Main container for reaction
2) Hose pipe (for flow of acetylene gas)
3) Universal temperature controller
4) Infrared thermometer
5) Automatic electric ignition system
6) Supplementary air injector pump
7) Burner
8) Control valve
9) Stainless steel beaker
10) Weighing scale
11) Cast iron cooktop to support beaker
12) Calcium carbide, water, ice and saline water

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**5.2 The purpose of the substance and material was as follows: -**

The calcium carbide & water/ice/saline water undergoes reaction in main container without any temperature losses and pressure losses, while there was also an opening in the container from which the calcium carbide and water is filled into it before reaction as well as the container was emptied after the completion of reaction.The hose pipe carries acetylene gas produced in container to the burner.Universal temperature controller and infrared thermometer measures water temperature in vessel, temperature of the container before and after reaction, flame temperature and outer temperature of beaker containing water at specific time interval.

The automatic electric ignition system uses electronic circuits, usually by transistors controlled by sensor to generate electric pulse which turns into spark generation and burn the acetylene gas. It is fitted near flame burner to start the burning process asgas comes out from burner. This electric ignition system is used as it has fewer moving parts, low maintenance required, generates no emission, provide good efficiency. Supplementary air injector pump is used to increase pressure of acetylene gas. Burner provides multiple continuous flame in a controlled way by combustion of acetylene gas. Control valve is used to regulate gas flow rate and pressure of gas which was used to control intensity of flame produced. Stainless steel beaker hold water in heat and it was heated from bottom by burner. Weighing scale measure the amount of calcium carbide and water needed to be filled for one cycle of reaction. Cast iron cooktop supports beaker from below and that cooktop was kept above the burner.

6. Experimental Procedure

The whole process of the experiments can be described as: -

Firstly, the amount of calcium carbide & ice/water/saline water to be filled in the main container was measured with the help of weighing scale, then all substance was measured and taken in a fixed proportion and after that small nuggets of calcium carbide was injected into the main container filled with water/ice/ saline water. Thus, exothermic reaction take place which produce non-toxic, colourless, odourless and flammable acetylene gas. Then by operating the control valve, the gas flows from container to burner through hose pipe attached between them. As gas flow reach to burner, the electric ignition was switched on, which causes spark and start combustion of acetylene gas and produce flame at high temperature. That flame was directed on to the beaker containing water which is to be heated and it was kept above cooktop support. Thus, flame heats the water and with the help of universal temperature controller and infrared thermometer various temperature of vessel, water, container was jotted down. Then after the heating process, the residue mixture (calcium hydroxide) left in the container was emptied.

In this way experimental procedure was conducted

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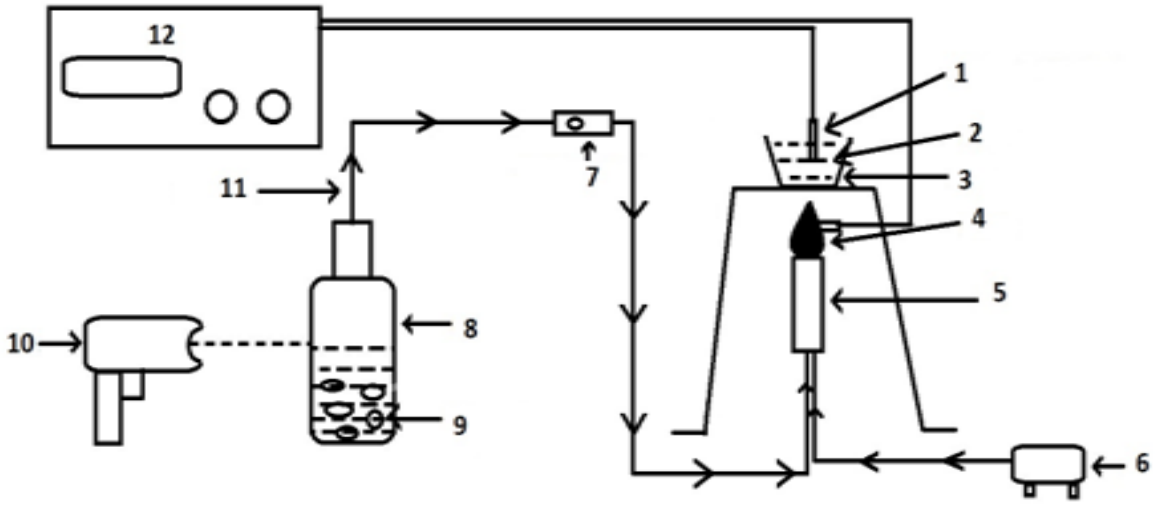


**Figure 1**
Experimental setup

The numerals in the figure are described as follows: -

1) Temperature sensor
2) Water
3) Beaker (vessel)
4) Flame
5) Burner
6) Air pump
7) Gas control knob
8) Main container
9) Calcium carbide + (water/ ice/ saline water)
10) Infrared thermometer
11) Hose pipe
12) Universal temperature controller

## 7. Results and discussions

Several experiments were conducted to analyse the change in temperature of water in vessel, copper specimen, space graded aluminium specimen when heated with acetylene flame obtained from reaction of calcium carbide and Ice/Water/Saline water. The experiments were conducted with or without the aid of air pump. The temperature was jotted down in all experiments with reference to a fixed time interval and then the values were plotted in a line graph to examine the changes in temperature at the time of heating.

### 7.1 Experiment 1

Heating copper pipe with flame produced from acetylene gas, which is a mixture of calcium carbide and water.

