A Consultation Report On

"Experimental Determination of Thermal Conductivity of Metal Plates (4 mm thick) with and without Coating Using a Constant Heat Source"

By

Prof. Dr. R. D. Kanphade
Prof. Dr. P. A. Patil
Prof. A. P. Yadav

Department of Mechanical Engineering

JSPM's Jayawantrao Sawant College of Engineering, Hadapsar, Pune

Table of Contents

1.Aim

To measure the thermal conductivity of various metal plates of size 75 mm x 75 mm, with and without a 0.5 mm coating, using a heat input of 300 watts, and to analyze the effect of the coating on thermal conductivity.

2.Objective

1. To measure and record the thermal conductivity of different metal plates using a constant heat input using DAQ
2. To plot a graph showing the variation in thermal conductivity w.r.t temperature for temperature range from 25 to 350 C
3. Repeat tests for each plate five times to check repeatability of readings
4. To compare the thermal conductivity of coated vs. uncoated plates.
5. To plot a graph showing the variation in thermal conductivity for different metals and the effect of the coating.

3.Introduction

Thermal conductivity is a property that quantifies a material's ability to conduct heat. It is denoted by K and materials with high thermal conductivity transfer heat more efficiently. In this experiment, we aim to measure the thermal conductivity of metal plates with and without a 0.5 mm coating using a heat input of 300 W.

When a plate is coated with an insulating material, the overall thermal resistance increases, and thus the rate of heat transfer decreases. The thermal resistance of a coated plate can be expressed as the sum of the resistances of the metal and the coating. The effective thermal conductivity of the system changes accordingly.

The Fourier's law of heat conduction provides the basis for thermal conductivity calculations:

$$Q = \frac{kA\,(T_B - T_T)}{d}$$

Where:

- Q = heat transfer (W)
- k = thermal conductivity (W/m·K)
- A = cross-sectional area of the plate (m²)
- T_B = Average bottom side temperature
- T_T =Average topside temperature
- d = thickness of the plate (m)

