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# Experimental Estimation of Emissivity of Surfaces with Various Coating

Saib A. Hamid[#1], Muhannad A. Sayel[#2]

[#]*Department of Mechanical Engineering, Al-Mustansiriyah University, Iraq*

***Abstract—*** *An Experimental test rig has been manufactured to measure a horizontal painted iron plate's emissivity. This plate was painted with two different colors. The first color was semi-black, and the other color was semi-white. The test was carried out at temperatures range between 52 ° C and 125 ° C. The results showed that the plate's emissivity with semi-black surface color was higher than the same plate's emissivity but with the semi-white surface color. The results also showed that the emissivity increases with increasing temperature for both color cases.*

**Keywords —** *Emissivity, Experimental Estimation of Emissivity*

## I. INTRODUCTION

The emissivity of the surface of a material is its effectiveness in emitting energy as thermal radiation. Thermal radiation is electromagnetic radiation, and it may include both visible radiation (light) and infrared radiation, which is not visible to human eyes. The thermal radiation from very hot objects is easily visible [1]. Quantitatively, emissivity is the thermal radiation ratio from a surface to the radiation from an ideal black surface at the same temperature as given by the Stefan–Boltzmann law. The ratio varies from 0 to 1. The surface of a perfect black body (with an emissivity of 1) emits thermal radiation at the rate of approximately 448 watts per square meter at room temperature (25 °C, 298.15 K); all real objects have emissivity's less than 1.0 and emit radiation at correspondingly lower rates. In this research, the emissivity will measure in a practical way using an infrared thermometer (IR thermometer). When using an IR thermometer normally, it is important to know the approximate emissivity of the measuring surface. As a general rule, most IR thermometers will be set to a default emissivity of 0.95. This means that the IR thermometer assumes that the surface it is measuring has an emissivity value of 0.95. For many applications, this default reading will be suitable, and you may not need to change the settings on your IR thermometer. Indeed, some thermometers will not even allow you to make changes to the emissivity setting. Below is a chart of some emissivity coefficients of commonly measured items [2].

| Material | Emissivity |
|---|---|
| Polished aluminum | 0.05 |
| Asbestos board | 0.96 |
| Black electrical tape | 0.95 |
| Glass/Frosted glass | 0.92-0.96 |
| White paper | 0.90 |
| Black paper | 0.94 |
| Black plastic | 0.95 |
| Clear plastic | 0.94 |
| Water | 0.98 |
| Concrete | 0.95 |
| Ice | 0.97 |
| Skin | 0.98 |
| Typical foods | 0.8-0.95 |

## II. HOW CAN THE EMISSIVITY OF AN OBJECT BE DETERMINED?

The following procedure show how we can determine the emissivity by using an IR thermometer:

First, measure the surface temperature of the object to be measured with a surface-type thermocouple probe. Measure the same surface temperature with an infrared thermometer, adjusting emissivity on the thermometer until the temperature readings on both the thermocouple and infrared thermometer meters agree [3].

## III. RIG DESCRIPTION

*We can list the components of the rig used in this project as follows (see Figure 1):*

***a-*** *IR thermometer.*

***b-*** *Temperature measuring device.*

***c-*** *Main rig structure that contains the following parts:*

- *Power supply*
- *Electrical heater*
- *Thermocouples connections*
- *Power regulator*
- *Selector switch*

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## IV. EXPERIMENTAL PROCEDURE

The following steps represent the main experimental work procedure to obtain the emissivity of horizontal coated plate experimentally with internal heat generation:

1. Firstly make a table to write reading data from this test.
2. Connect all parts of the electrical circuit, thermocouple, and IR thermometer, as shown in Figure (1).

***Figure 1: Test rig***

3. Close the electrical circuit.
4. Adjust the voltage and current. You want to heat the plate to a certain steady-state temperature.
5. Write the values of current and voltage at the table in one above.
6. Wait until the plate temperature Tw that measured by the thermocouple connection reaches steady-state.
7. Read Tw and write it at the table above against the values of current and voltage in five above.
8. Now read emissivity value (from IR thermometer), leading to the same Tw in step seven above.
9. Repeat step eight above for four distances (15 cm, 25 cm, 38 cm, and 55 cm).
10. Repeat the steps from 4 to 9 for different values of voltages and current.
11. Do the above procedure for both semi-black and semi-white colors.

## RESULTS AND DISCUSSION

The experimental results were obtained by heated the plate using an electrical heater at various power values (0.2A≤current≤0.6A). The wall temperature was measured when it reached a steady-state situation (52C∘≤Tw≤125C∘) for both colors (semi-black and semi-white). At the steady-state wall temperature, the value of emissivity can be obtained from the infrared temperature device.

Figures (2 to 5) show the behavior of emissivity against temperature at four distances (15 cm, 25 cm, 38 cm, and 55 cm), respectively. The results showed increases in emissivity when temperature increased (i. e. the emissivity is a temperature) function. The emissivity of the semi-black case is more than that in the case of semi white.

Figures (6 and 7) show the effect of distance on the emissivity value, where the emissivity decreased when the distance increased and vice versa.

## V. CONCLUSIONS

The results of the current research led us to the following main conclusions:

1. The emissivity is a function of temperature.
2. The emissivity is a function of color.

Finally, changing the surface color of the same metal plate will change its emissivity.

