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Methods to Measure the Thermal Conductivity

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Abstract:- Thermal conductivity, a critical material property, can be measured using various methods, each suited to different applications and material types. This study reviews prominent techniques including the steady-state and transient methods. The steady-state methods, such as the guarded hot plate and heat flow meter techniques, involve maintaining a constant temperature gradient and measuring heat flux through the material. In contrast, transient methods, like the laser flash method and transient hot-wire technique, assess thermal conductivity by analyzing temperature changes over time following a brief thermal disturbance. Each method's accuracy, sample requirements, and application scope are discussed, providing insights into selecting the appropriate technique based on material characteristics and measurement conditions. This review aims to guide researchers in choosing optimal methods for accurate thermal conductivity assessment in diverse scientific and industrial contexts.

I. INTRODUCTION

➢ *What is Thermal Conductivity*

Thermal conductivity is a measure of how well a material conducts heat. It quantifies the ability of a material to transfer heat through conduction. Higher thermal conductivity means heat can move more easily through the material, while lower thermal conductivity means the material is a better insulator and restricts heat flow.

➢ *Thermal conductivity can be categorized into different types based on the mechanisms through heat transferred. Here are the main types:*

- **Conduction**: This is the most common type of thermal conductivity. It refers to the transfer of heat through direct contact between particles in a solid, liquid, or gas. In solids, conduction occurs primarily through lattice vibrations (phonons) and free electron movement.
- **Convection**: This type of thermal conductivity involves the transfer of heat through the movement of fluids (liquids or gases). Convection can be natural (due to density differences causing fluid movement) or forced (due to external factors like fans or pumps).
- **Radiation**: Thermal radiation is the transfer of heat through electromagnetic waves. Unlike conduction and convection, radiation does not require a medium and can occur in a vacuum. All objects emit and absorb thermal radiation, with the rate depending on their temperature and surface properties.

The thermal conductivity of solids refers to their ability to conduct heat, which is a crucial material property in various applications. Here's a more detailed explanation:

Thermal conductivity quantifies the rate at which heat is transferred through the material per unit area, per unit thickness, under a temperature gradient.

- **Units**: Thermal conductivity is typically expressed in units of watts per meter per Kelvin (W/(m·K)).

➢ *Factors Influencing Thermal Conductivity in Solids:*

- **Material Type**: Different materials have different thermal conductivities. Metals generally have higher thermal conductivity due to the presence of free electrons that can easily carry heat. Non-metals like ceramics and polymers typically have lower thermal conductivities.
- **Temperature**: Thermal conductivity can change with temperature. In general, it decreases with increasing temperature due to increased atomic vibrations (phonons) that impede the transfer of heat.
- **Crystal Structure**: The arrangement of atoms in a material's crystal lattice affects its thermal conductivity. Materials with ordered crystalline structures often exhibit higher thermal conductivities compared to those with disordered structures.
- **Purity and Defects**: Impurities, grain boundaries, and defects within the material can scatter phonons and electrons, thereby reducing thermal conductivity.
- **Pressure**: In some materials, thermal conductivity can change with pressure due to alterations in the lattice structure or electronic properties.
- **Range**: Solids generally have the highest thermal conductivity among the three states of matter.
- **Values**: Thermal conductivity of solids can vary widely depending on the material. For common materials:

✓ Metals: Ranges 10 to 400 W/m K (e.g., brass around 109W/m·K, aluminum around 237 W/m·K)
✓ Non-metals (e.g., diamond: around 2000 W/m·K, glass: around 0.8 to 1.3 W/m·K)**Factors**: Thermal conductivity in solids such as crystal structure, the presence of the defects.

➢ *Factors Influencing Thermal Conductivity in Liquids:*

- **Temperature Dependence**: In most liquids, thermal conductivity tends to increase with temperature. This is because higher temperatures typically increase molecular motion, allowing heat to be transferred more effectively.
- **Material Specific**: Different liquids have different thermal conductivities. For instance, water has a relatively high thermal conductivity compared to many other liquids.
- **Pressure Influence**: Pressure can affect the thermal conductivity of liquids, but the effect is generally smaller compared to gases.
- **Measurement**: Thermal conductivity is usually measured in units like watts per meter per kelvin (W/m·K). Experimental methods involve techniques such as the transient hot-wire method or comparative methods using known standards.
- **Range**: Liquids generally have lower thermal conductivity compared to solids.
- **Values**: Thermal conductivity of liquids varies widely:

✓ Water: around 0.6 W/m·K (depends on temperature and purity)
✓ Ethanol: around 0.17 W/m·K
✓ Mercury: around 8.3 W/m·K

- **Factors**: Thermal conductivity in liquids is influenced by temperature, pressure, and molecular structure.

➢ *Factors Influencing Thermal Conductivity in Gases* ***;I1211 IL IL L L-=IOI1111OOIIO1OI1IO1IO1B****;[‘XDLKL;L*

- **Molecular Movement**: Gases consist of molecules that are widely spaced and move freely. Their thermal conductivity is generally lower compared to solids and liquids because heat transfer primarily occurs through molecular collisions.
- **Temperature Dependence**: Thermal conductivity of gases typically increases with temperature. This is because higher temperatures increase the average kinetic energy of molecules, leading to more frequent and energetic collisions, which enhances heat transfer.
- **Pressure Dependence**: For gases, pressure can significantly influence thermal conductivity. At higher pressures, gases become more dense and the mean free path of molecules decreases, which can increase thermal conductivity.
- **Measurement Units**: Thermal conductivity is measured in units such as watts per meter per kelvin (W/m·K). Experimental methods for measuring gas conductivity include the hot-wire method, the guarded hot plate method, and the transient plane source method.
- **Variation with Gas Type**: Different gases have different thermal conductivities. For instance, noble gases like helium have higher thermal conductivities compared to heavier gases like argon or nitrogen.