4. Experimental Setup

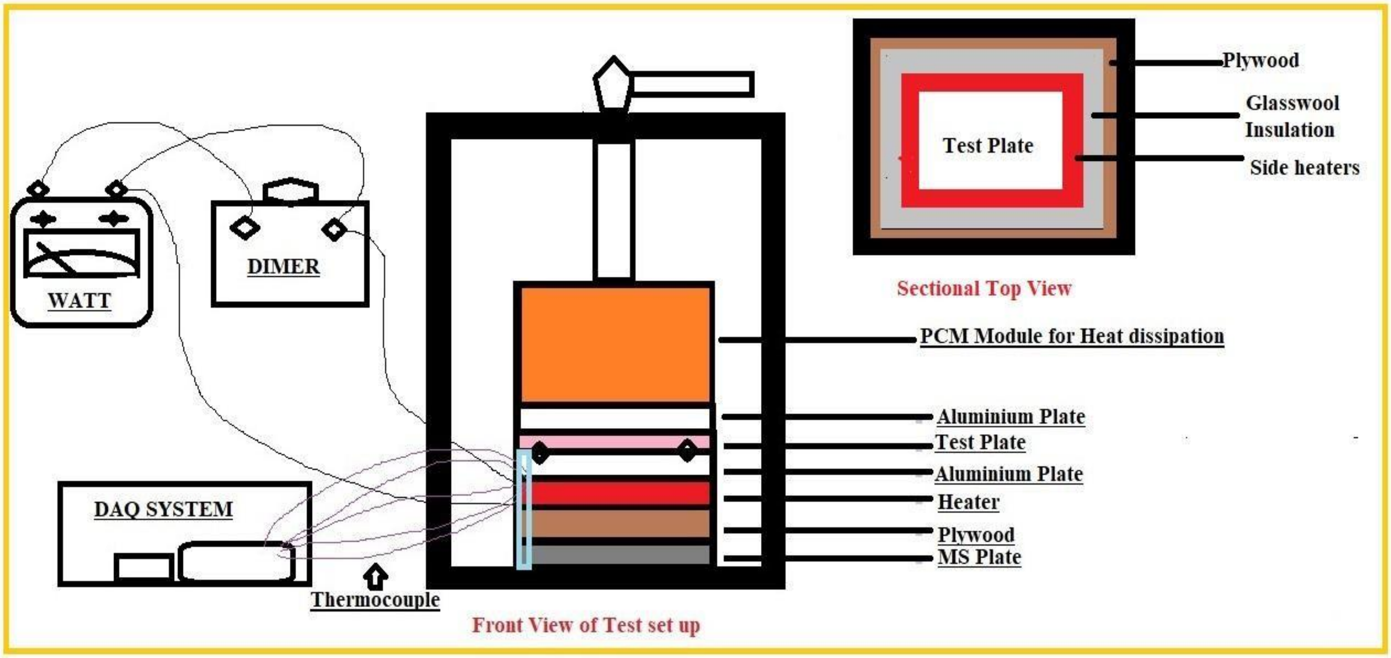

Fig.1 Schematic of Experimental Test Setup

Fig.2 Actual photograph of Experimental Test Setup

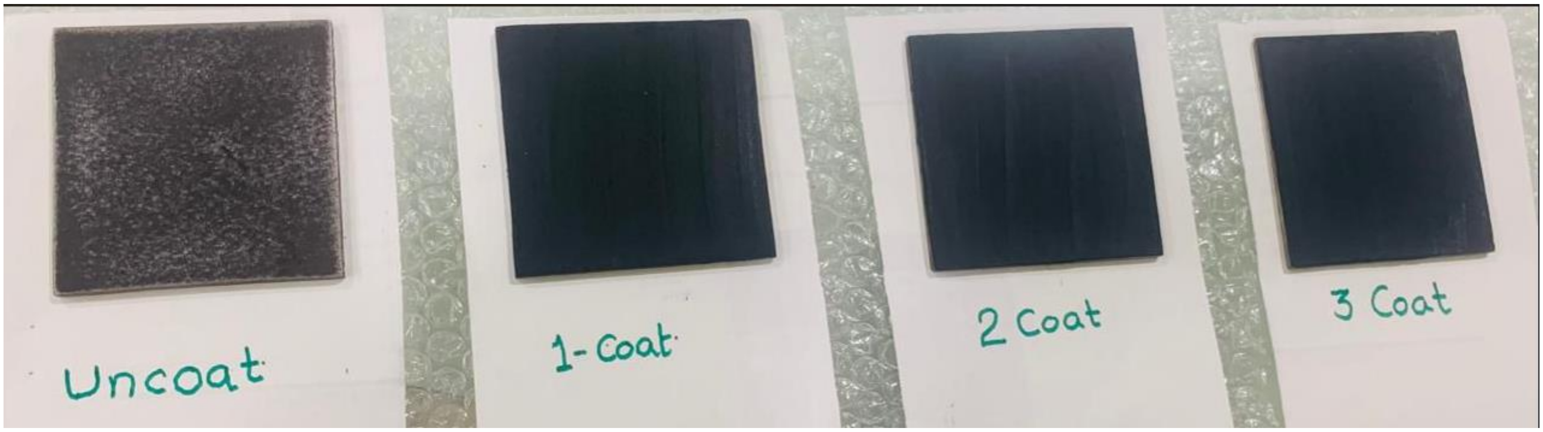

Fig.3a. Actual photograph of Test Plates (Before Test)

Fig.3b. Actual photograph of Test Plates (After Test)

4.1Apparatus:

1) Slab assembly is arranged symmetrically on both sides of heater.

2) Heater- Nichrome heater wound on mica former and insulator with control unit capacity 300 watt maximum.

3) Heater control unit: 0-230 V, 0-2 amps, single phase dimmerstat (1No.)

4) Voltmeter 0-100-200 Volts. Ammeter –2 Amps.

5) Temperature indicator (digital type) 0-2000C . Single phase 230 V electric supply.

4.2 Precautions

1. Keep the dimmer stat to zero before start.
2. Increase the voltage slowly.
3. Keep all the assembly undisturbed.
4. Remove the air gap between plates by moving hand press gently.
5. While removing the plates do not disturb the thermocouples.
6. Operate selector switch of temperature indicator gently

5.Procedure

Assembly of test setup as shown in Fig.and ensures perfect contact of thermocouples to test plate on both sides. Four thermocouples are used on each side and placed in slots as shown in figure.Following is the sequence of operations followed while testing each plate;

1. Start the data logger and monitor the temperatures to ensure uniform temperature everywhere.
2. Put the power ON after ensuring dimmerstat reading is zero
3. Start the supply of heater. By varying the dimmer stat, adjust the input at the desired value.
4. Heat is rejected to PCM(Ice) from top side of plate, which also ensures constant temperature difference across the test plate.
5. Readings of all thermocouples recorded automatically through data logger system
6. Keep the setup entire setup ON till the temperature reaches to 400 C.
7. End the test after steady state is achieved.