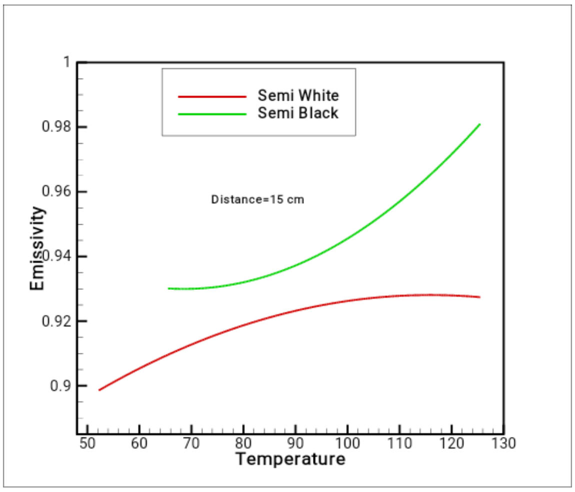


**Figure 2: Emissivity comparison at 15 cm**

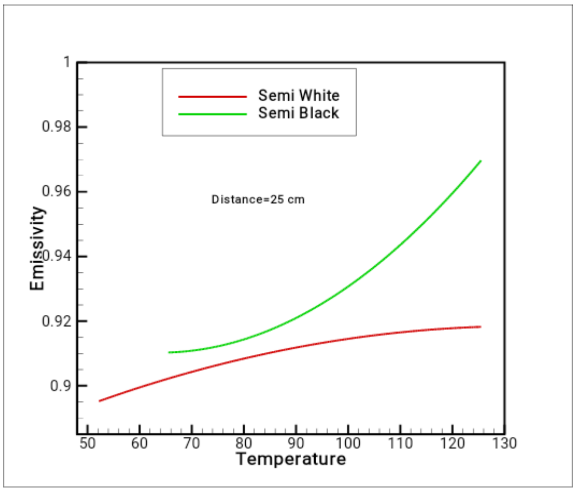


**Figure 3: Emissivity comparison at 25 cm**

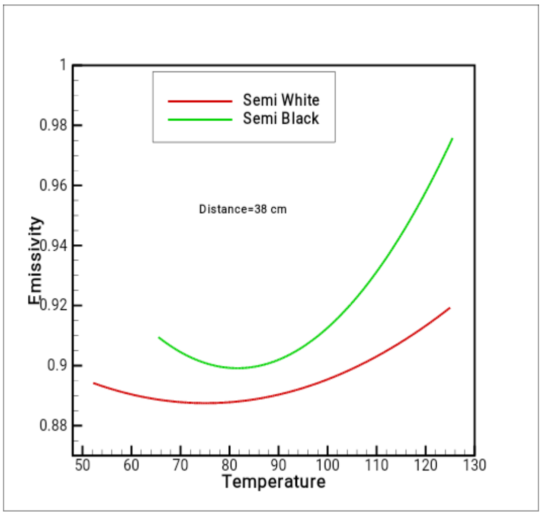


**Figure 4: Emissivity comparison at 38 cm**

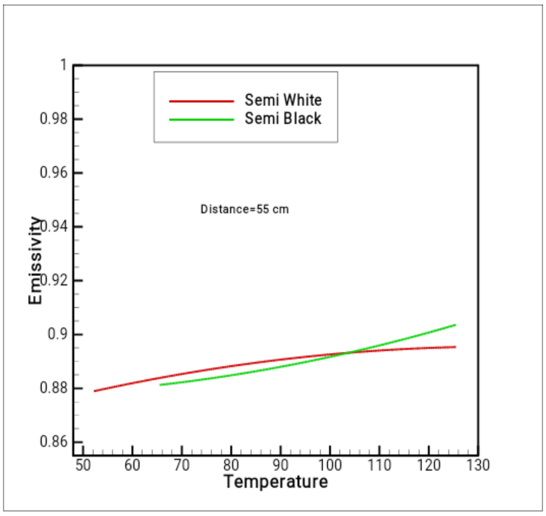


**Figure 5: Emissivity comparison at 55 cm**

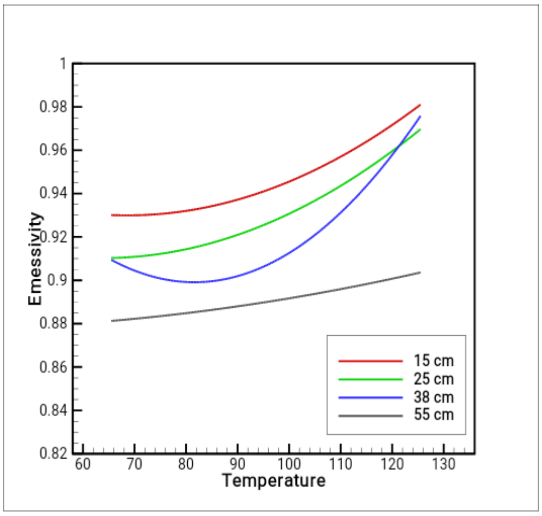


**Figure 6: Distance effect for semi black case**

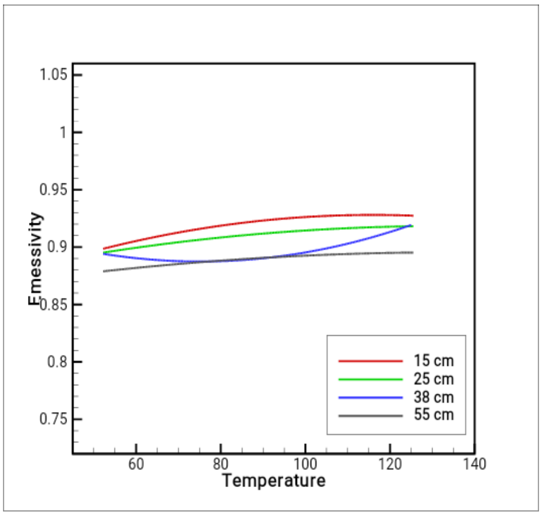


**Figure 7: Distance effect for the semi-white case**

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[3] Bacto Laboratories Pty Ltd © 2005 *"IR Thermometers"* & Emissivity Tables www.bacto.com.au.