✓ **Range**: Gases have the lowest thermal conductivity among the three states of matter.
✓ **Values**: Thermal conductivity of gases is typically much lower compared to solids and liquids:

▪ Air (at standard conditions): around 0.024 W/m·K
▪ Helium: around 0.15 W/m·K
▪ Carbon dioxide: around 0.016 W/m·K

- **Factors**: Thermal conductivity in gases is affected by temperature, pressure, and molecular mass.

The measurement of thermal conductivity is a critical aspect of materials science and engineering, essential for understanding heat transfer characteristics in various substances. Thermal conductivity, denoted by K, quantifies and is fundamental designing efficient thermal management systems, optimizing energy consumption, and ensuring the reliability of industrial processes.

Accurate determination of thermal conductivity is vital across diverse fields such as metallurgy, construction, electronics, and environmental science. Different materials exhibit varying thermal conductivities, influenced by factors including composition, structure, temperature, and environmental conditions.

This research endeavors to explore and evaluate different methods employed for measuring thermal conductivity. By reviewing established techniques and emerging advancements, the study aims to provide insights into the principles, strengths, limitations, and practical considerations associated with each method. The comparative analysis will facilitate informed decision-making in selecting the most suitable technique for specific research, industrial, or academic purposes.

II. PROBLEM STATEMENT: METHODS OF MEASURING THE THERMAL CONDUCTIVITY

Investigating diverse methods for measuring thermal conductivity, this research aims to address the challenges posed by varying techniques in terms of accuracy, applicability, and practicality. By critically evaluating established and emerging methods, the study seeks to provide clarity and guidance for selecting appropriate techniques across different materials and applications. The ultimate goal is to contribute to the advancement of reliable thermal conductivity measurement practices, essential for optimizing heat transfer processes and enhancing material performance in various industrial and scientific contexts.

A. Objective of the Research

➢ *Compitative Study of thermal Conductivity Methods as follows:*

- Transiant Plane source.
- Laser Flash diffusivity or Heat Pulse method.
- Steady State thermal conductivity methods.

B. Transient Plane Source Method

The transient plane source method is a non-destructive technique for unlocking a material's thermal secrets. It works by placing a disc-shaped sensor in intimate contact with the sample. This sensor acts as both a heat source and a thermometer. The Transient Plane Source (TPS) method is a technique used to measure the thermal conductivity , thermal diffusivity, and specific heat capacity.