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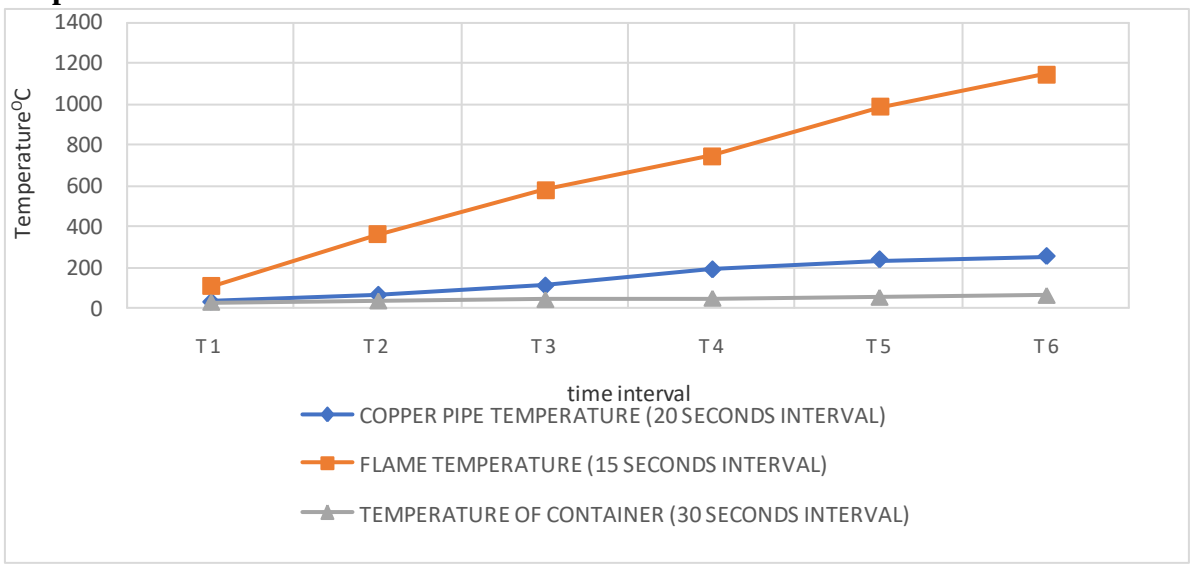
➔ Experiment is done with the use of small air pump: -
Weight of main container before experiment: - 155 grams
Weight of main container after experiment: - 152 grams
Mass of copper pipe: - 29 grams
Weight of main container: - 40 grams (empty bottle)
Water or ice weight: - 100 gm
Calcium carbide weight: - 15 grams
Atmospheric temperature: - 25.1$^{O}$C
Adverse effect: - round type of ash stick on top of copper pipe which decrease heat transfer to pipe
Good sign: - high flames with high temperature

**Table 2**

| TIME INTERVAL | COPPER PIPE TEMPERATURE (20 SECONDS INTERVAL) | FLAME TEMPERATURE (15 SECONDS INTERVAL) | TEMPERATURE OF CONTAINER (30 SECONDS INTERVAL) |
|---|---|---|---|
| T1 | 31 | 105 | 26 |
| T2 | 65 | 356 | 33 |
| T3 | 110 | 580 | 40 |
| T4 | 189 | 745 | 47 |
| T5 | 238 | 986 | 52 |
| T6 | 254 | 1147 | 62 |

**Graph 1**




Here in the graph, the flame temperature when plotted with respect to time interval (T) of 20 second, a linear relation is obtained where flame temperature constantly increases with respect to time (T) and the range of flame temperature obtained is 105-1147$^{o}$C. The copper

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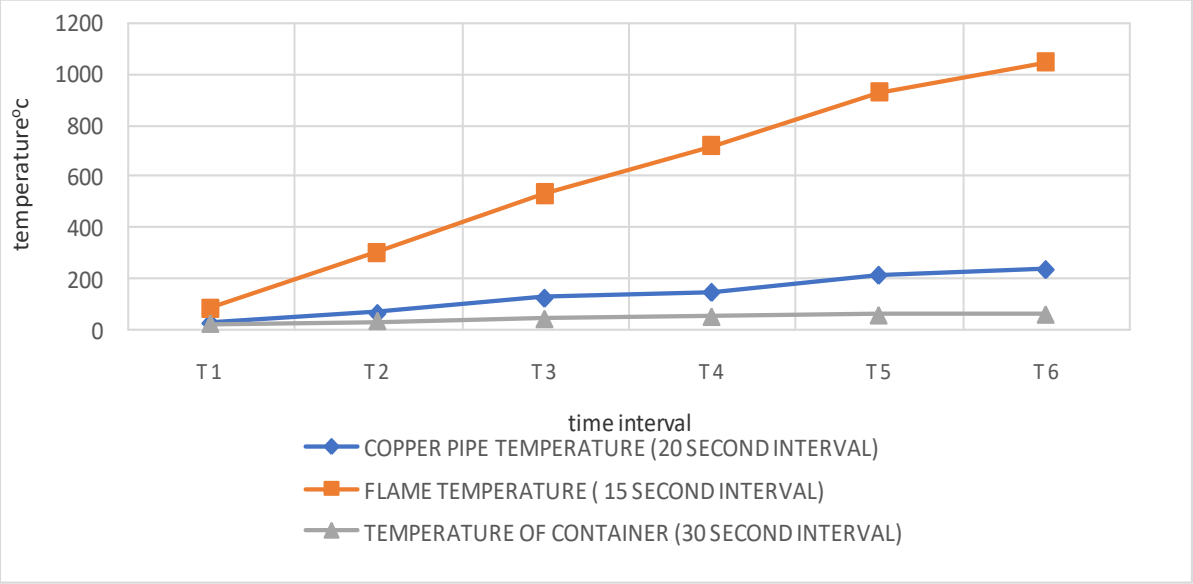
pipe temperature when plotted exhibited a s- bend curve and the temperature of main temperature increased at a very slow pace with respect to time interval (T).

