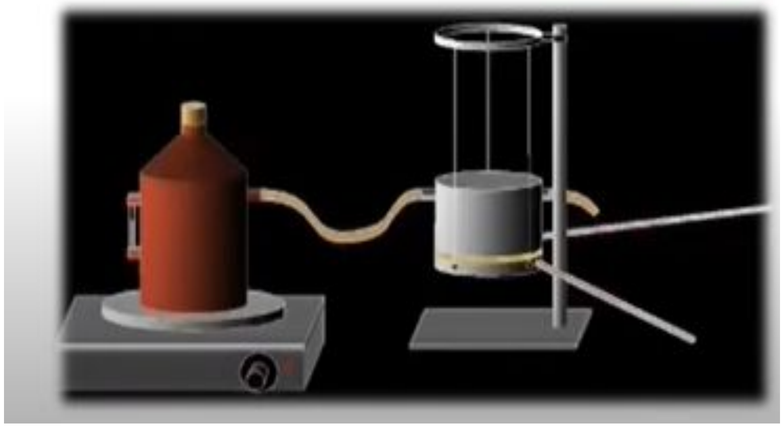
THERMAL CONDUCTIVITY OF A BAD CONDUCTOR OF HEAT - LEE'S METHOD



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Aim

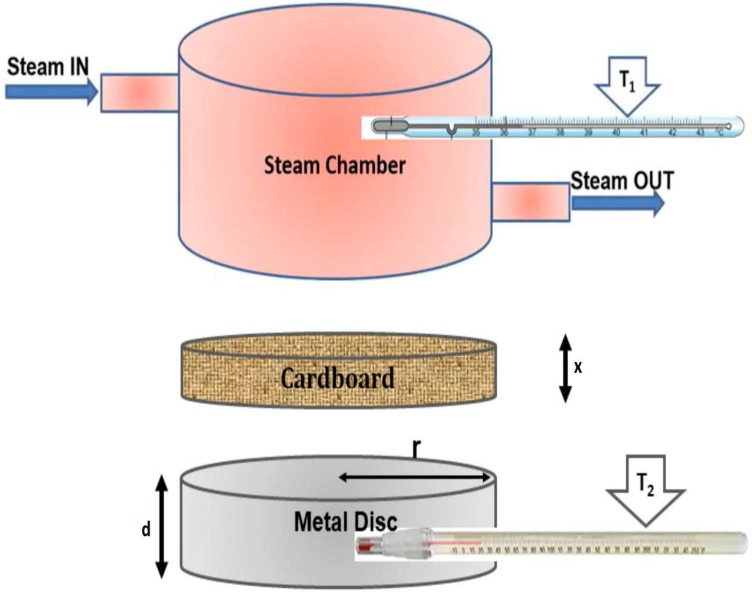
- To determine the coefficient of thermal Conductivity of bad conductor by Lee’s method.

- *“ Coefficient of thermal conductivity (K) is defined as the quantity of heat flowing per second normally through unit area per unit temperature gradient.”*

Apparatus

- Lee's Apparatus
- Steam Generator
- Bad conductor
- Two Thermometers
- Stop Watch
- Screw Gauge
- Vernier Calipers
- Rough Balance

BASIC COMPONENTS

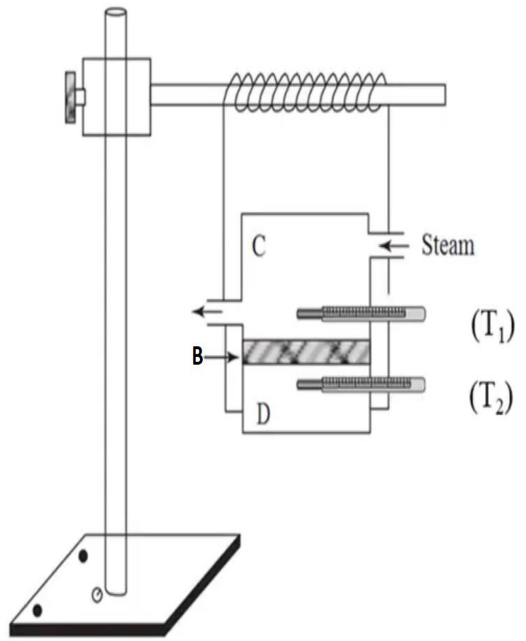


Formula

- Where k is coefficient of thermal conductivity of bad conductor
- m - mass of Lee's disc
- d - thickness of the lower disc
- r - radius of the bad conductor
- x - thickness of the bad conductor
- T_1 - Steady temperature of steam chamber
- T_2 - Steady temperature of lower disc
- s - Specific heat of the material of the lower disc
- α - Rate of Cooling = (dT/dt)

