# Design Modification of a Copper Water Heater for Rapid Heating

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**Abstract -** *Consumption of purified water is the major issue in rural areas as we are heading towards development. Industrialization and technological advancement have caused water supplies, which are a primary source for native areas, to become contaminated. Therefore, the only method of eliminating pollutants from water is through heating. People from remote regions are still not adapting the improvements in the energy industry, for reasons being various. The traditional copper bumba, which burns firewood, is a form of water heating that's commonly used in rural areas. In this essay, we tried to change the design of the same copper bumba so that it would eventually run on an LPG gas stove and use less energy while saving time.*

***Key Words*: Water heater, copper bumba, water purification, firewood burning, remote regions, water contamination.**

## 1.INTRODUCTION

The most essential element for life is water, and any human being must have access to clean, purified water on a daily basis. A reliable source of pure water is essential for society's health and well-being. Although technological progress has been made to supply safe water, a wide range people living in rural areas are unable to afford these advancements. As a result, only the traditional approach of purification is left to make the water suitable for consumption.

Boiling is the process that is most frequently used to treat water. All the disease-causing microorganisms in the water are destroyed by boiling, making it safe to consume and use for other purposes. It is the water treatment approach that works best. Usually, a container called a "Water heater" is used for this. The output from the heater can be used for numerous reasons, including drinking, cooking, and other domestic chores, but it needs a sufficient amount of heat source to heat.

The majority of homes in remote regions are familiar with old copper vessel used only for water heating. This copper vessel uses firewood to heat itself and operates on the conductive and radiative heat transfer theory. It usually takes a long time to heat, which also produces $CO_2$. Therefore, we attempted to alter the design of the same vessel so that the time for heating dwindles. In addition, we have made an effort to move from firewood to LPG gas for heating, which would ultimately cut $CO_2$ emissions.

## 2. LITERATURE REVIEW

With regard to the nation's gross domestic product, forestry contributes 1.7%; undocumented withdrawals are not included. (NTFPs, fuelwood, fodder, etc.). A greater percentage of individuals utilize fuelwood in rural areas (67.3% of the population), compared to urban and semi-urban areas (14%), which accounts for over 93% of India's forestry sector's GHG emissions. For domestic cooking and other purposes, it is estimated that 80% of rural families in India use unprocessed organic matter, such as wood, dung, and crop residue. Around 274 hours per year are put in by women harvesting fuelwood. India's 854 million people consumes 216.4 million tons of fuelwood annually. According to World Bank research, 18.5% of the 1.3 billion people who live in "environmentally fragile lands," which include arid regions, slopes, and forest ecosystems, are believed to be living in extreme poverty. These people typically reside in remote, often hilly, and relatively inaccessible areas, where access to new technology and market advancement is hindered or slowed.

### 2.1 Solar Energy (Solar Water Heater) Current Scenario

India's advantageous location close to the equator makes it an ideal contender for the development of solar energy. Across the nation, it receives solar radiation ranging from 4 to 7 kWh/m2/day, with stronger solar incidence in the west and south. Utilizing these natural assets contributes to a reduction in global warming and emission of greenhouse gases. Additionally, the government of India has introduced a number of initiatives to implement and fully harness these non-renewable resources. In three phases, India had previously envisioned to increase the installed solar power capacity. The installation of 1100 MW of capacity was the goal for the first phase (2010–2013). 10,000 MW and 20,000 MW were anticipated to be reached in the second phase (2013–2017) and the subsequent phase of the process, respectively (2017–2022). However, the current circumstances haven't worked out as expected.

The energy utilization in India by various fuels in 2021 is shown below.