➔ Experiment done without the use of small air pump: -
Adverse effect: - Much ash found around pipe
Good sign: - proper ignition start.

**Table 3**

| TIME INTERVAL | COPPER PIPE TEMPERATURE (20 SECOND INTERVAL) | FLAME TEMPERATURE (15 SECOND INTERVAL) | TEMPERATURE OF CONTAINER (30 SECOND INTERVAL) |
|---|---|---|---|
| T1 | 30 | 89 | 26 |
| T2 | 68 | 310 | 37 |
| T3 | 128 | 536 | 45 |
| T4 | 151 | 723 | 54 |
| T5 | 218 | 930 | 60 |
| T6 | 240 | 1050 | 63 |

**Graph 2**




Here the flame temperature when represented in line graph with respect to time was increasing at a constant rate with respect to time (T) and the flame temperature ranged from 89-1050 $^{o}$C. The temperature of copper pipe and temperature of main container exhibited a slow rate of increase in temperature with respect to time (T).

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### 7.2 Experiment 2

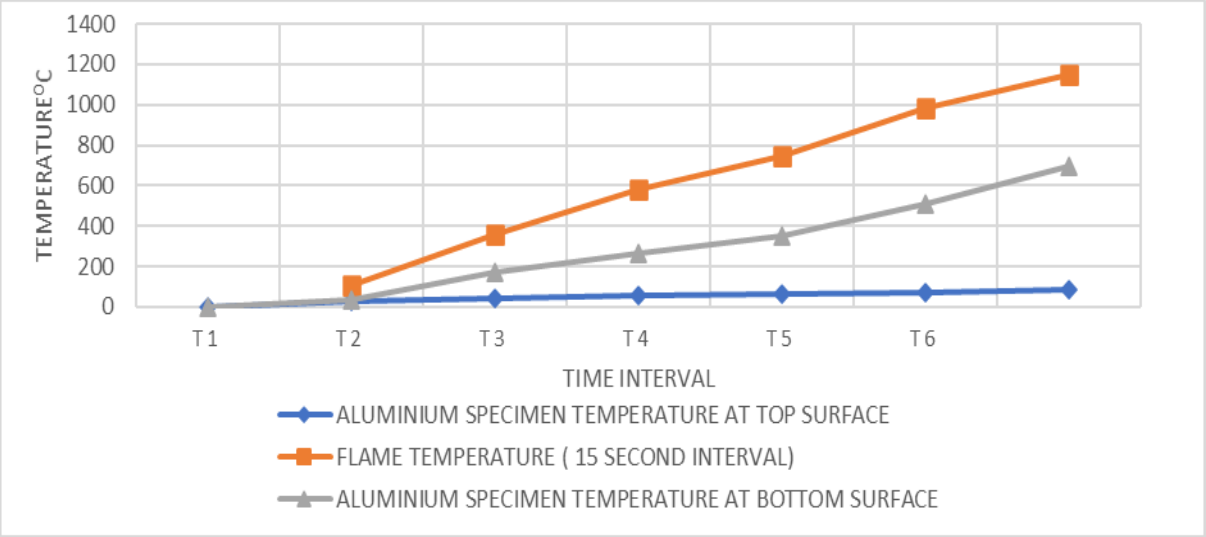
➔ Heating aluminium 3000 grade specimen with flame obtained from acetylene gas**.**

Mass of aluminium specimen: - 79 grams
Weight of container before experiment: -155 grams
Weight of container after experiment: - 152 grams
Weight of container starting (empty): - 40 grams
Atmospheric temperature: -24 $^{O}$c
Mass of water of ice: - 100 grams
Mass of carbide: - 15 grams
➔ Experiment done with air pump: -
Adverse effect: - excessive pressure observed which is difficult to control
Good sign: - high flames with high temperature can be seen

**Table 4**

| TIME INTERVAL | ALUMINIUM SPECIMEN TEMPERATURE AT TOP SURFACE (20 SECOND INTERVAL) | FLAME TEMPERATURE (15 SECOND INTERVAL) | ALUMINIUM SPECIMEN TEMPERATURE AT BOTTOM SURFACE (25 SECOND INTERVAL) |
|---|---|---|---|
| T1 | 30 | 105 | 32 |
| T2 | 42 | 356 | 170 |
| T3 | 55 | 580 | 263 |
| T4 | 64 | 745 | 352 |
| T5 | 73 | 986 | 511 |
| T6 | 82 | 1147 | 698 |

**Graph 3**

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Here in the graph, the flame temperature when plotted with respect to time interval (T) of 15 second, a linear relation is obtained where flame temperature constantly increases with respect to time (T) and the range of flame temperature obtained is 105-1147ºC.The aluminium specimen temperature at bottom surface remained constant till T2 time interval then started increasing linearly with reference to time (T). The aluminium temperature at top surface ranged from 30-82 ºC. and when plotted showed nearly constant temperature with reference to time (T).