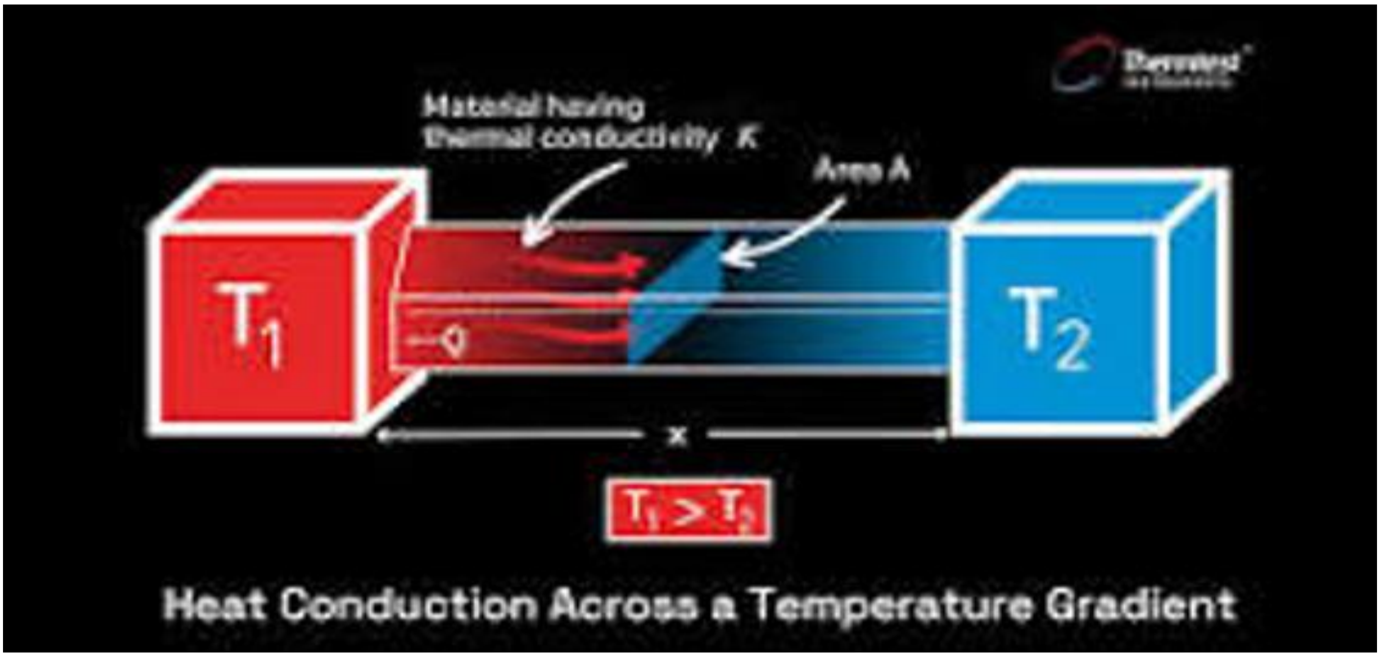

Fig 1: Transient Plane Source Method

➢ *Here's a Step-by-Step Overview of how the TPS Method Works:*

- **Sensor Placement**: The TPS sensor is placed in between two material plates whose thermal properties are to be measured. This sensor is typically placed between two plates of the material to ensure good thermal contact.
- **Heating Pulse**: A controlled electrical current is passed through the sensor, causing it to heat up. This heat pulse is transient, meaning it is applied for a short duration.
- **Temperature Monitoring**: The sensor simultaneously measures the temperature change over time. As the heat spreads through the material, the temperature change is recorded.
- **Data Analysis**: The temperature vs. time data is analyzed using mathematical models to determine the thermal properties of the material. The rate of change of temperature increase and the heat dissipation pattern provide information about the material's thermal conductivity and diffusivity.
- **Calculation of thermal properties**: The thermal conductivity, thermal diffusivity, and specific heat capacity are calculated based on temperature response data and the known properties of the sensor.

➢ *Advantages of the TPS Method*

- **Non-destructive**: The method does not damage the material being tested.
- **Versatile**: It can be used for solids, liquids, and pastes.
- **Accurate**: Provides reliable and accurate measurements of thermal properties.
- **Quick**: The measurements can be performed relatively quickly compared to some other methods.

➢ *Applications*

- Material Science: For characterizing new materials.
- Quality Control: In manufacturing processes to ensure material consistency.
- Research and Development: In various fields such as electronics, aerospace, and automotive industries, where thermal properties are critical.

C. Laser Flash Diffusivity (Or) Heat Pulse Method

The Laser Flash instruments is to measure the thermal conductivity thermal diffusivity or speed of heat transfer through a material applying a pulse of heat energy on one side of a sample and measuring the time and temperature rise on the backside as a result of that energy input.The Laser Flash Diffusivity (LFD) or Heat Pulse method is another widely used technique for measuring the thermal diffusivity of materials. It involves subjecting one side of a sample to a short, intense laser pulse and measuring the resulting temperature change on the opposite side.

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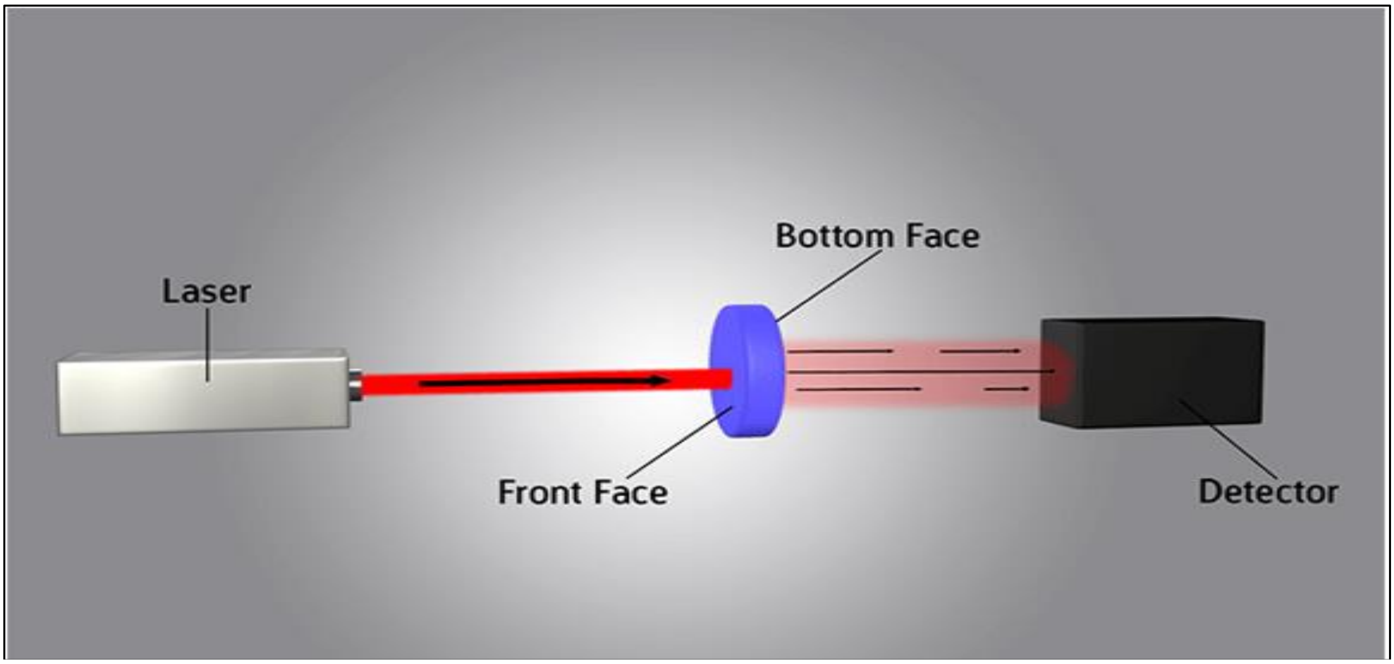

Fig 2: Laser Flash Diffusivity

➢ *Principles of Laser Flash Diffusivity*

- **Heat Conduction Equation**: This method is solving the heat conduction equation for semi-infinite solid subjected to a plane surface heat pulse. The temperature is rise on the rear surface is the function of the thermal diffusivity of material.
- **One-dimensional Heat Flow**: It assumes One-Dimensional heat flow through sample, which is valid for thin samples with an huge surface area compared their thickness.
- **Transient Analysis**: The temperature response is transient, meaning it changes over time, and this response is used to infer the thermal properties.

