International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 04 , April - 2026

Development of IoT Based Thermal Conductivity Measurement Setup

Mr. Sahil Mayekar
Student, Department of Mechanical Engineering
Rajiv Gandhi Institute of Technology Andheri, Maharashtra.

Ms. Shravani Parab
Student, Department of Mechanical Engineering
Rajiv Gandhi Institute of Technology
Andheri, Maharashtra

Mr. Abhishek Bishwas
Student, Department of Mechanical Engineering
Rajiv Gandhi Institute of Technology
Andheri, Maharashtra

Prof. Nitin Panaskar
Professor, Department of Mechanical Engineering
Rajiv Gandhi Institute of Technology
Andheri, Maharashtra

Ms. Shrushti Chavan
Student, Department of Mechanical Engineering
Rajiv Gandhi Institute of Technology
Andheri, Maharashtra

***Abstract* - This paper presents the development of a system which is automated for measuring the thermal conductivity of various materials which work on Load cell and Arduino. The system work on the phenomenon of steady-state heat conduction, where heat is passed through a test specimen which will melt ice. This mass of melted ice in the system is continuously measured using a load cell, which let us get real-time calculation of heat transfer. By integrating multiple sensors and a microcontroller, the setup will improve accuracy as compared to traditional manual methods. The design system is cost-effective, more reliable, and suitable for educational and laboratory applications.**

Keywords - Conductivity, Heat Transfer, Load Cell, Automation, Fourier's Law, ESP32

I. INTRODUCTION

1]Heat Transfer- Heat transfer is a phenomenon science and engineering that deals with the how heat is transfer from one place to another place. We do experience this in our daily life where heat transfer occurs many simple situations, such as boiling water, cooking food, or even feeling the warmth of sunlight. Heat transfer law states that heat transfer always takes place from high temperature body to low temperature body. Understanding how heat flows is very important in designing systems like engines, refrigerators, electronic devices, and buildings.

2]Thermal Conductivity- Thermal conductivity is the fundamental property that determines how efficiently heat flows through materials. Every material has different thermal conductivity. Material having higher thermal conductivity shows the high rates of heat transfer or dissipates from hot area to cold area. One might think higher thermal conductivity is always useful on industry. High conductivity can lead to fast energy loss which can cause issue while transporting, handling the material. So therefore, selecting proper thermal conductivity material is needed. Hence learning thermal conductivity is important for industry work.

- ***Importance of thermal conductivity-***

1. Thermal conductivity is the ability of a material to transfer heat from one place to another.
2. It helps us understand why some materials feel hot or cold quickly (like metals), while others do not (like wood or plastic).
3. It is important in cooking because materials with high thermal conductivity (like metal pans) help food cook evenly.
4. It keeps us safe, as insulating materials (like oven mitts) prevent heat from reaching our hands and causing burns.
5. It plays a key role in construction by helping maintain comfortable indoor temperatures in buildings.
6. It helps save energy by reducing the need for excessive heating or cooling.
7. It is important in electronics, as it helps devices release heat and avoid overheating.
8. It is widely used in engineering to design efficient machines and systems.

II. RESEARCH GAP

1]Gap 1: Conventional calculation:
Previously design setup or setup which where use related to our project were using conventional method of calculation, where melted water was collected in container and then mass was calculated on weighing machine. This led to many small technical and human errors. Calculation error also was observed

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 04 , April - 2026

in old technique. Therefore, we added load cell which will do calculation when it is connected with Esp 30. This upgradation gives as more accuracy and save time as well as a greater number of results. In the Esp we added code which we integrated all value in the thermal conductivity formula and it will provide result in just a second. The code is integrated with help of ESP app by method of Trail and change in which code is put in the app and set to run and error which are observer are solved by us.

2]Gap 2: Integration of IOT:

We added IOT in our project which was missing in various research. This let us get result on mobile or desktop. With the help of get result at remote distance which let solve the problem where person has to stand in front or setup too know the result. This unable the user to get numerous of result without stopping the experiment. In this we connect ESP to the user with help of hotspot by keeping password of both device exact same.
There were many small gap which where overserve like steam generator, setup material, position of plate and many more.

III. . MATERIALS AND METHODOLOGY

1]Specimens:

- **Specimen 1: Copper:**

The reason we use copper as specimen in our research as copper play an important role in heat transfer industry. It is used in various machine-like heat exchanger, microgroove technology, heat sinks, solar water heaters and many more. The reasons behind of using copper at many places is that it has properties like high thermal conductivity, corrosion, sustainability.
In the research we try to find the thermal conductivity of copper. The constant value of thermal conductivity of pure copper is 401W/m.k at 25℃. As we are not using pure copper thermal conductivity value will be less s compare to constant value. While doing research we also have to consider other losses like gap between insulated box, uneven supply of steam generation, forming of water vapour in the tubes. By considering all these losses we should get calculated value near to 350 to 360 W/m.k.