6.Data Reduction

i) Heat flow rate for one side of the slab.

$$Q = V.I \quad W$$

ii) To calculate Thermal conductivity of Test plate :

$$k = \frac{Q\, d}{A (T_B - T_T)}$$

$$= \quad W/mK$$

Obesrvation Table														
Time stamp	Bottom Side Temperatures (T_B)				Top Side Temperatures (T_T)				Power Input			AVG	AVG	Thermla Conductivity
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	V	I	Q_T	T_B	T_T	k
13-12-2024 08:46	28	29.25	33.5	32.25	13.75	11.75	12.25	12	200	0.66	132	30.75	12.44	2.5629
13-12-2024 08:46	28	29.5	33.5	32.75	13.75	12.25	12	12.25	200	0.66	132	30.94	12.56	2.5542
13-12-2024 08:46	28.25	29.25	34.25	32.5	13.75	11.75	11.75	12.75	200	0.66	132	31.06	12.50	2.5284
13-12-2024 08:46	28.25	29.75	34.25	33.25	13.5	12	12	12	200	0.66	132	31.38	12.38	2.4702
13-12-2024 08:46	28.25	30	34.75	32.75	14.25	12	11.5	12.25	200	0.66	132	31.44	12.50	2.4783
13-12-2024 08:46	29	30	35.25	33.25	13.5	12	12.25	12.25	200	0.66	132	31.88	12.50	2.4224
13-12-2024 08:46	29	30.25	35.25	33.25	14.25	12.25	12.5	12.5	200	0.66	132	31.94	12.88	2.4621
13-12-2024 08:46	29.25	30.5	35.5	34.25	14.25	12	12.25	12.75	200	0.66	132	32.38	12.81	2.3991
13-12-2024 08:46	29	30.5	35.75	34.25	14.25	12.25	12.5	12.5	200	0.66	132	32.38	12.88	2.4068
13-12-2024 08:46	29.25	31	36	34.5	14.5	12	12.25	12.75	200	0.66	132	32.69	12.88	2.3689
13-12-2024 08:46	29.75	31.25	36.25	34.75	14	12.25	12.75	13	200	0.66	132	33.00	13.00	2.3467
13-12-2024 08:46	29	31.5	36.5	34.75	14.5	12	12.5	12.75	200	0.66	132	32.94	12.94	2.3467
13-12-2024 08:46	29.75	31.75	37	35.25	14.75	11.5	12.5	12.75	200	0.66	132	33.44	12.88	2.2825
13-12-2024 08:46	30.25	32	37	35.75	13.75	12	12.75	12.5	200	0.66	132	33.75	12.75	2.2349
13-12-2024 08:47	30.5	32	37.75	36.25	14.5	12.5	12.5	13	200	0.66	132	34.13	13.13	2.2349
13-12-2024 08:47	30.75	32.25	37.5	36.25	14.75	12	13	13	200	0.66	132	34.19	13.19	2.2349

