Thermal conductivity

1. Aim of the experiment: Determination of thermal conductivity of a bad conductor by Lee's method.

2. Thermal conductivity: Thermal conductivity is the property of the material that indicates its ability to conduct heat.

3. Bad conductor of heat: The materials that do not allow heat to pass through them are ~~that~~ called bad conductor. Ex: wood, plastic, rubber, wool etc.

* Bad conductor of electricity: The materials which offers very high resistance to the flow (or in path) of electric current is called bad conductor of electricity.

4. Lee's apparatus: Lee's disc apparatus consist of a metallic disc resting on a 5 cm deep hollow cylinder (steam chamber) of same diameter. It has inlet and outlet tubes for steam.

5. Lee's method: Lee's method is used to measure the thermal conductivity of a poorly conducting material, such as glass, wood or polymer.

6. Specific heat: The specific heat is the amount of heat per unit mass required to raise the temperature by one degree celsius.

$$\text{i.e } c = \frac{Q}{m\Delta T}$$

7. SI Unit of thermal conductivity: $Wm^{-1}K^{-1}$

CGS: $cal \cdot s^{-1} \cdot cm^{-1} \cdot {}^{\circ}C^{-1}$

MKS: $Wm^{-1}K^{-1}$

8. Heat conduction: Heat conduction is the movement of heat from one object to another one that has different temperature when they are touching each other.

9. Temperature gradient: A temperature gradient is a physical quantity that describes in which direction and at what rate the temperature changes the most rapidly around a particular location.

$$\text{i.e } \nabla T = -\frac{q}{k} \quad \text{or,} \quad \frac{dT}{dx} = -\frac{1}{kA}\frac{dQ}{dt}$$

$q \rightarrow$ heat flux density

10. Heat convection: Convection is the transfer of heat from one place to another due to the movement of gas or fluid.

11. Heat Radiation: Heat transfer from a body with a high temperature to a body with a lower temperature without any physical contact between the materials.

12. Conduction occurred in this Exp: steam chamber to Lee's apparatus. And bad conductor resisting the flow of heat upwards.

13. Convection occured in this Exp: Lee's apparatus to the ~~outflow of~~ pipeline.

14. Radiation occurred in this Exp: Lee's apparatus to pipleline that outflows the steam or gass.

15. Poor conducting material: Insulators or bad conductors have a low coefficient of conductivity; they do not conduct heat well is called poor ~~conding~~ conducting material. Ex: Nonmetals, wood, textiles, ~~a~~ plastic, wood, wool etc.

16. Formula used in this experiment:

$$\text{Thermal conductivity, } k = \frac{ms\frac{d\theta}{dT} \cdot d}{A(\theta_1 - \theta_2)}$$

17. Thermal conductor:

A thermal conductor is a meterial that allows energy in the form of heat, to be transferred within the material, without any movement of the material itself.

18. Differnence between good and bad conductor:
The substances through which heat is easily conducted are called good conductor of heat. On the other hand the substances through which heat is not conducted easily are called conductor of heat.

19. Searles apparatus: searle's apparatus is an apparatus used as an experiment to measure thermal conductivity of material. It has two wires namely control and test wires which are connected to a horizontal bar at the other ends.

20. Materrial conductivity measured by Searles apparatus: good conductor (i.e, copper, silver, Aluminium).

21. Difference between Lee's and Searles apparatus:

(1) Lee's apparatus consist of a metalic disc resting on a 5 cm deep hollow cylinder of same diameter whereas Searle's apparatus has two wires namely control

and test wires which are connected to a horizontal bar at the other ends.

(ii) Used: Lee's apparatus used to measure the conductivity of bad conductor (i.e poor material) whereas Searle's apparatus used to measure the conductivity of a good conductor.