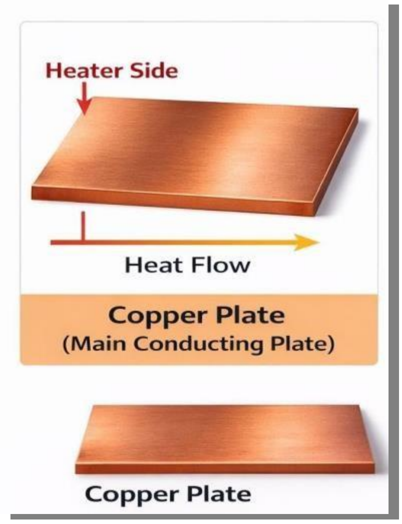

Fig 1: Copper plate

- **Specimen 2: Aluminium:**

Aluminium is high thermal conductive and have low density and high reflective. It is the premium material for heat dissipation. It is use in heat shield as it reflects 80% of heat. It is also use in automotive and aerospace components. Aluminium heat related properties are heat treatability, high temperature performance, recyclability.
In the research we try to find the thermal conductivity of copper. The constant value of thermal conductivity of pure copper is 237W/m.k at 25℃. As we are not using pure copper thermal conductivity value will be less s compare to constant value. While doing research we also have to consider other losses like gap between insulated box, uneven supply of steam generation, forming of water vapour in the tubes. By considering all these losses we should get calculated value near to 190 to 200W/m.k.
Each specimen gives broad idea of thermal conductivity and how to calculate it. We can use numerous of various metal to calculate their thermal conductivity.

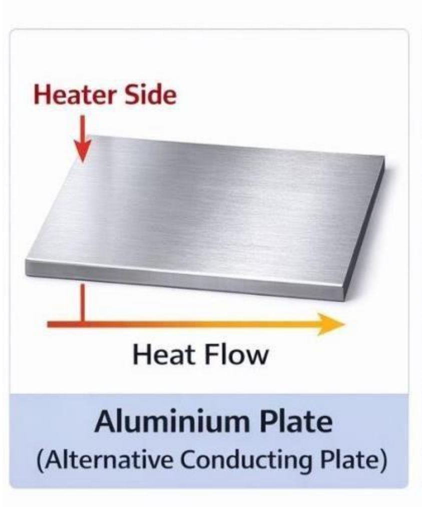

Fig 2: Aluminium plate

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 04 , April - 2026

2] Methodology and working

Fig 3: Setup

Here the step-by-step methodology describing how this setup is made.
First, we selected method of how temperature is need to supply and measurement is to be calculated. There were two method steady state and transient state. It all depend on material to ensure the accuracy.
Secondly, we did design of setup where we decide the heater for heat supply, cooling arrangement for temperature gradient, proper isolation for the setup.
Third step we this instrumentation of the setup where we decided placement of all component of the setup like sensor position and thermocouple position to measure the readings. Fourth step is data acquisition where all measuring unit are connected to get temperature reading and monitor the records of the setup.
Fifth step is calibration where standard value is use for reference to ensure the accuracy of setup.
Last step is doing testing and validation under the different condition to verify reliability and repeatability.

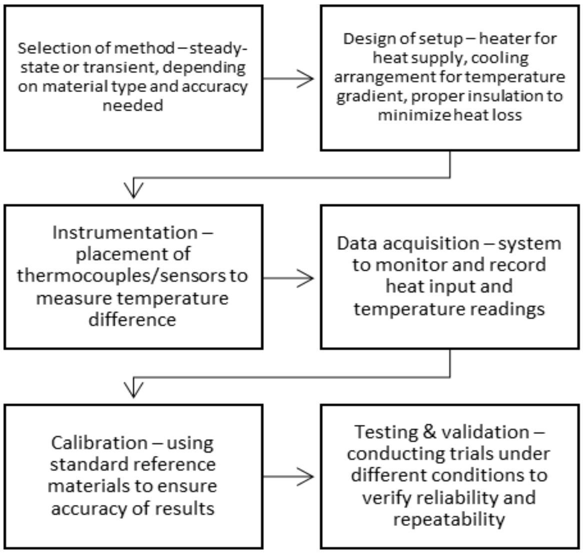

Fig 4: Methodology

The setup is started and steam generator will start making steam from water. It will take certain time to form the steam. As steam is generated and pass to the specimen and specimen will start heating. It will take some time to reach a constant temperature. When specimen reach to required temperature the ice box is kept and data actuation system is started. The Arduino will start the time of the system. The ice start melting and water is collected in the load cell. Load cell will keep taking live weight of water. As the time complete of the experiment the Arduino will take couple of seconds to integrate in the formula and find the thermal conductivity of the metal.