Construction

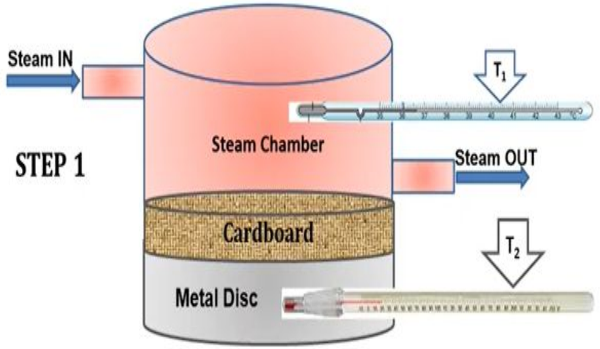
- Lee's disc D is suspended by strings using a stand.
- Bad conductor B of same radius as the disc is placed above the disc
- Steel chamber c is placed over the bad conductor B
- Two thermometers are inserted into the holes in C and D to record their temperatures



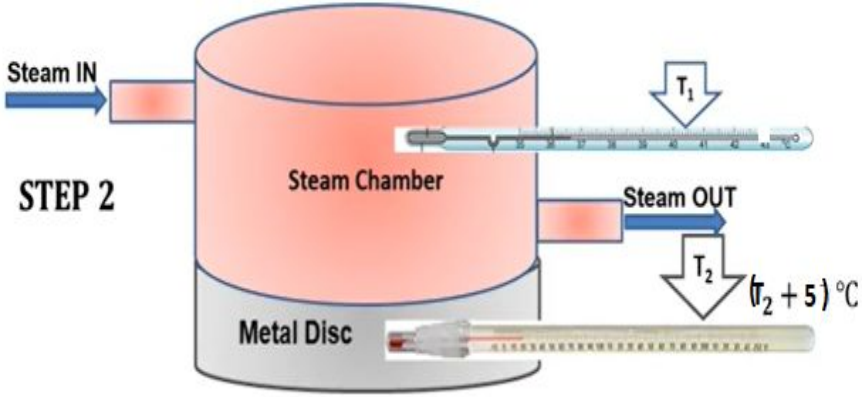
Working

- <u>Procedure</u>:
- The mass ‘m’ of the lower brass disc is found with a rough balance.
- The mean thickness of the Lees disc ‘d’ and the mean radius ‘r’ of bad conductor are determined with vernier calipers.
- The mean thickness ‘t’ of bad conductor is determined with screw gauge.

- Step 1:
- The bad conductor is placed in its proper position between the lower brass disc and the steam chamber.
- Steam is passed for a sufficiently long time until thermometers shows steady temperatures T_1 and T_2 .
- *In this steady state, the heat conducted across the bad conductor is equal to the heat radiated by the exposed portion of the lower slab.*
- Here heat gained by conduction per second by the brass disc is equal to heat lost by it per second due to radiation.

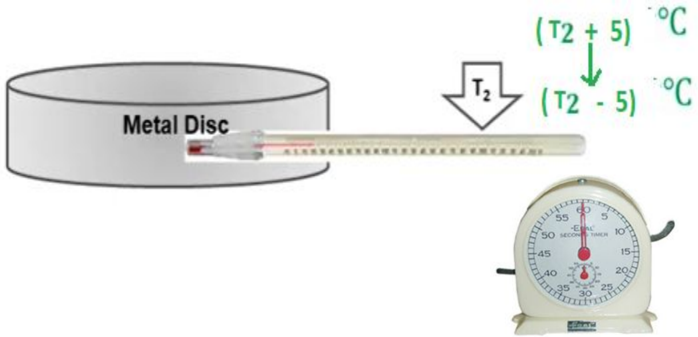


- Step 2:
- The bad conductor is removed and the lower disc is directly put in contact with the steam chamber.
- The brass disc is heated until its temperature rises by about 5°C above its steady temperature T_2°C .



Step 3:

- The steam chamber is removed and the brass disc is allowed to cool.
- As the brass disc cools, the temperature is noted at intervals of half a minute until the temperature of the disc cools 5°C below the steady temperature T_2°C . The readings are tabulated.



Time (minute)	0	½	1	….	…..	…..	…..	……	…….
Temperature °C									

GRAPH:

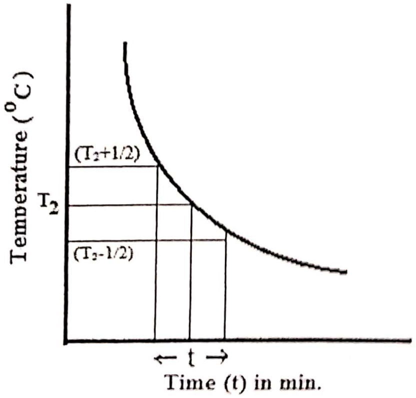
A cooling curve is drawn between the time intervals(in minutes)on X-axis and the corresponding temperatures on Y-axis

.