22: Vernier constant: Vernier constant is defined as the difference between the value of one main scale division and one vernier scale division.

$$V.C = \frac{\text{one division of main s}}{\text{Total division}}$$

i.e $V.C = \frac{20-19}{20} = 1-\frac{19}{20} = \frac{1}{20} = 0.05\,mm$

23: Least count: The least count of the screw gauge is defined as the distance moved by the ~~trip~~ tip of the screw when turned ~~or~~ through one division of the main scale:

$$\text{Pitch} = \frac{\text{distance moved by screw gauge}}{\text{Number of rotation}}$$

$$= \frac{0.5}{1} = 0.5\ mm$$

$$L.C = \frac{\text{pitch}}{\text{no. of division of circular scale}} = \frac{0.5}{50}$$

$$= 0.01\,mm$$

24. constant perameter: m, s, d, A, $(\theta_1 - \theta_2)$

25. Variable perameter: $\frac{d\theta}{dt}$

26. Dependency of thermal conductivity:
(i) Substance of the material or nature of the materia
(ii) Temperature gradient;
(iii) The path length that the heat ~~bolt~~ flows.

27. Thermal conductivity depend on the nature of the material because the heat conductivi of a matarial is dependent on two main factor. (i) number of free electron ~~(ii) speed~~
(ii) speed of free electron.
that indicates how far thee can travel before they ~~d~~ bump into some atoms and change their direction.

28.

29. No. Thermal conductivity decreasing by increasing Temperature.

30. Heat transfered: Heat transfer is defined as the process in which the molecules are moved from the region of higher temperature to lower temperature.

31. Types of heat transfered: Thermal –
(i) conduction (ii) convection (iii) Radiation.

32. Fourier law of heat conduction: Fourier's law states that the negative gradient of temperature and the time rate of heat transfer is proportional to the area at right angles of that gradient through which the heat flows.

i.e $Q \propto -A \cdot \frac{d\theta}{dx}$

or, $Q = -KA \frac{d\theta}{dx}$

33. Exact value of specific heat: 0.092 cal/g°c

34. SI unit of specific heat: ~~J/kg~~ $Jkg^{-1}K^{-1}$
CG.S: Cal/g°c

35. Thermal conductivity of this (brass) bad conductor is 4.2×10^{-4} $cal\,s^{-1}\,cm^{-1}\,°c^{-1}$.

36. Internal mechanism of a bad conductor:

37. Heat flowing direction in this Exp: ~~Steam chamber → Lee's apparatus → pipe~~
~~Steam~~ Steam chamber → Pipe (in) → Lee's apparatus → Pipe (out) → Air

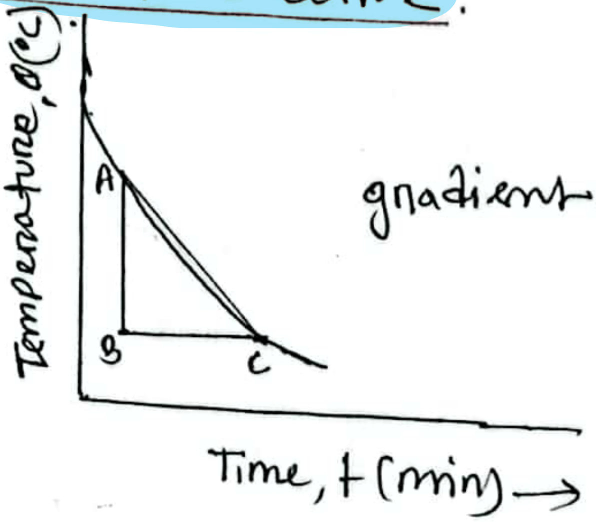
38. Dimension of thermal conductivity: $[K] = [QL^{-1}T^{-1}\theta^{-1}]$

39. Thermal Equilibrium: Heat is the flow of energy from a high temperature to a low temperature. When these temperatures balance out, heat stops flowing (in this exp) then the system is said to be in thermal equilibrium. OR: Two substances in physical contact with each other exchange no heat energy is called thermal equilibrium.