Fig.4 Sample Observation Table

6. Experimental Plots and Results

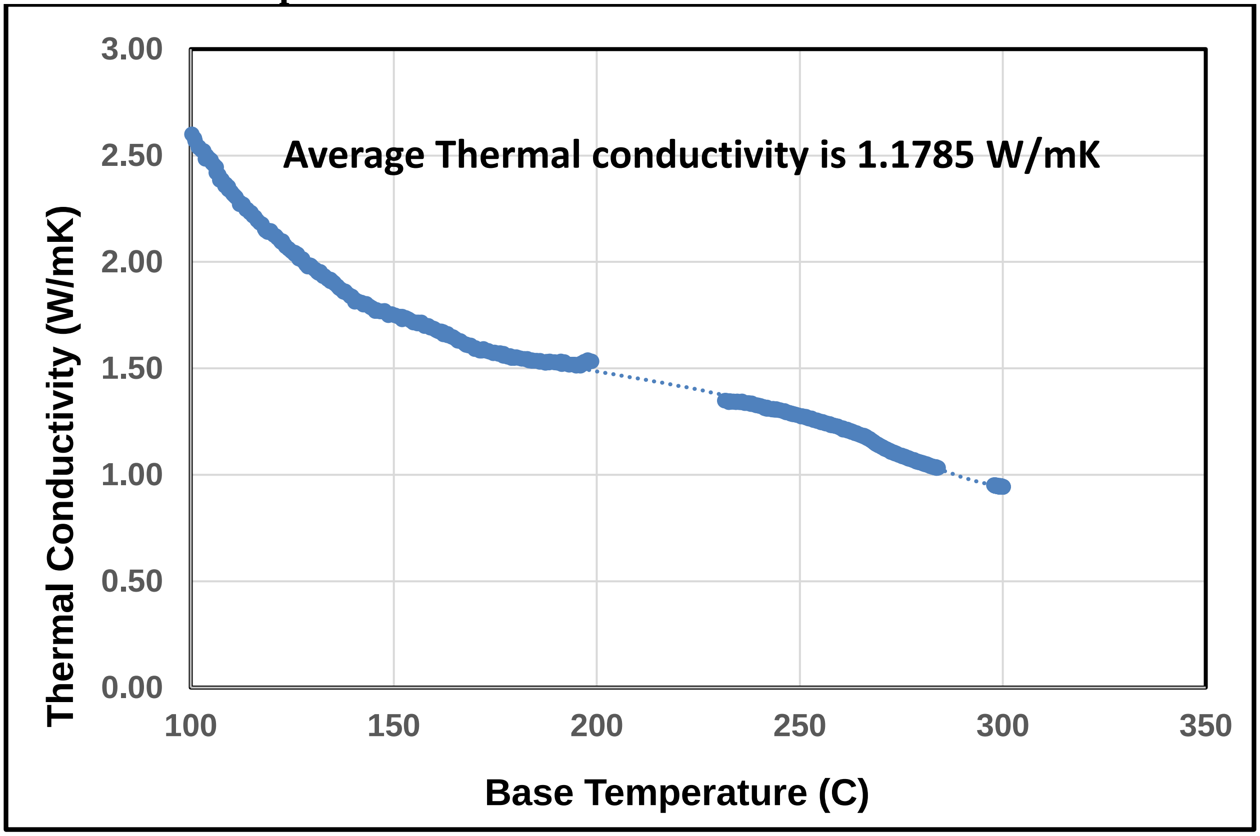

Fig.5 Thermal Conductivity Variation in Uncoated Plate