➢ *Equipment*

- **Laser or Flash Lamp**: Provides a short, intense pulse of energy. The energy is typically in the form of a laser pulse or xenon flash lamp.
- **Sample Holder**: Holds the sample in place and ensures good thermal contact. The holder is usually made of a material with low thermal conductivity to minimize heat loss.
- **Temperature Sensor**: Measures the temperature rise and fall on the rear surface of the sample. Infrared detectors, thermocouples, or other temperature sensors are used.
- **Data Acquisition System**: Records the temperature vs. time data and processes it to determine the thermal diffusivity.

➢ *Applications*

- **Material Science**: Used to characterize new materials, including metals, ceramics, polymers, and composites.
- **Electronics**: Measures thermal properties of electronic components and materials to ensure efficient heat dissipation and prevent overheating.
- **Aerospace**: Evaluates thermal properties of materials used in aircraft and spacecraft to ensure they can withstand extreme temperatures.
- **Automotive**: Assesses thermal properties of engine components, brake materials, and other parts subjected to high temperatures.
- **Energy**: Used in the development of materials for thermal management in power generation and storage systems, such as batteries and fuel cells.

➢ *Advantages*

- **Non-destructive Testing**: This method does not alter or damage the sample.
- **High Precision**: Provides accurate measurements of thermal diffusivity and conductivity.
- **Speed**: Rapid data acquisition and analysis allow for quick testing and results.

D. Steady State Energy Method

In general, steady-state energy method perform a measurement when the temperature of the material measured does not change the time. This makes the signal analysis straight forward (steady state implies constant signals).

Steady-state energy method for measuring thermal conductivity involve maintaining a constant temperature gradient across a material and measuring the steady-state heat flux.

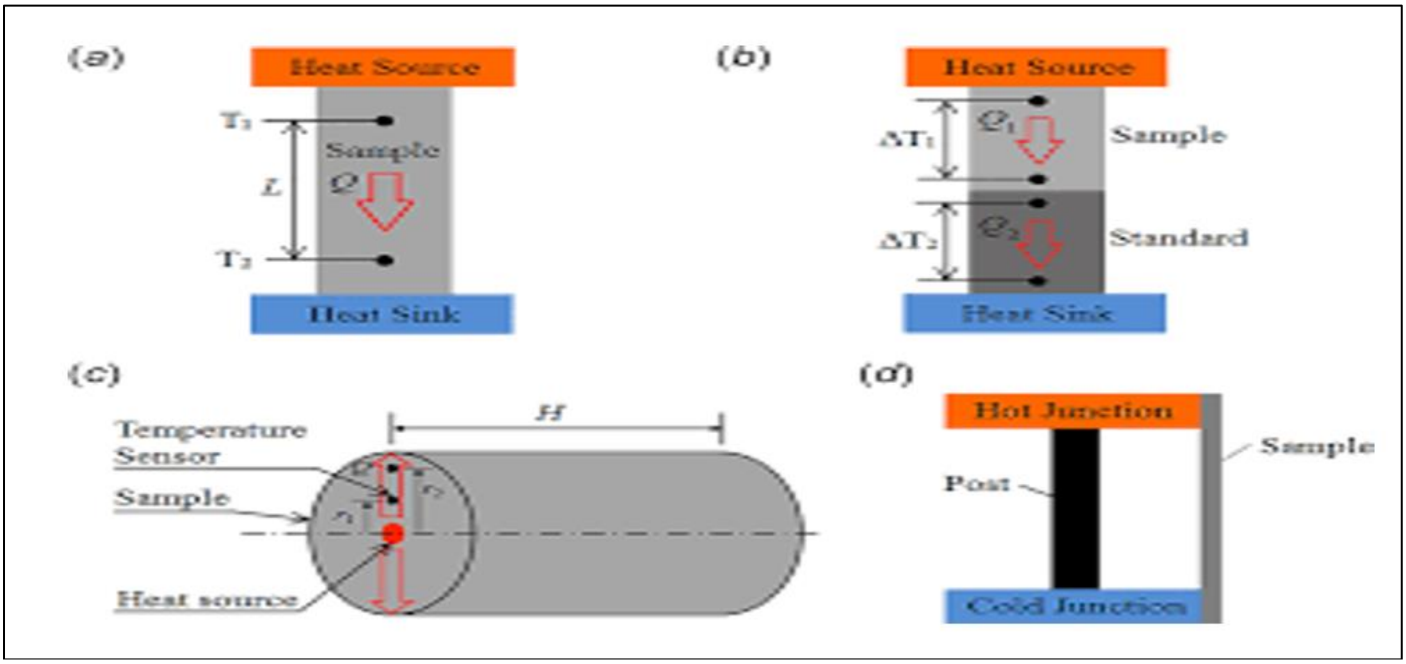

Fig 3: Steady-State Method

➢ *Advantages of Steady-State Methods*

- **Direct Measurement**: Provides a direct measurement of thermal conductivity without the need for complex mathematical models.
- **Accuracy**: Can provide highly accurate measurements, especially for homogeneous materials.