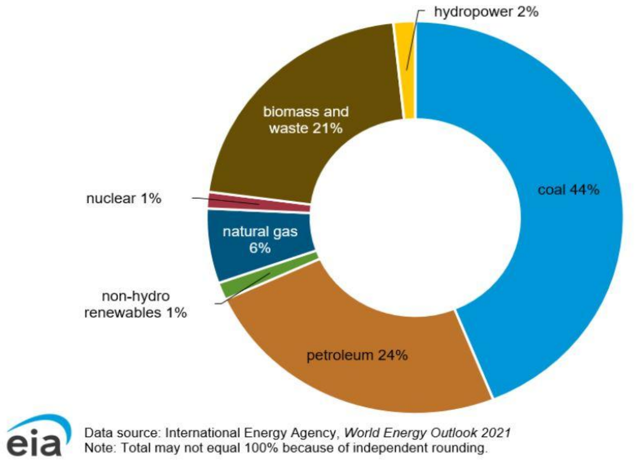


**Fig -1**: Energy consumption chart

The following is a list of the government of India's solar project initiatives:

- ❖ The Government of India provides monetary support for a variety of solar systems, including solar air heating/drying and solar concentrating systems.
- ❖ By 2050, the Government of India hopes to produce 500 GW of clean energy using nuclear energy based on thorium and reduce the intensity of harmful gas emissions by 20–25%.
- ❖ Different Indian states are active in the generation of solar energy, with Gujarat leading the way with 600 MW and Rajasthan following in second with around 500 MW. With their huge solar power plants, Madhya Pradesh and Andhra Pradesh are rapidly catching up with each other.
- ❖ The global renewable energy investor's meet was supported by 293 companies, including NTPC (National Thermal Power Generation), Suzlon Power, and Reliance Power, among others. These companies made commitments to build plants that will produce 26,600 MW of renewable energy in the years to come.
- ❖ SBI (State Bank of India), the largest lender in India, pledged to make investments of Rs 750,000 million in the next five years in order to produce 15,000 MW of sustainable energy.

India has made significant advancements towards the use of solar energy, establishing government organizations like the Ministry of New and Renewable Energy (MNRE), the India Renewable Energy Development Agency (IREDA), and the Solar Energy Centre (SEC), and launching substantial solar projects. These solar projects nonetheless confront a variety of obstacles that eventually prevent their development in rural areas, forcing people to use fossil fuels and natural resources. Based on multiple literature reviews, multiple barriers to the use of solar energy have been pointed out.

1) Institutional limitations.

- Agencies' lack of collaboration.
- Inadequate R&D culture.
- Local infrastructure deficiency.
- Ambiguous government policies.

2) Technical challenges.

- Inadequate standards.
- Lack of community involvement.
- Lack of competent workers and training facilities.
- Technology risk and performance limitations.
- Storage challenges.
- Design and flexibility of use.

3) Regulatory and Political roadblocks.

- Lacking political will.
- Political upheaval.
- Local government agencies failing to operate.

4) Market constraints.

- Inadequate competition.
- A relatively small market.
- Issues with partnerships.

5) Barriers that are Social, Cultural, and Behavioral.

- Lack of understanding.
- Hostility to emerging technologies.
- Low affordability for society's poorest populations.

6) Financial obstacles.

- Inability to obtain credit or capital.
- Insufficient financial institutions.
- Limits to the budget.
- Inadequate Financial literacy.

7) Substantial capital costs.

- Long payback time.
- Difficulties with solar manufacturing.
- Cost of operation and upkeep.

Due to the aforementioned hurdles, people from remote regions switch to conventional forms of energy use. So by studying the many scenario of energy consumption of fuels and also to reduce greenhouse gas emissions, we designed a vessel layout that doesn't require special skills to operate or maintain and is also affordable for lower-class residents of rural locations. .

## 3. DESIGN OF WATER HEATER

As it is well-known, the cylindrical structure of the traditional copper water heater (bumba) has a hollow tube in its center. The filled water becomes enclosed between the cylinder's wall and the hollow tube in its center. On a plate known as the ash plate, the fuel, such as firewood and coconut husk, is delivered from the very bottom of the vessel. Radiative and conductive heat transfer, which transpires while the fuel burns, occurs as the heat flows through the hollow tube, heating the water as an outcome. The process appears to take a long time, and prolonged fuel burning stimulates the release of hazardous gases.

The vessel's comparable structure has been updated to provide efficient heating in less time. We must raise the water's temperature to the boiling point while we are heating it. When the liquid's vapor pressure equals the air pressure acting on the liquid, a change from a liquid phase to a gaseous phase occurs. Boiling happens when atoms or molecules in a liquid are able to sufficiently disperse to transition from a liquid to a gaseous state.