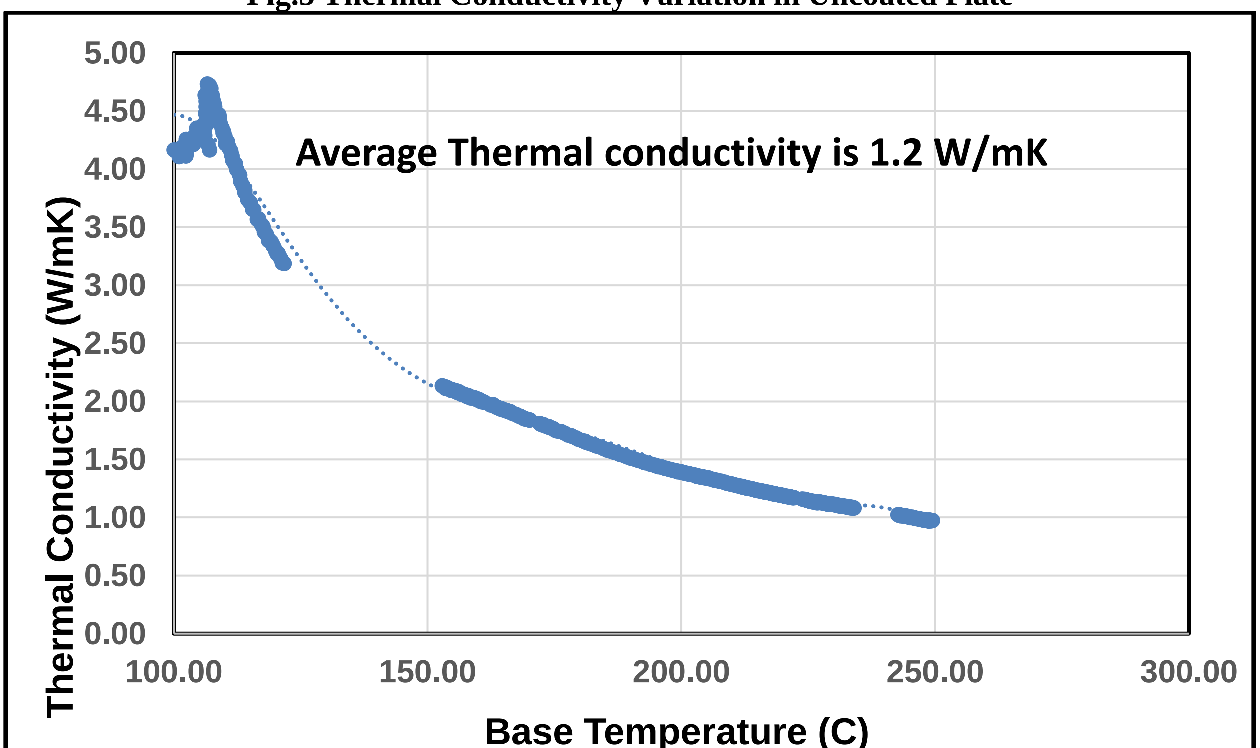

Fig.6 Thermal Conductivity Variation in Single Coat Plate

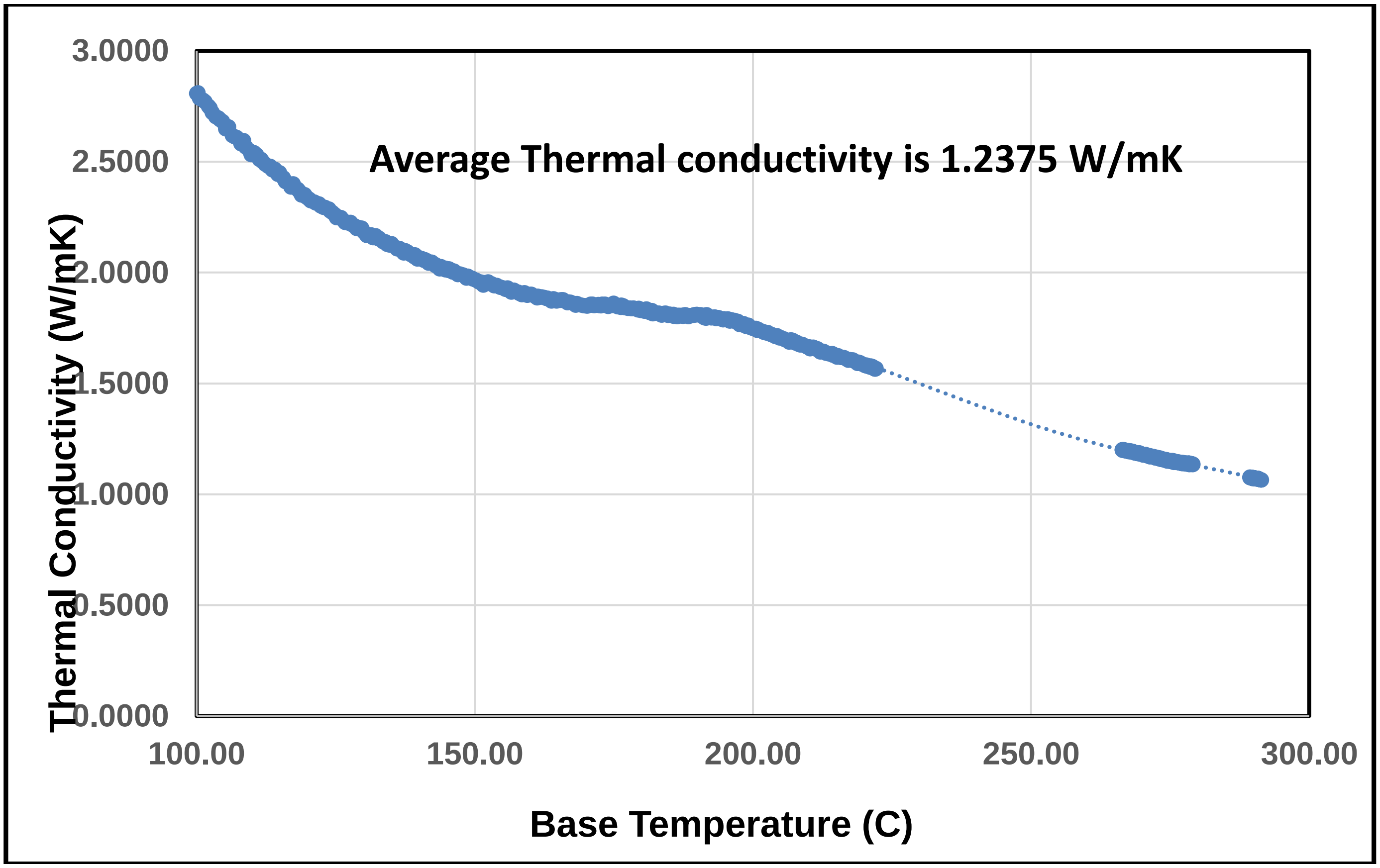