➔ Experiment done without air pump: -

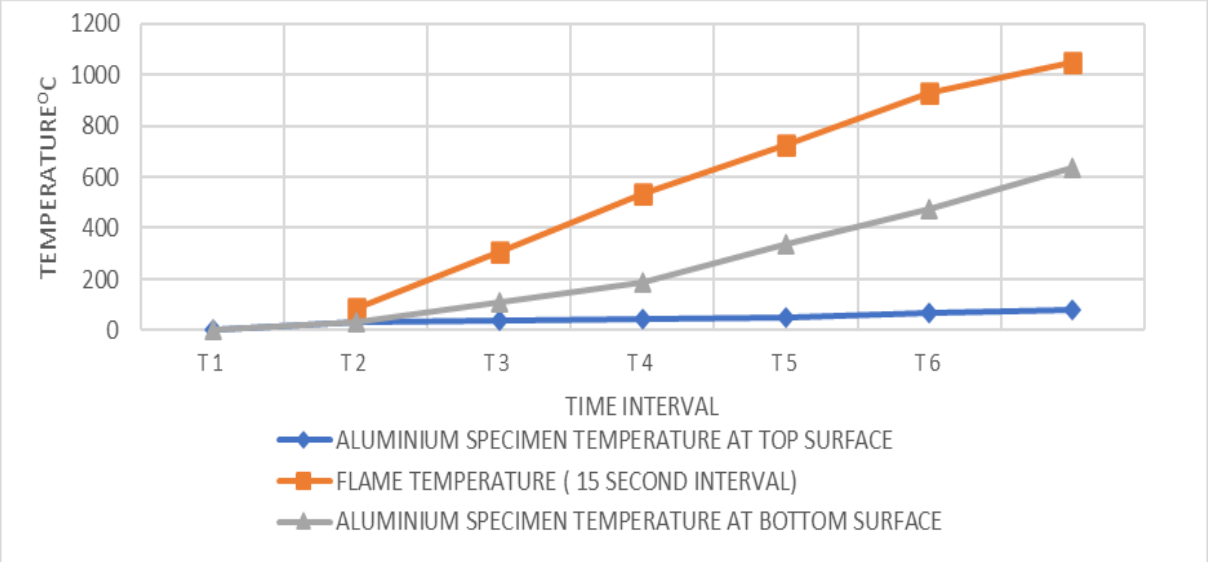
Adverse effect: - change in flame colour observed

Good sign: - lower flames with low temperature

**Table 5**

| TIME INTERVAL | ALUMINIUM SPECIMEN TEMPERATURE AT TOP SURFACE (20 SECOND INTERVAL) | FLAME TEMPERATURE (15 SECOND INTERVAL) | ALUMINIUM SPECIMEN TEMPERATURE AT BOTTOM SURFACE (25 SECOND INTERVAL) |
|---|---|---|---|
| T1 | 30 | 89 | 32 |
| T2 | 37 | 310 | 108 |
| T3 | 46 | 536 | 185 |
| T4 | 52 | 723 | 340 |
| T5 | 68 | 93 | 473 |
| T6 | 79 | 1050 | 638 |

**Graph 4**

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Here in the graph, the flame temperature when plotted with respect to time interval (T) of 15 second, a linear relation is obtained where flame temperature constantly increases with respect to time (T) and the range of flame temperature obtained is 89-1050$^{o}$C.The aluminium specimen temperature at bottom surface remained constant till T2 time interval then increase at a moderate rate up to T4 time interval and then started increasing linearly with reference to time (T). The aluminium temperature at top surface ranged from 30-79 $^{o}$C. and when plotted showed nearly constant temperature with reference to time (T).

### 7.3 Experiment 3

Heating bowl of stainless steel filled with water from acetylene gas produced from calcium carbide and water reaction.
Mass of S.S. vessel: - 60 grams
Weight of container before experiment: -155 grams
Weight of container after experiment: - 153 grams
Weight of container after experiment: -152 grams
Weight of water in S.S. vessel in grams: - 80 grams
Weight of container without water & $CaC_{2:}$ - 40 grams
Atmospheric temperature: -21.4 $^{o}$C
Mass of water: -100 grams
Mass of carbide: - 15 grams

➔ Experiment done with air pump: -
Adverse effect: - high pressure observed
Good sign: - high flame with higher temperature

**Table 6**

| TIME INTERVAL | TEMPERATURE OF WATER IN VESSEL (AT 20 SECOND IN - TERVAL) | VESSEL TEMPERATURE (AT 25 SECOND INTERVAL) | TEMPERATURE OF MAIN COPNTAINER (AT 30 SECOND INTERVAL) |
|---|---|---|---|
| T1 | 29 | 70 | 25 |
| T2 | 40 | 161 | 32 |
| T3 | 55 | 219 | 38 |
| T4 | 71 | 292 | 44 |
| T5 | 92 | 340 | 48 |
| T6 | 108 | 400 | 55 |

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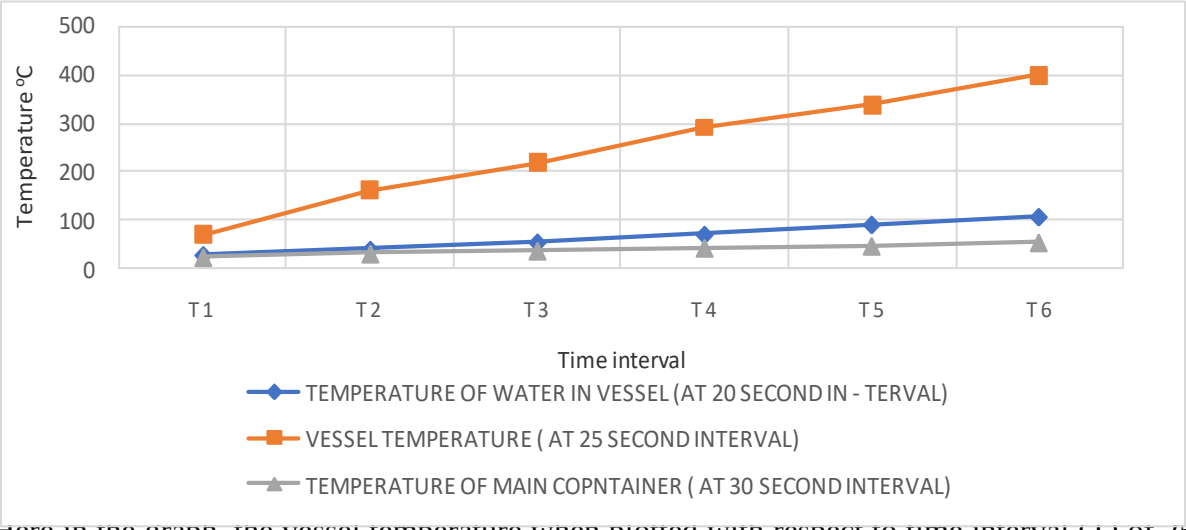
**Graph 5**




Here in the graph, the vessel temperature when plotted with respect to time interval (T) of 25 second, a linear relation is obtained where vessel temperature constantly increases with respect to time (T) and the range of vessel temperature obtained is 70-400$^{o}$C. The temperature of water in vessel and the temperature of main container increased at a moderate rate with respect to time interval (T).