The water at the bottom of the vessel heats up at a faster pace during the boiling process than the water at the top, resulting in a differential in temperature and density. In boiling water, these differences produce convection currents. Now, in the prior design of the vessel, the hollow section in the center of the vessel makes it difficult for convection currents to form during heating. The design of that hollow part has been altered in this paper as a result. The redesigned structure still contains a hollow copper tube in the core, but this time, tiny copper tubes have also been introduced in a crossing pattern. As a result, the crossing design allows for effective heat transfer, providing quick and continuous water heating.

**Fig -2**: Modified core section of vessel

**Fig -3**: Hollow section placed in SS Vessel

**Fig -4**: Bottom view of the vessel

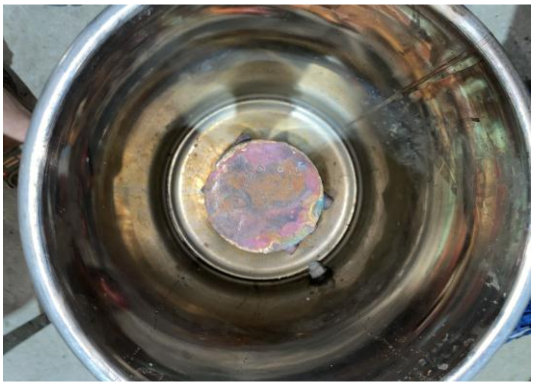

**Fig -5**: Top view of the vessel

### 3.1 Process of Heating with Altered Design

In the center portion of the vessel, which is also made of copper, there are 10mm hollow copper tubes inserted as part of the modified design. The entire geometry is then placed in the center of the stainless-steel vessel in crisscross pattern, as shown. Furthermore, heat transmission is accelerated by copper's superior thermal conductivity, which is 385 W/m K. When the vessel is filled with water, the hollow tubes in the middle also gets filled, leaving no air gap in tubes. Heat is transferred through conduction as well as radiation as the flame from the fuel source—in this instance, LPG flame—begins to warm the center of the vessel from its base. The primary hollow portion of the vessel is heated by conduction. (Made of copper). Along with raising the water's temperature, it additionally elevates the vessel's bottom surface temperature. In light of this, radiation heat transmission also causes the small hollow copper tubes, which are a component of the main vertical hollow section, to become heated. Furthermore, radiation from the blaze raises the temperature of tiny hollow tubes filled with water, heating the water through radiation and conduction.

Thus, proper convection currents are produced in water as a result of effective heat transfer through conduction and radiation which ultimately shortens the time it takes to heat the water and reduces the amount of fuel used.

**Fig -6**: Testing the design with LPG

## 4. OBSERVATIONS AND RESULT

The readings obtained by altering both the fuel supply and the water content in both vessels are outlined below: -

**Observation No. 1: -**

Vessel: **-** Copper Bumba – 38L

Fuel Source: **-** Firewood

Time taken for heating is tabulated below: -

| Sr. No | Time (min) | Temperature (°C) |
|---|---|---|
| T0 | 0 | 25 |
| T1 | 5 | 25 |
| T2 | 10 | 36 |
| T3 | 15 | 48 |
| T4 | 25 | 62 |

**Observation No. 2: -**

Vessel: **-** Copper Bumba – 20L

Fuel Source: **-** LPG (5L Tank)

Time taken for heating is tabulated below: -

| Sr. No | Time (min) | Temperature (°C) |
|---|---|---|
| T0 | 0 | 25 |
| T1 | 5 | 28 |
| T2 | 10 | 42 |
| T3 | 15 | 54 |
| T4 | 25 | 70 |

**Observation No. 3: -**

Vessel: **-** Modified Water Heater – 20L

Fuel Source: **-** LPG (5L Tank)

Time taken for heating is tabulated below: -

| Sr. No | Time (min) | Temperature (°C) |
|---|---|---|
| T0 | 0 | 25 |
| T1 | 5 | 35 |
| T2 | 10 | 53 |
| T3 | 15 | 77 |
| T4 | 25 | 84 |

In order to compare, let's start with Observation No. 1, which depicts the heating of water using a natural source, such as firewood and other organic materials. It is clear that more time was required for the water to attain its highest temperature of 62°C. Burning natural fuel for an extended period of time results in the release of harmful gases and time loss.