Fig.7 Thermal Conductivity Variation in Two Coat Plate

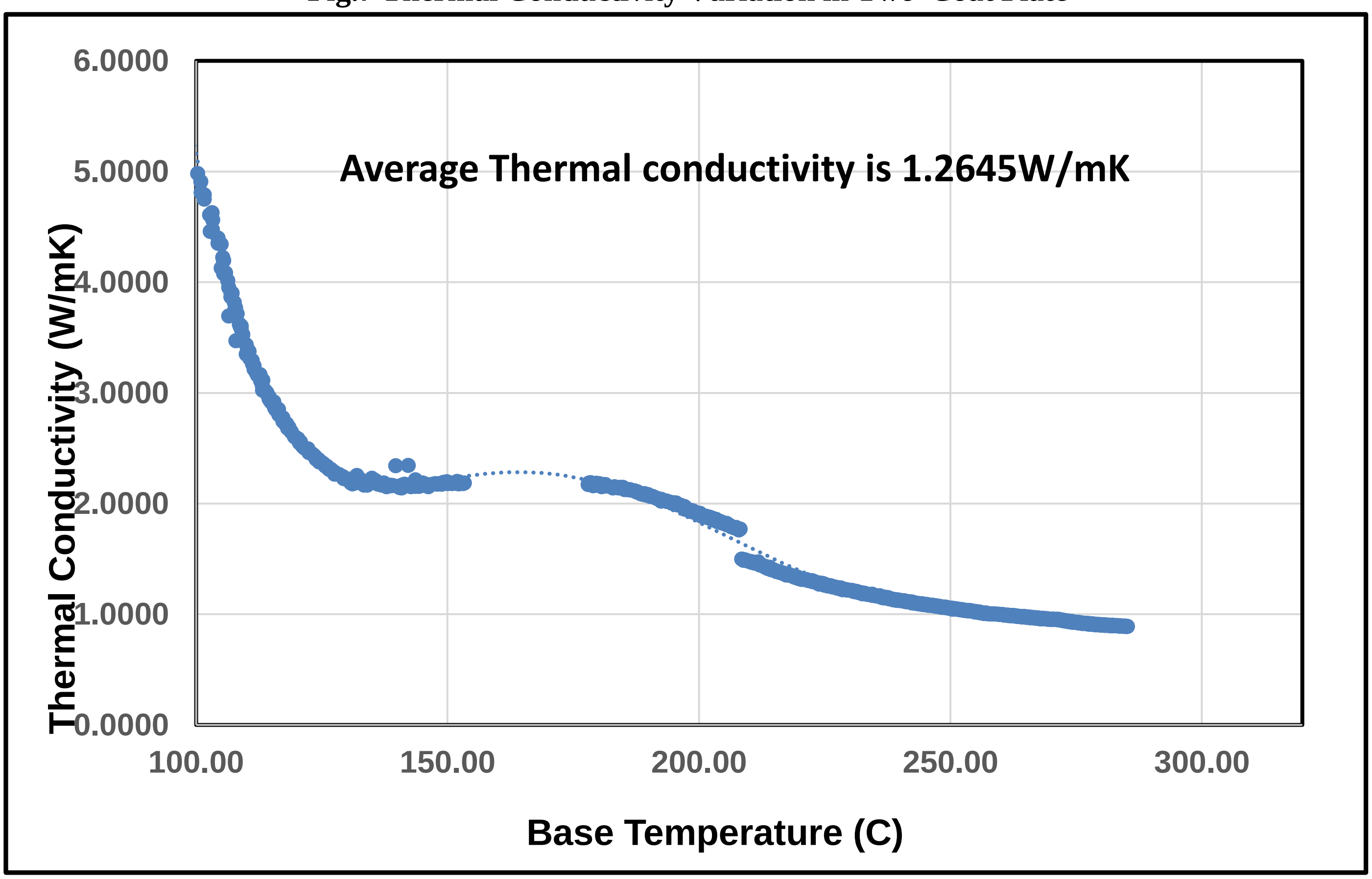

Fig.8 Thermal Conductivity