From graph the time taken' t' in minutes to cool the slab from $(T_2+1/2)$°C to $(T_2-1/2)$°C is noted.

Then the rate of cooling 'α' at the steady temperature T_2°C is found by,

$$\alpha = (1/60t)\ °C/sec$$



- Theory:
  - Amount of heat conducted through the poor conductor per second=Q
    - $Q = KA(T_2-T_1) / x$
    - $Q=K(\pi r^{2)})(T_2-T_1) / x$ (1)
  - When the whole system is at the steady temperature,the amount of heat radiated
  - to the surroundings per second by the exposed area of the disc is given by
    - $Q=msR$ (2)
    - where R is rate of cooling

The area of the disc exposed to the surrounding during the first part is

$$\pi r^2 + 2\pi rh = \pi r(r+2h)$$ (The top of the disc is covered by poor conductor)

- The area of the disc exposed to surroundings in the last part is
- $$2\pi r^2 + 2\pi rh = 2\pi r(r+h)$$

As the rate of cooling is proportional to area of the surface exposed

$$R \propto \pi r(r+2h) \quad (4)$$

$$(dT/dt)_{at\ T2} \propto 2\pi r(r+h) \quad (5)$$

Dividing equation (4) by equation (5)

$$\frac{R}{\left(\frac{dT}{dt}\right)_{T_2}} = \frac{\pi r(r+2d)}{2\pi r(r+d)} = \frac{(r+2d)}{2(r+d)} = \frac{r+2d}{2r+2d}$$

$$R = \left(\frac{r+2d}{2r+2d}\right)\left(\frac{dT}{dt}\right)_{T_2} \qquad (6)$$

Substituting the values of equation (6) in equation (3)

$$K = \frac{msx\left(\frac{dT}{dt}\right)_{T_2}}{\pi r^2(T_1 - T_2)} \times \left(\frac{r+2d}{2r+2d}\right)$$

$$\boldsymbol{K = \frac{msx\left(\frac{dT}{dt}\right)_{T_2}}{2\pi r^2(T_1 - T_2)} \frac{(r+2d)}{(r+d)}} \quad \text{cal sec}^{-1}\ \text{cm}^{-1}\ {}^{0}\text{C}^{-1} \qquad (7)$$

PRECAUTIONS

1) The experimental disc should be thin.
2) Observations for “x” and “r” of the experimental disc should be taken before starting the experiment.
3) Screen off the apparatus from the boiler.
4) The steady state should be obtained very accurately.
5) Ensure that steam chamber and the syatem are horizontal other wise water be accumulate
6) The value of(dT/dt) from the graph should be obtained very accurately.

VIVA-VOcE

1) Define coefficient of thermal conductivity ?
2) Ans : Thermal conductivity is the quantity of heat flowing per second normally through unit area per unit temperature gradient.

3) What are the units of K ?
4) Ans : Cal sec^{-1} cm^{-2} / unit temperature gradient

5) What is the principal involved in this method?
6) Ans: In steady state, temperature of lees disc becomes constant and then heat lost by it to the surroundings is equal to heat gained it through the experimental disc of bad conductor .

7) Does the value of K depends upon the dimensions?
8) Ans:No, It only depends upon the material of the surface .

9) Why is the experimental material taken in the form of thin disk?
10) Ans: A thin disc is taken because its area of cross section is large, while thickness is small.
11) It increases the quantity of heat conducted across its faces. .
12) Why the two discs between which the disk of bad conductor is pressed, are taken of metals?
13) Ans: It ensures normal flow of heat from one face of experimental disc to another.

7. what is Bedford's correction?

Ans: When the rate of cooling of the lower disc is measured, the disc is allowed to cool by radiating heat from its top, bottom and side surface.

The actual experiment is however performed with radiation taking place from the bottom and side surface of the same disc. In order to correlate . These two measurement Bedford introduced a multiplying factor which is known as Bedford's multiplying term which is known as Bedford's correction . The correction factor is the relative of the two radiating surface areas.

8. At what temperature , do you find rate radiation?

Ans: At steady state temperature.

9. Can this method be used in case of good conductors.

Ans: No, because the two sides of the experimental disc will at once acquire the same temperature.

10. Can this method be used in case of liquids?

Ans: With liquids, the difficulty is that the convection currents are easily setup and transfer more heat than the conduction actually does. To overcome this this difficulty, liquid should be heated at the top and should be taken in the form of thin film.