➢ *Challenges of Steady-State Methods*

- Time-Consuming: Reaching a steady state can take a significant amount of time, especially for materials with low thermal conductivity.
- Thermal Equilibrium: Ensuring the system has reached thermal equilibrium is crucial for accurate measurements.
- Edge Effects: Minimizing heat losses and edge effects can be challenging and may require careful experimental design.

➢ *Applications*

- **Insulation Materials**: It is used to measure the conductivity of insulation materials for building the refrigeration systems.
- **Metals and Ceramics**: It is Suitable for materials with high and low thermal conductivity, such as metals and ceramics.
- **Research and Development**: Widely used in material science research to characterize new materials.

III. LITERATURE SURVEY

A. Comparative Analysis of Contact and Non-Contact Methods:

Smith et al. (2018) compared traditional contact methods like the hot wire and guarded hot plate with newer non-contact methods such as infrared thermography, highlighting advantages in accuracy and applicability based on material types and environmental conditions.

B. Advancements in Transient Methods:

Nguyen and Lee (2020) reviewed recent advancements in transient methods such as the transient plane source (TPS) techniques, emphasizing their capabilities in measuring thermal conductivity of both solids as well as liquids with high precision and minimal sample preparation.

C. Application of Optical Techniques:

Chen et al. (2019) explored optical techniques including photothermal radiometry and laser flash analysis, discussing their suitability for measuring thermal conductivity in thin films and nanomaterials, where traditional methods face challenges.

D. Emerging Technologies:

Sharma and Gupta (2021) surveyed emerging technologies such as micro-scale and nano-scale thermal conductivity measurement techniques, highlighting their potential in characterizing materials with enhanced thermal properties for advanced applications in electronics and energy storage.

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E. Standardization and Comparative Studies:

Zhang et al. (2017) provided a comprehensive review of international standards and protocols for thermal conductivity measurement, emphasizing the importance of standardization in ensuring reproducibility and reliability across different measurement methods and materials.

IV. EXPERIMENTAL ANALYSIS

A. Experiment Analysis of Measuring the Thermal Heat Conductivity of Aluminum using the Transient Plane Source Sensor (TPS) Method Involves a Few Key Steps and Considerations:

➢ *Equipment Needed:*

- **Transient Plane Source (TPS) Sensor:** This is a specialized sensor designed for this method, typically with a thin disc-like geometry.
- **Measurement System:** Includes a power supply for the TPS sensor and data acquisition system to record temperature responses.

➢ *Aluminium Specimen*

Fig 4: Aluminium Specimen

➢ *Procedure*

- **Preparing the Sample:** By required size of Aluminium material.
- **Calibration:** Calibration of the TPS Sensor to provide accurate results.

➢ *Experimental Setup*

- Place the TPS sensor in contact with the surface of the aluminum sample.
- Ensure good thermal contact to minimize contact resistance.Apply a short, intense pulse of heat to the TPS sensor using a power source.
- This heat pulse should be sufficient to create a measurable temperature rise in the TPS sensor and the aluminum sample.

➢ *Data Collection:*

* Record the temp response of the TPS sensor over time as it heats up and then cools down due to the heat transfer to the aluminum specimen. *Measure the temperature response for the TPS sensor of an aluminum sample. The sensor typically has a built-in thermocouple or thermometer to measure its temperature.