Fig 4: Working of setup

IV. RESULT AND DISCUSSION

After performing the experiment, data was collected from the load cell and temperature sensors in real time. The load cell recorded the change in weight of the melted ice, while the thermocouples provided the temperature difference across the metal plate. These readings were continuously monitored and stored through the automated system.

As the heater supplied heat, the temperature on the hot side of the plate gradually increased, while the cold side â€" in contact

with the ice — remained near 0°C. This temperature difference caused heat to flow through the metal plate, resulting in the melting of ice. The rate of melting was directly proportional to the heat conducted through the plate, allowing us to calculate the rate of heat transfer (Q) and ultimately the thermal conductivity (k) of the material.
A graph of melted ice mass vs. time typically showed a steady linear increase, indicating a consistent rate of heat flow once steady-state conditions were reached. Similarly, the temperature difference ($T_1 - T_2$) remained almost constant during this period, confirming that the experiment achieved stable heat conduction through the plate.

Published by :
https://www.ijert.org/
An International Peer-Reviewed Journal

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 04 , April - 2026

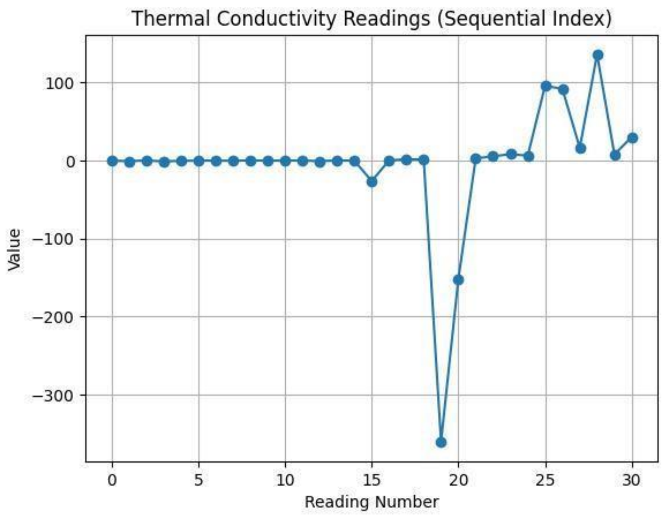

Fig 5: Chart of Reading and 'K' value

Using the relation:

$$K = \frac{(m*Lf*L)}{(A*\Delta T*t)}$$

The calculated thermal conductivity values of the specimen were found to be close to the standard reference values for the tested metal (e.g., aluminium or copper). Minor deviations were observed, which could be attributed to heat losses to the surroundings, uneven contact surfaces, or minor calibration errors in the sensors.

Overall, the results confirmed that the automated setup was effective and reliable. The system successfully measured the melting rate and temperature difference, enabling accurate computation of thermal conductivity without manual intervention. The experiment demonstrated that automation improves precision, saves time, and enhances repeatability compared to traditional manual methods.

21	28/09/2025 10:08:07	3 min	-0.2298
22	28/09/2025 10:20:21	3 min	-0.8559
23	28/09/2025 10:29:02	3 min	0.0039
24	28/09/2025 10:33:42	3 min	-1.1879
25	28/09/2025 10:40:09	5 min	-0.4174
26	28/09/2025 10:44:25	3 min	-0.3524
27	28/09/2025 14:15:00	3 min	-0.1889
28	02/10/2025 15:55:35	3 min	-0.3879
29	02/10/2025 16:21:55	7 min	0.1109
30	03/03/2026 17:42:55	3 min	-0.2134
31	03/03/2026 17:48:25	3 min	-0.1951
32	03/03/2026 17:53:08	3 min	-0.0624
33	03/03/2026 18:08:34	3 min	-0.84
34	25/03/2026 20:19:56	3 min	-0.0426
35	29/03/2026 12:33:41	3 min	-0.2638
36	29/03/2026 12:41:13	3 min	-26.4728
37	29/03/2026 12:52:46	3 min	0.0205
38	30/03/2026 12:01:35	3 min	1.5863
39	30/03/2026 12:05:48	3 min	1.2346
40	05/04/2026 15:15:44	3 min	-360.6079
41	05/04/2026 15:22:04	3 min	-151.7049
42	05/04/2026 15:28:18	3 min	2.7699
43	05/04/2026 17:23:12	5 min	5.1899
44	05/04/2026 17:45:50	3 min	8.203
45	05/04/2026 17:49:27	3 min	6.0739
46	05/04/2026 18:17:40	3 min	95.8464
47	05/04/2026 18:23:01	3 min	91.7424
48	05/04/2026 18:26:33	3 min	16.2175
49	05/04/2026 18:32:13	3 min	136.0159
50	11/04/2026 21:56:33	3 min	7.7267
51	11/04/2026 22:04:56	5 min	30.137