Then, in the following stage, we attempted to compare the heating of the water with our modified vessel design. The water content and fuel source for both vessels, however, were maintained the same this time. And we discover that the modified vessel design produces significantly superior results than the conventional one due to an increase in the heating surface area. Below is a chart that compares the outcomes.

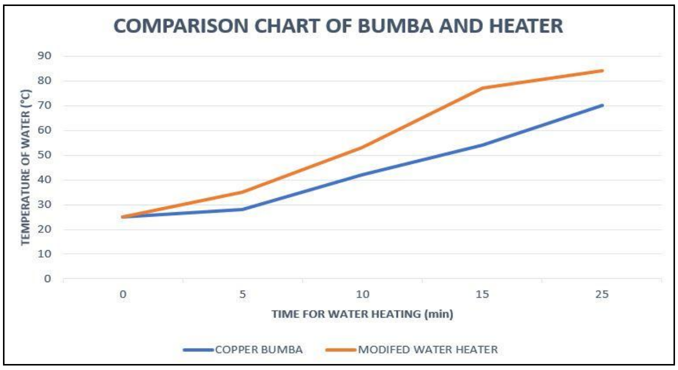


**Fig -7**: Final Result comparative chart

## 5. CONCLUSION

Water heating is a necessity for the people in India, as was also addressed in the paper's introduction. Water heating becomes a crucial aspect of living, especially for those who live in remote areas where it is challenging to access clean water. However, the heating should not be carried out at the expense of fuel waste or environmental deterioration. Various types of solar water heating devices have also been introduced, but they are also expensive and unaffordable for the various reasons stated above. One of the alternatives in such a scenario is the adapted copper vessel design. When compared to the conventional design, the modified design consumes less fuel and takes less time for heating up.

The increased surface area in the modified construction is what causes the water to heat up quickly. Because of the entire hollow section in the center of the vessel in the traditional design, heat transfer is slow. The modified version, on the other hand, uses hollow copper tubes filled with water to speed up the heating process through conduction and radiation. Compared to the conventional design, which eventually pollutes the environment by burning firewood, the modified design runs on LPG and consumes less fuel.

## REFERENCES

[1] "A review on traditional water purification methods used in Rural Area", January 2016 Indian Journal of Environmental Protection, Sadhana Chaurasia & Ashok Tiwari. M. Young, The Technical Writer's Handbook. Mill Valley, CA: University Science, 1989.

[2] "Efficient fuelwood consumption with innovative solar water-heating system for forest conservation and mitigation of household carbon emission", CURRENT SCIENCE, VOL. 120, NO. 5, 10 MARCH 2021, Lal Singh*, Maninder Jeet Kaur and D. K. Thakur Himalayan Research Group Core Group, Department of Science and Technology (Government of India).

[3] "A Descriptive Comprehension Study on Solar Energy, Solar Products, and Solar Products Marketing in Indian Context", International Series in Operations Research & Management Science book series (ISOR,volume 333), Ansari Sarwar Alam & Arshiya Fathima M.S, 17 January 2023.

[4] "Why Have Improved Cook-Stove Initiatives in India Failed?", World Development Volume 92, April 2017, Pages 13-27.

[5] "Analysis of barriers to implement solar power installations in India using interpretive structural modeling technique", Renewable and Sustainable Energy Reviews Volume 27, November 2013, Pages 163-174.

[6] "Recognition and prioritization of challenges in growth of solar energy using analytical hierarchy process: Indian outlook", Energy Volume 100, 1 April 2016, Pages 332-348.

[7] http://www.indiaenvironmentportal.org.in/

[8] https://en.wikipedia.org/wiki/Water_heating

[9] https://byjus.com/chemistry/thermal-conductivity-of-copper/

[10] https://www.eia.gov/international/analysis/country/IND

[11] https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Physical_Properties_of_Matter/States_of_Matter/Phase_Transitions/Boiling