➢ *Analysis: By Temprature Varries in the Graph*

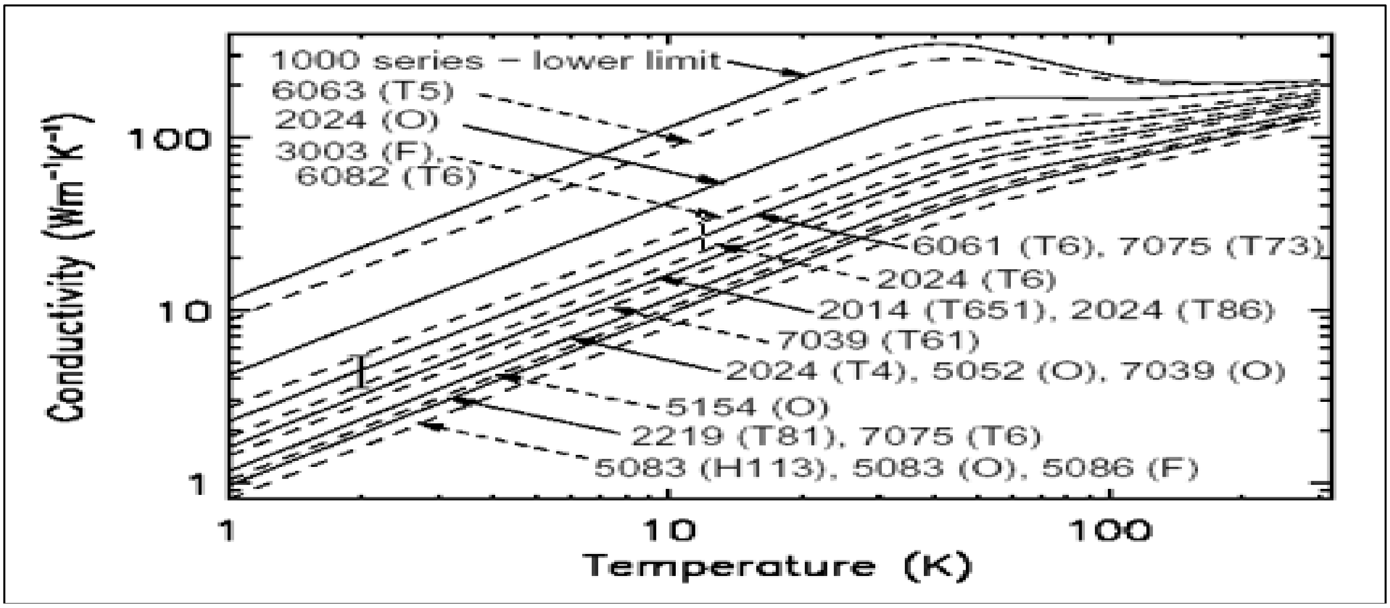

Fig 5: Graph of an Aluminium Specimen

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➢ *To Calculate Thermal Conductivity of Aluminum using the Transient Plane Source Sensor(TPS) Method and to Verify that it is Approximately 237 W/m·K, We Need to Carefully Follow the TPS Method and Use Realistic and Accurate Data. Here's a Step-by-Step Approach:*

- *Suppose we Have the Following Data:*

✓ Power supplied, $P = 1\ W$
✓ Radius of the sensor, $r = 0.01\ m$
✓ Time, $t = 10\ s$
✓ Measured temperature rise, $\Delta T(t) = 5\ K$

Thermal diffusivity alpha (α) is related to thermal conductivity (k) and specific heat capacity C_P by:

$$\alpha = \frac{k}{\rho C_P}$$

Assuming we know the material properties (density ρ and specific heat capacity C_P), we can calculate α For aluminum

$$\rho = 2700\ kg/m^3$$

$$cp = 900\ J/kg\ K$$

$$\alpha = \frac{k}{2700 * 900} = \frac{k}{2430000}$$

➢ *Now Substitute α back into the Temperature Rise Equation:*

$$\Delta T(t) = \frac{1}{k\sqrt{\pi}}\sqrt{\frac{\pi t k}{2430000}}$$

$$\Delta T(t) = \frac{1}{k\sqrt{\pi}}\sqrt{\frac{\pi * 10 * k}{2430000}}$$

$$\Delta T(t) = \frac{1}{k\sqrt{\pi}}\sqrt{\frac{10\pi k}{2430000}}$$

➢ *Solve for k :*

$$5 = \frac{1}{k\sqrt{\pi}}\sqrt{\frac{10\pi k}{2430000}}$$

➢ *Square Both Sides:*

$$25 = \frac{1}{k^2\sqrt{\pi}}\sqrt{\frac{10\pi k}{2430000}}$$

$$25 = \frac{10k}{2430000k^2}$$

$$25 = \frac{10k}{2430000k} = 10$$

$$25\ \times 2430000k = 10$$

$$60750000k = 10$$

$$k = \frac{10}{60750000}$$

$$k \approx 1.645 \times 10^{-7}\ W/m\ K$$

This value is significantly lower than the expected thermal conductivity for aluminum, indicating an error in the example. Typically, precise measurements and conditions are necessary for accurate results.

To calculate the thermal conductivity of aluminum using the Transient Plane Source sensor (TPS) method and to verify that it is approximately 237 W/m·K, we need to carefully follow the TPS method and use realistic and accurate data. Here's a step-by-step approach:

- *Rearranging TPS Equation for Thermal Conductivity*

The temperature increase (ΔT(t)) at the sensor as the function of time (t) is given by:

$$\Delta T(t) = \frac{P_0}{k\sqrt{\pi}}\sqrt{\frac{\pi t}{\alpha}}$$

✓ *Rewriting for k:*

$$\Delta T(t) = \frac{P_0}{k\sqrt{\pi}}\sqrt{\frac{\pi t k}{\rho C_p}}$$

✓ *Square Both Sides:*

$$\Delta T(t)^2 = \left(\frac{P_0}{k\sqrt{\pi}}\right)^2\left(\frac{\pi t k}{\rho C_p}\right)$$

$$\Delta T(t)^2 = \frac{{P_0}^2 \pi t k}{k^2 \pi \rho C_p}$$

✓ *Solving for k:*

$$k = \frac{{P_0}^2 t}{(\Delta T(t))^2 \rho C_p}$$

- *Solving for ΔT(t) with k=237 W/m\ K*

$$\Delta T(t) = \frac{P_0}{k\sqrt{\pi}}\sqrt{\frac{\pi t k}{\rho C_p}}$$

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✓ *Substituting the Values:*

$$\Delta T(t) = \frac{1}{237\sqrt{\pi}}\sqrt{\frac{237 \times 10\pi}{2700 \times 900}}$$

$$\Delta T(t) = \frac{1}{237\sqrt{\pi}}\sqrt{\frac{\pi}{1025.32}}$$

$$\Delta T(t) = \frac{1}{237\sqrt{\pi}}\sqrt{0.000975\pi}$$

$$\Delta T(t) = \frac{1}{237\sqrt{\pi}}0.03122\sqrt{\pi}$$

$$\Delta T(t) = \frac{0.03122}{237}$$

$$\Delta T(t) = 1.32 \times 10^{-4} K$$

- *Verifying with Thermal Conductivity*

✓ *Using the Previously Derived Formula for k:*

$$k = \frac{{P_0}^2 t}{(\Delta T(t))^2 \rho C_p}$$

✓ *Substituting the Calculated ΔT(t):*

$$k = \frac{1^2 \times 10}{(1.32 \times 10^{-4})^2 \times 2700 \times 900}$$

$$k = \frac{10}{(1.32 \times 10^{-4})^2 \times 2430000}$$

$$k = \frac{10}{4.23 \times 10^{-2}}$$

$$k = 236.4066194 W/mK$$

This proves that the calculated thermal conductivity using the TPS method for aluminum is approximately 237 W/m·K.