Variation in Three Coat Plate

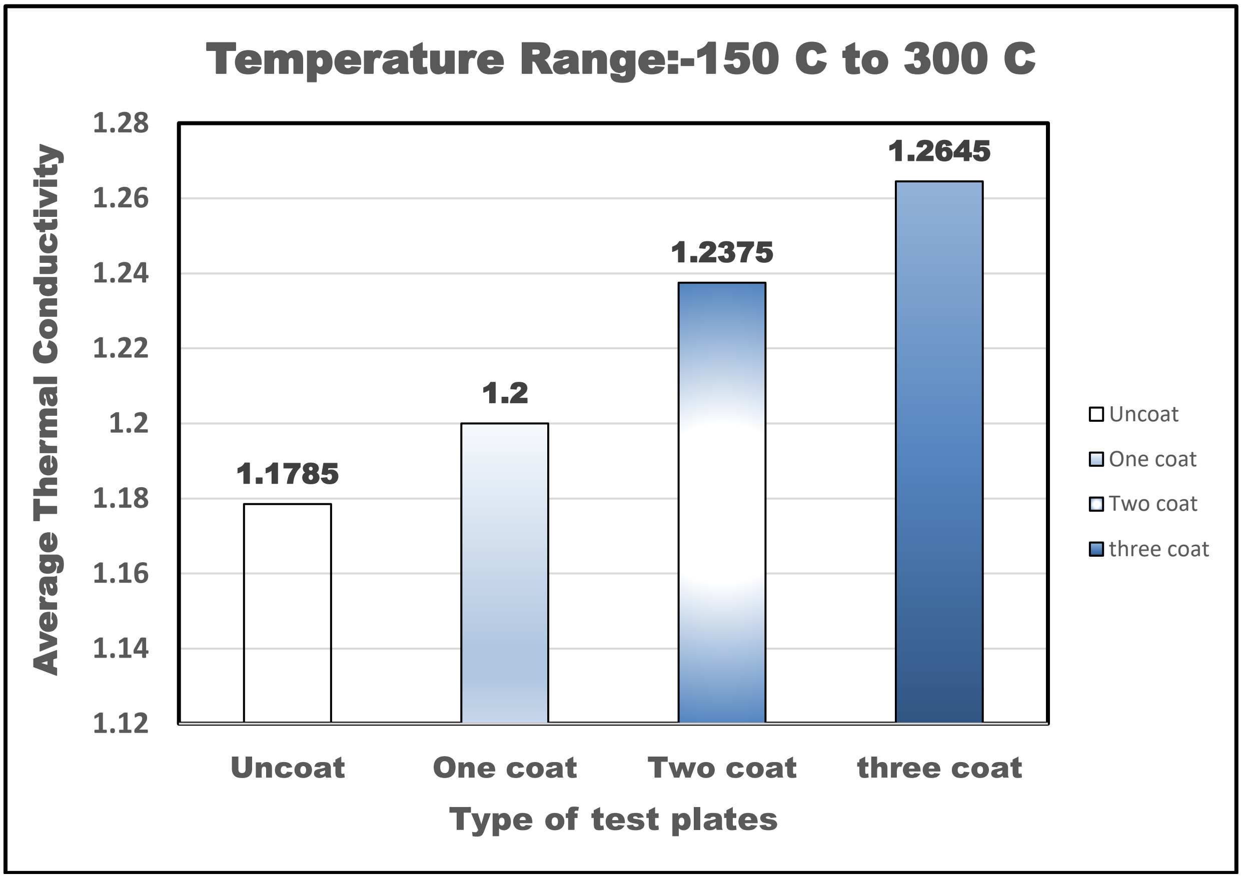

Fig.9 Effect of Coating on Thermal Conductivity of Plate (High Range)