➔ Experiment without air pump: -
Adverse effect: - Flame colour variation
Good sign: - Mild flame with lower temperature

**Table 7**

| TIME INTERVAL | TEMPERATURE OF WATER IN VESSEL (AT 20 SECOND IN - TERVAL) | VESSEL TEMPERATURE (AT 25 SECOND INTERVAL) | TEMPERATURE OF MAIN COPNTAINER (AT 30 SECOND INTERVAL) |
|---|---|---|---|
| T1 | 27 | 41 | 27 |
| T2 | 41 | 149 | 34 |
| T3 | 53 | 203 | 40 |
| T4 | 68 | 287 | 46 |
| T5 | 89 | 329 | 50 |
| T6 | 95 | 390 | 60 |

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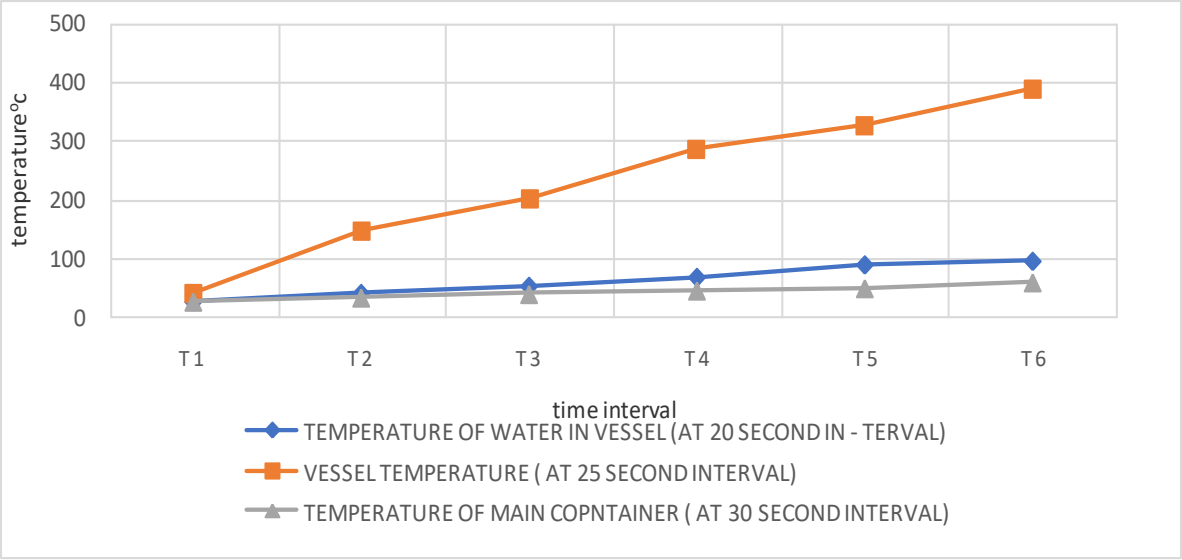
**Graph 6**




Here in the graph, the vessel temperature when plotted with respect to time interval (T) of 25 second, a linear relation is obtained where vessel temperature constantly increases with respect to time (T) and the range of vessel temperature obtained is 41-390°C. The temperature of water in vessel and the temperature of main container increased at a moderate rate with respect to time interval (T).

### 7.4 Experiment 4

Heating bowl of stainless steel with water from the flame of acetylene gas produced from calcium carbide and ice reaction.
Mass of S.S. vessel: - 60 grams
Weight of container before experiment: -155 grams
Weight of container after experiment: - 153 grams
Weight of container after experiment: -152 grams
Weight of water in S.S. vessel in grams: - 80 grams
Weight of container without ice & $CaC_2$: - 40 grams
Atmospheric temperature: -23 °C
Mass of ice: -100 grams
Mass of carbide: - 15 grams

➔ Experiment done with air pump: -
Adverse effect: - high bubble formation in the container
Good sign: - higher temperature can be obtained

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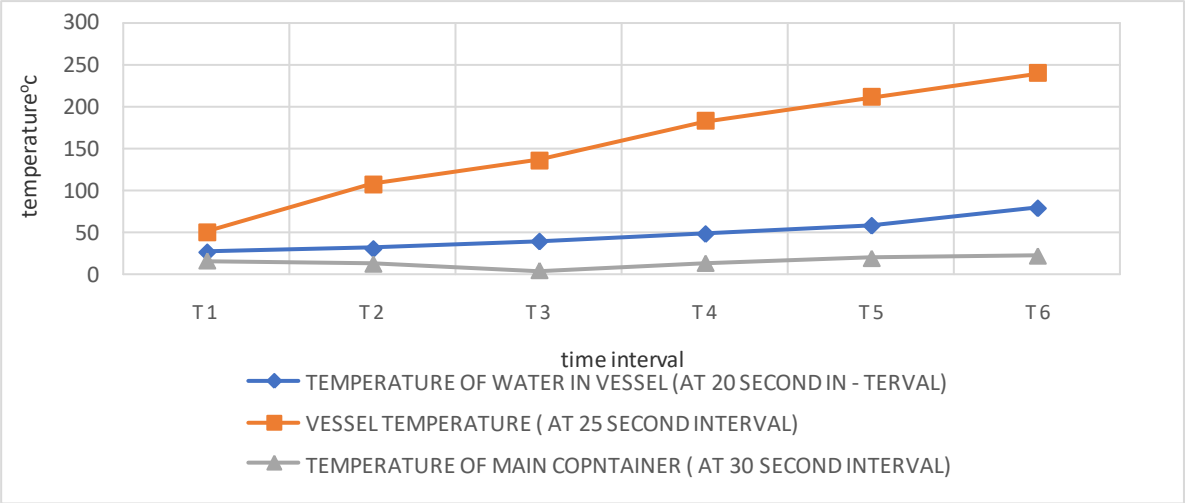
**Table 8**