Fig 6: Average thermal conductivity of aluminium and copper received through our setup with factor of '8'

V. CONCLUSION

In this project, an experimental setup for measuring the thermal conductivity of a material using a load cell has been successfully designed and studied. The main aim of the project was to develop a system that is simple, accurate, and more efficient compared to traditional methods of measurement. By combining basic principles of heat transfer with modern sensing technology, the project provides a practical and improved approach to determining thermal conductivity. The working of the setup is based on the concept of heat conduction, where heat flows from a higher temperature region to a lower temperature region through a test specimen. In this experiment, the heat supplied from a controlled source passes through a metal plate and is used to melt ice placed on the opposite side. The amount of melted ice is measured using a load cell, which continuously records the change in weight. This data is then used to calculate the rate of heat transfer and, ultimately, the thermal conductivity of the material. One of the major achievements of this project is the successful implementation of automation in the experimental process. Unlike traditional methods that require manual observation and recording, this system allows continuous and real-time data collection. This reduces human effort and minimizes the chances of errors, resulting in more reliable and consistent results. The use of a load cell makes the measurement process more precise, as even small changes in weight can be detected accurately.

The project also highlights the importance of proper setup, calibration, and data analysis. Careful arrangement of components and proper insulation are necessary to reduce heat loss and improve accuracy. Calibration of the load cell ensures that the readings obtained are correct and dependable. The mathematical calculations carried out using the collected data help in converting experimental observations into meaningful results.

Through this project, a clear understanding of heat transfer and thermal conductivity has been developed. It demonstrates Through this project, a clear understanding of heat transfer and thermal conductivity has been developed. It demonstrates how theoretical concepts can be applied in a practical experiment to obtain real-world results. The experiment also shows the importance of using appropriate materials and techniques to achieve accurate measurements.

Although the setup provides good results, some limitations such as heat loss to the surroundings and measurement errors may still affect the final outcome. However, these limitations can be reduced by improving insulation and using more advanced sensors.

Overall, the project successfully achieves its objective of developing an automated system for measuring thermal conductivity. It proves that modern technology can significantly improve traditional experimental methods by making them faster, more accurate, and easier to perform. In conclusion, this project not only enhances the understanding of thermal properties of materials but also demonstrates the benefits of automation in experimental setups. It has strong potential for further improvement and can be used as a foundation for advanced research and industrial applications in the field of heat transfer.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 15 Issue 04 , April - 2026

VI. REFRENCE

[1] American Society of Mechanical Engineers, Boiler and Pressure Vessel Code (BPVC). [Online]. Available: https://www.asme.org/codes-standards/bpvc

[2] American Society of Mechanical Engineers, ASME PTC 19.1 – Test Uncertainty. [Online]. Available: https://www.asme.org/codes-standards/find-codesstandards/ptc-19-1-test-uncertainty

[3] American Society of Mechanical Engineers, ASME PTC 4 – Fired Steam Generators. [Online]. Available: https://www.asme.org/codes-standards/find-codesstandards/ptc-4-fired-steam-generators

[4] American Society of Mechanical Engineers, ASME PTC 12.5 – Steam Surface Condensers. [Online]. Available: https://www.asme.org/codes-standards/find-codesstandards/ptc-12-5-steam-surface-condensers

[5] A fully automated measurement system for the characterization of temperature-dependent properties," ScienceDirect. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1359431123001400

[6] Thermal Conductivity Measurement System for Functional and Structural Products," MDPI, Processes, vol. 12, no. 10, 2023. [Online]. Available: https://www.mdpi.com/2227-9717/12/10/2219

[7] Automated thermal conductivity measurement algorithm for the transient hot-wire method," ResearchGate. [Online]. Available: https://www.researchgate.net/publication/333580285_Automated_thermal_conductivity_measurement_algorithm_for_the_transient_hot_wire_method

[8] "Understanding Load Cell Temperature Compensation," Interface Force. [Online]. Available: https://www.interfaceforce.com/understandingload-cell-temperature-compensation