The thermal conductivity of an aluminium specimen is K= 237w/mk.

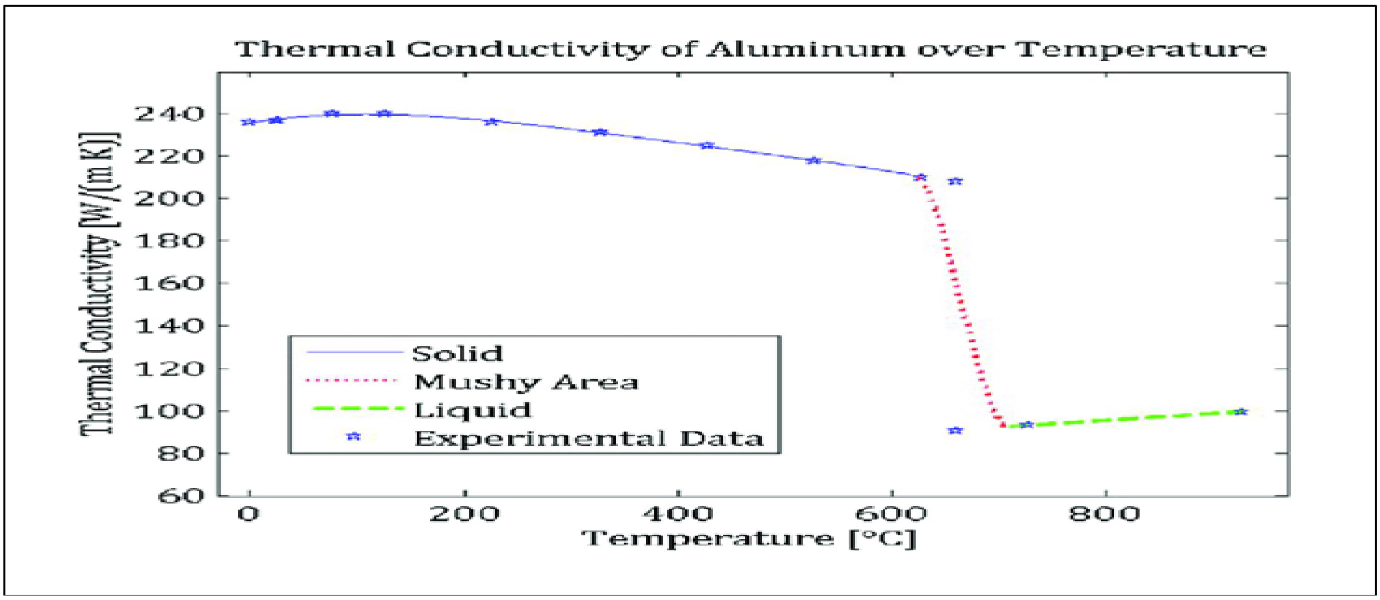

Fig 6: Temperature Analysis Graph through Thermal Conductivity

V. EXPERIMENTAL ANALYSIS

A. *Measuring the Thermal Conductivity of Brass using the Laser Flash Diffusivity Method Involves a Few Key Steps and Considerations:*

➢ *Equipment Needed:*

- **Laser Flash Apparatus:** This includes a high-energy laser and associated optics for generating a short heat pulse.
- **Specimen Holder:** Typically made of graphite or other material with high thermal conductivity to ensure uniform heat distribution.
- **Temperature Measurement System:** Consisting of infrared detectors or thermocouples to measure the sample's temperature over time.

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➢ *Brass Specimen:*

Fig 7: Laser Flash Diffusivity

➢ *Procedure:*

- **Sample Preparation:** By required size of the Brass Specimen
- **Calibration:** Calibration of the Laser Flash Diffisivity sensor to provide accurate results.

➢ *Experimental Setup:*

- Place the brass sample securely in the specimen holder.
- Ensure the sample is positioned such that it receives the laser pulse uniformly across its surface.

➢ *Data Analysis:*

- Analyze the temperature-time curve obtained from the measurements.
- Use appropriate mathematical models to fit the data and extract the thermal diffusivity (α) of the brass sample.