| TIME INTERVAL | TEMPERATURE OF WATER IN VESSEL (AT 20 SECOND IN - TERVAL) | VESSEL TEMPERATURE (AT 25 SECOND INTERVAL) | TEMPERATURE OF MAIN COPNTAINER (AT 30 SECOND INTERVAL) |
|---|---|---|---|
| T1 | 26 | 50 | 16 |
| T2 | 30 | 107 | 12 |
| T3 | 39 | 136 | 4 |
| T4 | 48 | 183 | 13 |
| T5 | 58 | 211 | 19 |
| T6 | 79 | 240 | 22 |

**Graph 7**




Here in the graph, the vessel temperature when plotted with respect to time interval (T) of 25 second, increased linearly and the range of vessel temperature obtained is 50-240$^{o}$C.The temperature of water in vessel increased at a moderate rate with respect to time interval (T) of 20 second and highest temperature obtained is 79$^{o}$C.. The temperature of calcium carbide and ice mixture in the main container first decreased till T3 time interval and then increased at a slow rate with reference to time interval (T).

➔ Experiment done without air pump: -
Adverse effect: - less bubbles formation in container
Good sign: - good temperature achieved & failure of container reduced

**Table 9**

| TIME INTERVAL | TEMPERATURE OF WATER IN VESSEL (AT 20 SECOND IN - TERVAL) | VESSEL TEMPERATURE (AT 25 SECOND INTERVAL) | TEMPERATURE OF MAIN COPNTAINER (AT 30 SECOND INTERVAL) |
|---|---|---|---|

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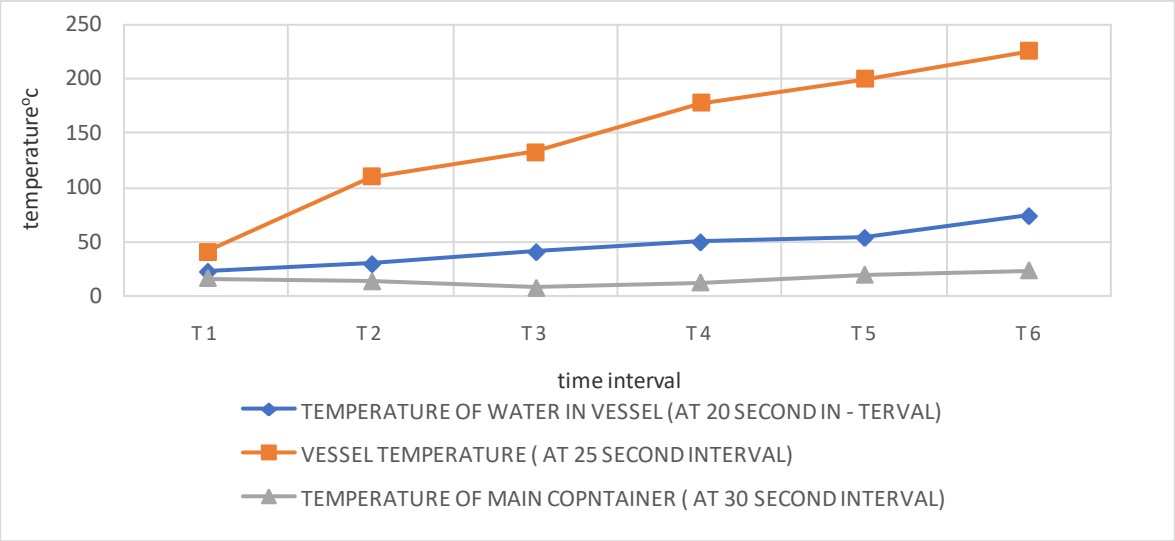
| | | | |
|---|---|---|---|
| T1 | 22 | 40 | 16 |
| T2 | 29 | 109 | 13 |
| T3 | 40 | 132 | 7 |
| T4 | 49 | 177 | 12 |
| T5 | 53 | 199 | 19 |
| T6 | 73 | 225 | 23 |

**Graph 8**




Here in the graph, the vessel temperature when plotted with respect to time interval (T) of 25 second, increased linearly and the range of vessel temperature obtained is 40-225$^{o}$C.The temperature of water in vessel increased at a moderate rate with respect to time interval (T) of 20 second and highest temperature obtained is 73$^{o}$C.. The temperature of calcium carbide and ice mixture in the main container first decreased from 16$^{o}$C to 7$^{o}$C and then increased to 23$^{o}$Cwith reference to time interval (T).