40. Main purpose of this experiment: Determination of thermal conductivity of a bad conductor by Lee's method.

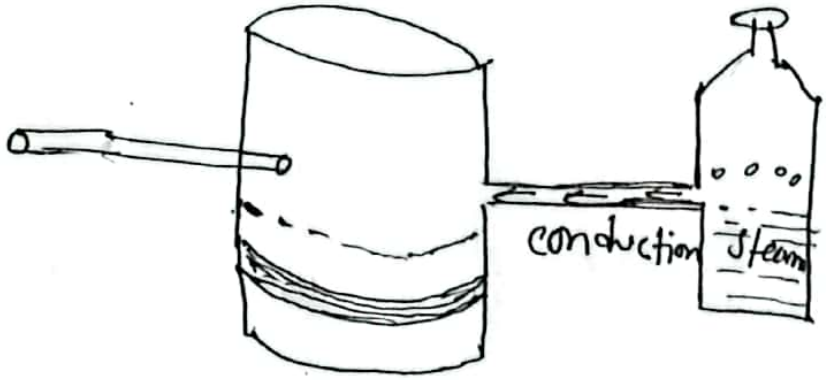
41. Heat equation of this exp: $Q = \frac{KA(\theta_1 - \theta_2)}{d}$

42: Temperature vs time curve:



gradient $= \frac{d\theta}{dt} = \frac{AB}{BC}$

43:



44. Slab A:

Slab B: Heat radiated or radiation occured.

45:

46: Zeroth law of thermodynamics: If two bodies are each in thermal equilibrium with a third body, the are also in equilibrium with each other.

47: Newton's law of cooling holds good only if the temperature difference between the body and surroundings is less than 10°C.

Thermocouple / Thermoelectric power

1. **Aim of the Experiment:** Calibration of a thermocouple and hence determination of unknown temperature and thermoelectric power.

2. **Thermocouple:** A thermocouple is a device that converts temperature differences into an electric voltage, based on the principle of the thermoelectric effect. It is a sensor for measuring temperature at a specific point or location.

3. **Principle of thermocouple:** The thermocouple working principle is based on the Seeback Effect. This effect states that when a closed circuit is formed by joining two dissimilar metals at two junctions, and junctions are maintained at different temperature then an electromotive force ~~or~~ (e.m.f) is induced in this closed circuit.

4. **Thermoelectric sensor:**

5. Thermoelectric power: Thermoelectric power refers to the rate of change of thermoelectro-motive force of a thermocouple with temperature.

6. Callibration ~~of~~ : Calibration is the process of configuring an instrument to provide a result for a sample within an acceptable rage. Eliminating or minimizing factors that cause inaccurate measurements is a fundamental aspect of instrumentation design. In these condition maintaing when ~~the~~ it represent the curve this curve is called calibration ~~of~~ curve.

7. Temperature: Temperature refers to the ~~the~~ holness or coldness of a body. It is the way of determing the kinetic energy of particles within an object.

8. Unknown temperature:

9. Difference metals are added in a thermocouple because, according two seeback effect:

A small thermoelectric current is generated when two dissimilar metal wires are put into contact at both end with their junctions having a different ~~at~~ temperature. If one junction is open, a contact electromotive force is generated.

10. **Thermometer:** Thermometer is a device used for measuring and indicating temperature. One consisting of a glass ~~tu~~ bulb attached to a fine glass tube with numerical scale and containing a liquid or mercury that is sealed in a rises and falls with changes of temperature.

12. **Thermoelectric effect:** Thermoelectric effect is the temperature change resulting from stretching or contracting of an elastic material.

OR: Thermoelectric effect is the direct conversion of temperature differences to electric voltage and vice versa via a thermocouple.

~~It creates~~

Thermoelectric devices create a voltage when there is different temperature on each other.

11. Principle of thermometer:

13. ~~How~~ Types of thermoelectric effect:

(I) seebeck effect (II) Peltier effect (III) Thomson effect

14. In this experiment seebeck effect applied.

15. Seebeck effect Explaination: The seebeck effect is a phenomenon in which a temperature difference between two dissimilar electrical conductors or semiconductors produces a voltage difference between the two substances.