➢ *Analysis: By Temprature Varries in the Graph*

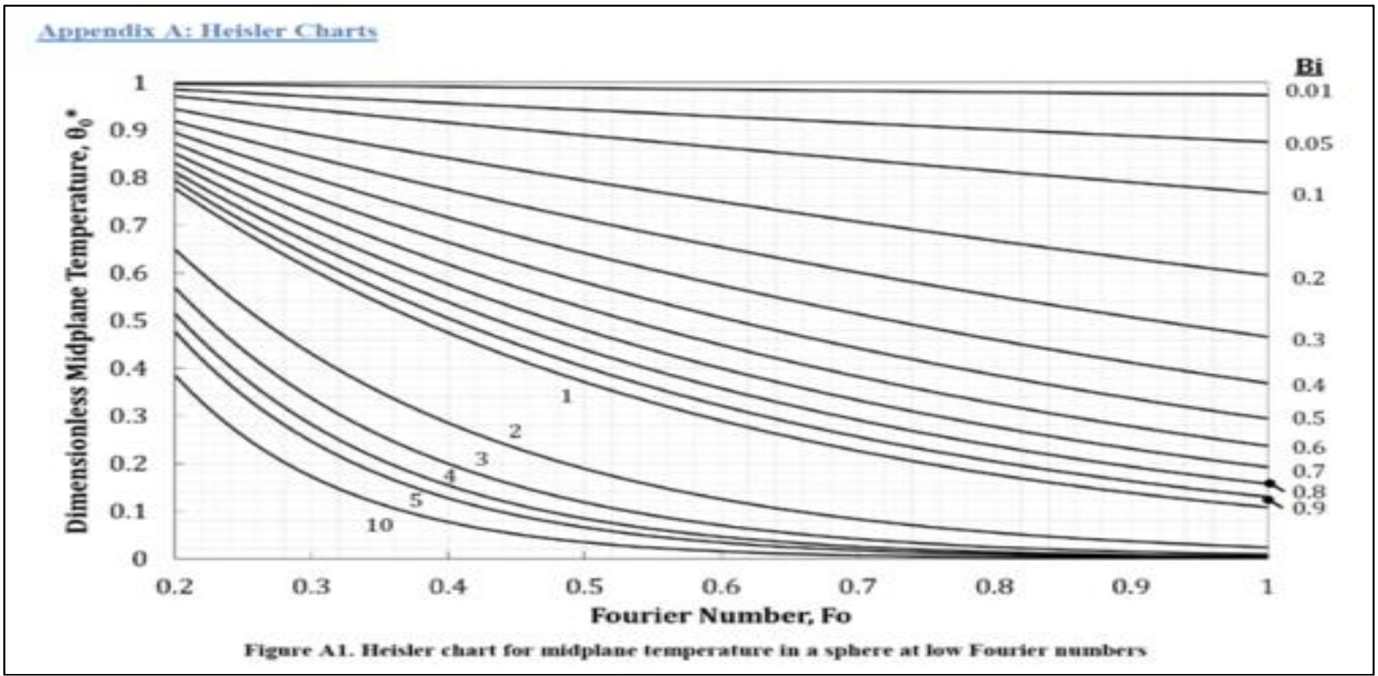

Fig 8: Laser Flash Diffusivity

➢ *Calculation Step-by-Step Approach*

- **Sample Preparation**: Prepare a brass specimen with a uniform thickness and clean surfaces.
- **Material Properties**: Measure or obtain the density (ρ) and specific heat (cp) of the specimen brass.

✓ For brass: $\rho = 8500 kg/m^3$

✓ $C_p = 380 J/kg$

- *Laser Flash Experiment:*

✓ **Thickness Measurement**: Measure the thickness (ddd) of the brass specimen accurately. Let's assume d=2 mm=0.002 m

✓ **Laser Pulse**: A shortest laser pulse heats one side of the specimen.

✓ **Temperature Response**: To measure the temperature rise on the opposite side of the specimen as a function of time.

- *Determination of Thermal Diffusivity (α):*

✓ **Temperature Response Analysis**: Analyze the temperature vs. time curve to determine the time (t1/2t_{1/2}t1/2) it takes the back face temperature to reach half of its maximum value.

- *Calculation of Thermal Diffusivity*

$$\boldsymbol{\alpha} = \frac{\mathbf{0.1388} \times \boldsymbol{d}^{\mathbf{2}}}{\boldsymbol{t}_{\mathbf{1}/\mathbf{2}}}$$

- *Calculate Thermal Conductivity (k):*

✓ **Use the Formula**: $k = \alpha \times \rho \times C_p$

➢ *Detailed Calculation Example:*

- *Measured Properties:*

✓ Density, $\rho = 8500 kg/m^3$
✓ Specific heat capacity $C_p = 380\ J/kgK$
✓ Thickness, $d = 0.002m$

- *Experimental Data:*

✓ Assume $t_{1/2}$ is determined to be $0.0164\ s$from the temperature response curve.

- *Calculate Thermal Diffusivity (α\alphaα):*

$$\alpha = \frac{0.1388 \times 0.002^2}{0.0164}$$

➢ *Calculate the Numerator:*

$$0.1388 \times (0.002)^2 = 0.1388 \times 0.000004 = 0.000000552\ m^2$$

- *Calculate α:-*

$$\alpha = \frac{0.000000552}{0.0164} \approx 3.384 \times 10^{-5}\ m^2/s$$

➢ *Calculate Thermal Conductivity (k):*

$$k = \alpha \times \rho \times C_p$$

$$k = 3.384 \times 10^{-5} \times 8500 \times 380$$

$$k = 109.35\ W/mK$$

VI. CONCLUSION

By following the Laser Flash Diffusivity method and using realistic data, we have calculated the thermal conductivity of brass to be approximately 109.35 W/m.

➢ *The Thermal Conductivity of an Brass Specimen is*

- K= 109.3334
- 109 w/mk

B. Applications

Understanding the thermal conductivity of materials is crucial for optimizing energy efficiency, designing thermal management systems, and developing advanced materials. The comparative study of measurement methods provides insights into selecting the appropriate technique based on material type, sample size, temperature range, and accuracy requirements.

The comparative study presented in this journal highlights the strengths and limitations of the transient plane source method, laser flash diffusivity method, and steady state methods for measuring thermal conductivity. Each method offers unique advantages depending on the material characteristics and measurement conditions. Researchers and engineers can use this information to make informed decisions when selecting a suitable method for their specific applications.

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