### 7.5 Experiment 5

Heating bowl of stainless steel with water from the flame of acetylene gas produced from saline water reaction.
Mass of S.S. vessel: - 60 grams
Weight of container before experiment: -155 grams
Weight of container after experiment: - 153 grams
Weight of container after experiment: -152 grams
Weight of water in S.S. vessel in grams: - 80 grams
Weight of container without ice & $CaC_2$: - 40 grams
Atmospheric temperature: -26 $^{o}$C
Mass of saline water: -100 grams
Mass of carbide: - 15 grams

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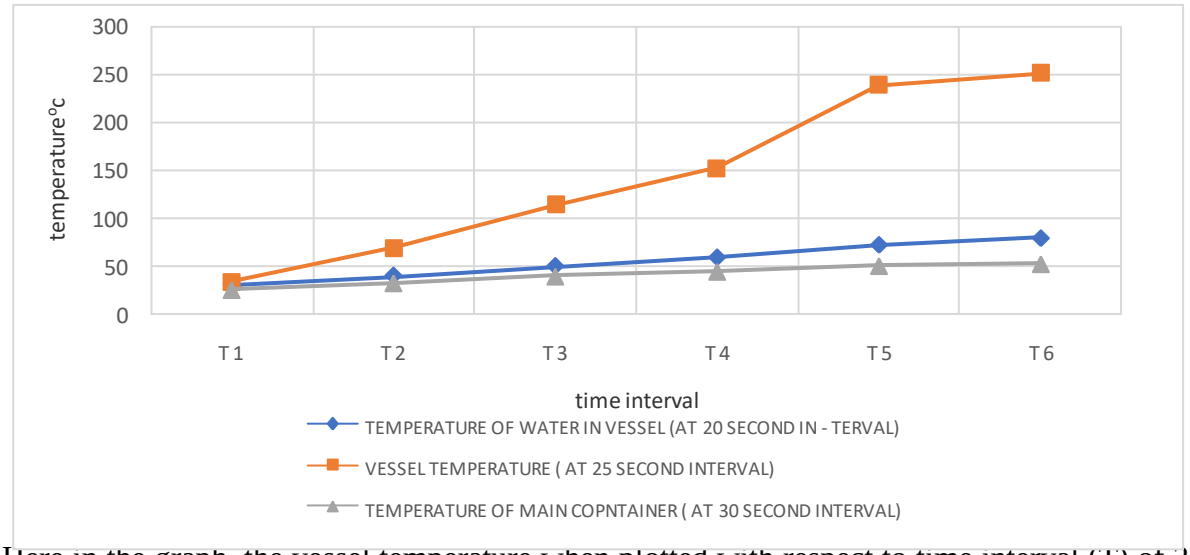
➔ Experiment done with air pump: -

Adverse effect: - high pressure observed
Good sign: - moderate temperature achieved

**Table 10**

| TIME INTERVAL | TEMPERATURE OF WATER IN VESSEL (AT 20 SECOND IN - TERVAL) | VESSEL TEMPERATURE (AT 25 SECOND INTERVAL) | TEMPERATURE OF MAIN COPNTAINER (AT 30 SECOND INTERVAL) |
|---|---|---|---|
| T1 | 32 | 35 | 26 |
| T2 | 41 | 70 | 33 |
| T3 | 51 | 115 | 40 |
| T4 | 60 | 153 | 45 |
| T5 | 73 | 240 | 51 |
| T6 | 80 | 252 | 53 |

**Graph 9**




Here in the graph, the vessel temperature when plotted with respect to time interval (T) of 25 second, increased linearly till T4 and then suddenly hiked till the end and the range of vessel temperature obtained is 35-252ºC.The temperature of water in vessel and the temperature of main container increased at a moderate rate with respect to time interval (T) of 20 second and highest temperature of water obtained is 80ºC.

➔ Experiment done without air pump: -

Adverse effect: - flame colour variation
Good sign: - moderate temperature achieved

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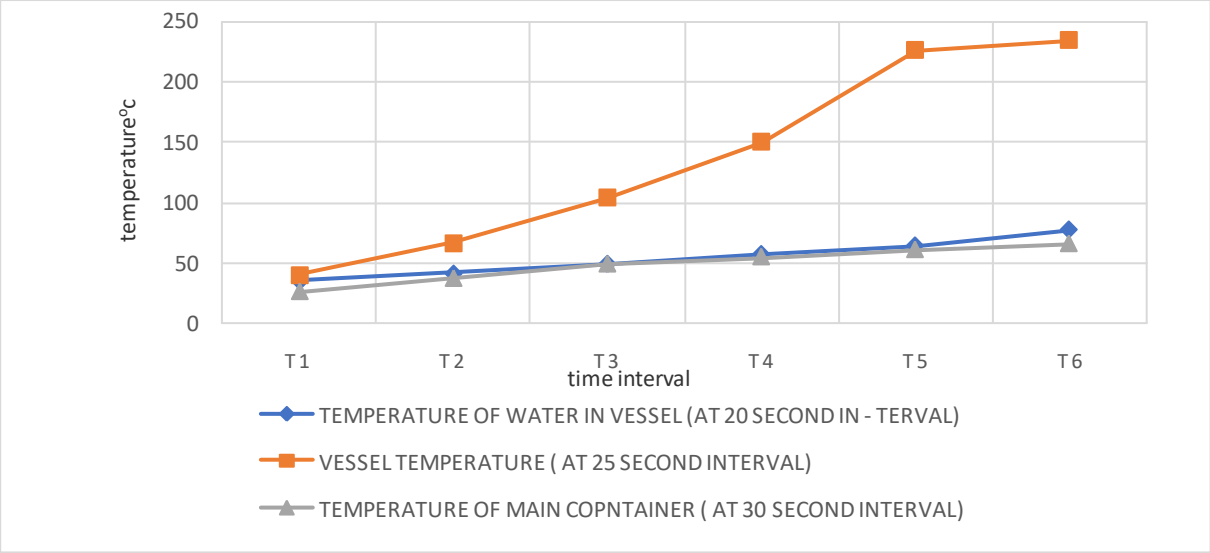
**Table 11**

| TIME INTERVAL | TEMPERATURE OF WATER IN VESSEL (AT 20 SECOND IN - TERVAL) | VESSEL TEMPERATURE (AT 25 SECOND INTERVAL) | TEMPERATURE OF MAIN COPNTAINER (AT 30 SECOND INTERVAL) |
|---|---|---|---|
| T1 | 35 | 40 | 26 |
| T2 | 41 | 67 | 37 |
| T3 | 49 | 104 | 49 |
| T4 | 57 | 150 | 55 |
| T5 | 64 | 226 | 61 |
| T6 | 77 | 235 | 66 |

**Graph 10**




Here in the graph, the vessel temperature when plotted with respect to time interval (T) of 25 second, increased linearly till T4 and then suddenly hiked till the end and the range of vessel temperature obtained is 40-235$^{o}$C.The temperature of water in vessel and the temperature of main container increased at a moderate rate with respect to time interval (T) of 20 second and highest temperature of water obtained is 77$^{o}$C.