Also said thermocouple junction:

16. Hot junction: It is the measuring point on a temperature sensor where the positive and negative legs of the thermocouple wire are welded together.

17: Cool junction: The junction between the thermocouple metals and the copper traces is called the reference or cold junction.

Thermo electric

19. Thermoelectromotive force: Designating on of the electromotive force produced by a thermocouple.

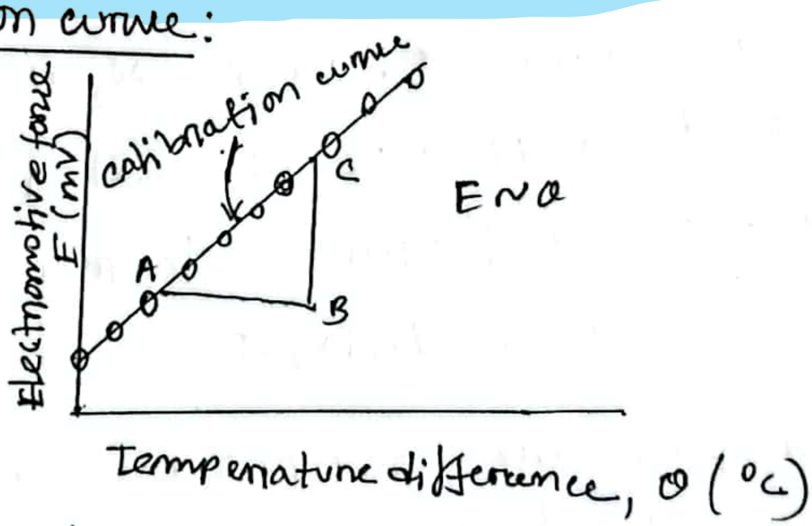
20. Equation of thermoelectric power: $P = \frac{dE}{d\theta}$

21. Multimeter: It is a multi-functional electrical measuring ~~ins~~ instrument. Its main function is measuring of characteristics of electric signal i.e combines functions of an (i) Ammeter (ii) Voltmeter (iii) ohmmeter.

22: Electric voltage is generated across the thermoelectric circuit; when there is a temperature difference between two junctions due to the thermoelectric effect.

24. Exact value of thermoelectric power: 0.046 $mV°C^{-1}$

25: Calibration curve:



27. SI unit of thermoelectric power: VK^{-1}

~~ans~~:

28: Same metal used in thermocouple: There is no temperature at the junction of two similar metals and so the generation of a ~~vot~~ voltage difference ~~between two~~ is zero and the seebeck effect can't work.

29. Variable perameter:

(i) voltage (ii) Reference junction temperature
(iii) Measurement junction temperature.

30. Measurment junction: Hot junction.

31. Reference junction: cold junction.

32. Temperature measuring instrument:

(i) Thermocouple, (ii) Thermistor (iii) Thermometer
(iv) Semiconductor sensor (v) My hand.

33. Thermal E.M.F: When two dissimilar metals are joined a voltage is created. This voltage is known as the thermal electromotive force (EMF) or seebeck voltage.

Thermocoples are used for measuring temperature because of it low cost, high-temperature limits, wide temperature rangs, and durable nature.

35. ph

35. Physical significance of ~~this expleow~~ thermocouple:

(i) Electric power generation;

(ii) Food and bevarage processing;

(iii) Automobile sensor

(v) Rocket, sattellite, space craft and air-craft engine.

Advantage of a thermocouple sensor:

(i) Thermocouples can be used at very high temperatures

(ii) Used in demanding environments.

(iii) high reproducibility.

(iv) have a faster response time.

(v) They are very accurate at a wide operating range.

Limitations of thermo couple:

(i) Thermocouples are not a accurate as RTD sensors in a certain set temperature range.

(ii) They are susceptible to drift over time.

(iii) when they are badly insulated, are. volnerable to corrosion.

(iv) Thermocouple signals are not perfectly linear.