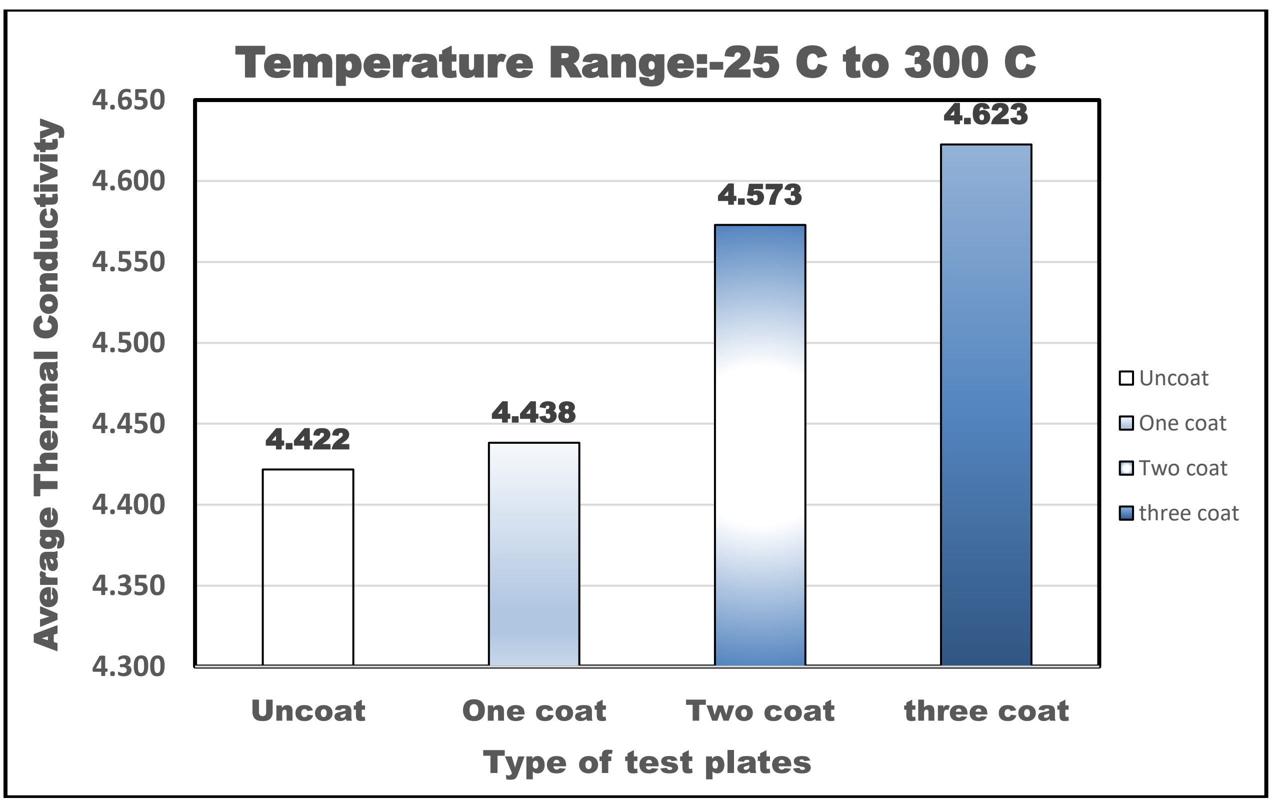

Fig.10 Effect of Coating on Thermal Conductivity of Plate(Overall Range)

7. Analysis of Plots

- For each plate thermal conductivity decreases exponentially from ambient temperature to around 120 C, after that the rate of decrease is reduced substantially.
- For each plate it is also found that Thermal conductivity is above 10 W/mK for temperature upto 50 C
- Average thermal conductivity for entire temperature range various from **4.42 to 4.62 W/mK** with little variation with coating.
- Average thermal conductivity for high temperature range various from **1.17 to 1.265 W/mK** with little variation with coating.
- Coating is not significantly affecting thermal conductivity of plate, but as coating thickness increases, thermal conductivity increases slightly.
- Thermal conductivity of uncoated test plate is lowest amongst coated plates for all temperature ranges.

Dr. P A Patil
Principal Investigator & HOD [Mech]

Professor & Head
In Mech. Engg. Department
JSPM's Jaywantrao Sawant College of Engineering
Hadapsar, Pune- 411 028

Dr. R D Kanphade
Principal