## 8. Conclusion

The outcome of the experiments was that we had a full proof data of flame temperature, container temperature, mass of carbide to be taken, mass of water to be taken, specimen (mild steel, aluminium, copper, stainless steel) temperature due to heating, residue amount, etc. The experiments resulted suggested that use of air pump will be an advantage as it will reduce the residue black ashes which is a hindrance to heat transfer and also air pump increases the pressure of acetylene gases which helps in good combustion processes. The automatic

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electric ignition system gave us an edge over conventional match sticks. The apparatus we used was cheap but were easily accessible and was of high standards. The readings obtained from experiments till now is way above satisfactory and gave us assurance for the large-scale manufacturing of the proposed model.

The acetylene flame temperature obtained highest was 1147° Celsius. The optimal weight of calcium carbide and water to be taken was obtained 15 grams and 100 grams respectively. The temperature of water in stainless steel vessel was finally obtained in the range of 70 ° to 108 °Celsius. Temperature of main container was obtained in the range of 4- 62 $^{0}$C, with 4$^{o}$C obtained at the time of calcium carbide and ice reaction and 62$^{o}$C obtained at the time of calcium carbide and saline water reaction. The copper pipe temperature obtained was maximum 254$^{o}$C when it was heated with acetylene flame obtained from reaction of calcium carbide and water. The space grade aluminium specimen temperature obtained was maximum 82$^{O}$C at top and 698$^{o}$C at bottom. High pressure build-up in the main container resulted into formation of cavity in the hose pipe.

The residue of the calcium carbide and water reaction is known as calcium hydroxide and it is particularly used in sewage treatment, paper production, construction, food processing and it also have medical and dental use.

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## 10. References

[1] Hariharan, M. and Raghavan, D. and Mohamed Rafi, K. (1990) Modelling of a calcium carbide furnace. Bulletin of Electrochemistry, 06 (03). pp. 298-301. ISSN 0256-1654[online] Available at: - http://cecri.csircentral.net/id/eprint/2628

[2] Thweatt, Jr. (2000) Electric water heater. United states patent application publication, Patent no: - US 20050129391A1. [online] Available at: - https://patents.google.com/patent/US20050129391

[3] M.H. EL-Naas, R.J. Munz, F. Ajersch (1997). Solid phase synthesis of calcium carbide in a plasma reactor. Plasma chemistry and plasma processing, vol. 18, No. 3 [online] Available at: - https://www.researchgate.net/publication/226963831_Solid-Phase_Synthesis_of_Calcium_Carbide_in_a_Plasma_Reactor

[4] John W.H. Price (2005). An acetylene cylinder explosion: a most probable cause analysis. Engineering failure analysis 13 pp.705-715. [online] Available at: - https://coek.info/pdf-an-acetylene-cylinder-explosion-a-most-probable-cause-analysis-.html

[5] William L. Vallett, Mohsen sarfehjoo (1998). Gas water heater / boiler. United states patent application publication, Patent no: - 4,793,800[online] Available at: -

https://patents.google.com/patent/US4793800

[6] Michal Bachtler, Rudolf R. Schnur, Peter Passler, Olaf Scheidsteger, Werner Kastenhuber, Gerd Schlindwein, Rainer Konig (1998). Process for production of acetylene and synthesis gas. United states patent application publication, Patent no: - US 005824834A [online] Available at: - https://patents.google.com/patent/US5824834A/en

[7] Shih-wen huang, Jun- sonobe (2009). Low pressure acetylene storage. United states patent application publication, Patent no: - US 20090182180A1 [online] Available at: - https://patents.google.com/patent/US20090182180

[8] Gregor K. Earl (1984). Calcium carbide/ water acetylene gas generator. United states patent application publication, Patent no: - US 4444159A, [online]Available at: - https://patents.google.com/patent/US4444159A/en

[9] Engineering Toolbox, (2003). *Fuels - Higher and Lower Calorific Values*. [online] Available at: https://www.engineeringtoolbox.com/fuels-higher-calorific-values-d_169.html.

[10] Prabin k. Sharma, Harihar kuinkel, Parveen- Shrestha, Suman Poudel (2012). Use of acetylene as an alternative fuel in I.C. engine. Rentech symposium compendium, Volume 1. [online] Available at: -https://www.yumpu.com/en/document/read/35214263/use-of-acetylene-as-an-alternative-fuel-in-ic-engine-kathmandu

[11] P. Kannan, Dinesh Kumar (2017). Experimental study of carbide as an alternate fuel using in internal combustion engine. International journal of emerging technologies in engineering research Volume-5, issue-5. [online] Available at: - https://www.ijeter.everscience.org/Manuscripts/Volume-5/Issue-5/Vol-5-issue-5-M-16.pdf

[12] Flin scientific chem fax. [online] Available at: https://www.google.com/url?sa=t&source=web&rct=j&url=https://www.flinnsci.com/api/library/Download/3afc013b5019456d8e6afe88e3877cfd&ved=2ahUKEwif-4yvzePuAhUqwYsBHRpDCywQFjAFegQIGxAE&usg=AOvVaw0MKyCw4CGL_ntbEtqGQOD6