

# A Review Paper on Interpretation of Thermal Paint

Tejas Tulshidas Shikhare

Department of Mechanical Engineering

Jawaharlal Darda Institute of Engineering and Technology, Yavatmal, Maharashtra

shikharetejas1972@gmail.com

**Abstract:** Thermal Paint is a kind of Temperature sensor and also the best way to measure the surface temperature of any hot component. Thermal paint is a type of functional paint that is mostly used to measure the temperature of a gas turbine by observing the difference in color change. It is used in a gas turbine for measuring the temperature of the hot component of a gas turbine. In Gas Turbines major components lose their dimensional accuracy due to uncontrolled temperature. Due to reduction in CO<sub>2</sub> emissions and increasing the efficiency of the Gas Turbine can lead to a temperature increase in Gas turbines. It is not easy to track the Temperature of the component of a gas turbine using electronic gadgets in such a high and complex structure. Here the thermal Paints are useful for measuring temperature. Proper information about temperature can be determined by observing the color change in thermal paint applied to components. This article discusses on Interpretation of thermal paint on gas turbines. Since a color change is happening in paints this can be analyzed by using different techniques and extracting the data after an operation and Can be examined using data image processing.

**Keywords:** Thermal paint, Gas Turbine, Temperature, Blades

## I. INTRODUCTION

Detailing of Temperature across the Gas Turbine is the most difficult to extract from an aviation point of view, the unwanted rising of temperature can damage the components and also, and the unwanted cooling can reduce the efficiency of the Aero-engine Gas Turbine. That's why it is necessary to have temperature information across the Aero Engine components. It is difficult to measure the Temperature of Turbine Components using Sensors or some Electronic Gadget. Therefore, it is necessary to measure the surface temperature of hot components using another method. Thermal paint is widely used to measure the surface temperature of hot components. We can measure the temperature distribution over the surface of components by analyzing the color change of Thermal Paint applied to components. It is difficult to measure the Turbine blade's temperature while rotating by using this technology we can measure the temperature of the Rotating blade quite easily. Thermal paint doesn't have restrictions or limitations compared to other techniques and thus has more advantages than other techniques.

### 1.1 Chemistry behind Thermal Paint

Color change occurs when the electrons interact with each other when light is present. Thermal paint has special chemical properties known as Thermochromism. Thermochromism is a property that can undergo a color change when subjected to Temperature. (Rupesh, Prakasajothi, Chandrashekhar, Mycherla, & Teja, 2019) There are two types of Thermal paint according to Thermochromism as follows:-

1) Single change Thermal paints:-

Where only one color change takes place.

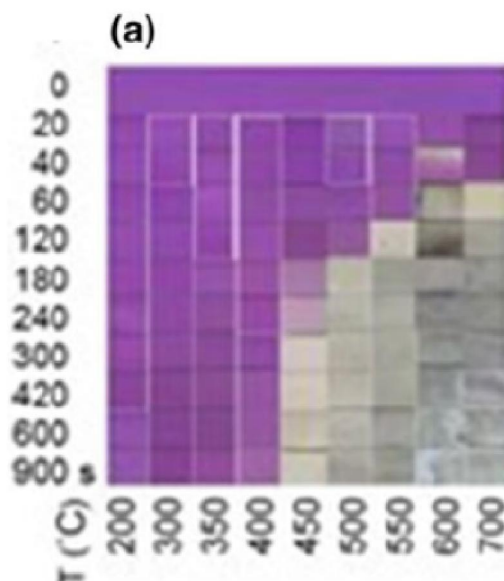


Fig. 1 Single color change

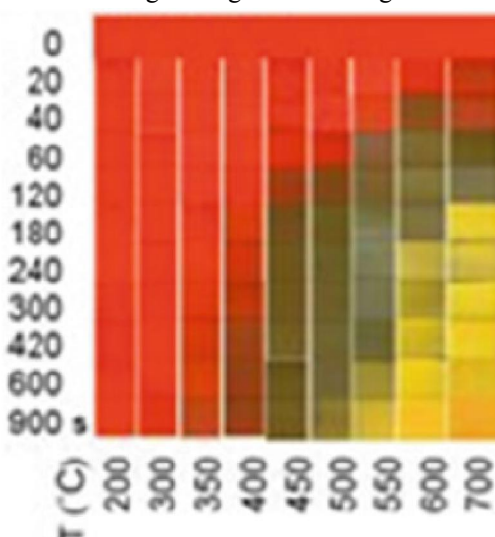


Fig. 2 Multi-color change

## 2) Multi Change Thermal Paint

In this, Thermal paint multiple color change takes place.

### 1.2 Chemistry of Color Changing

Thermal Paint consists of Resin which can withstand very high temperatures without breaking its molecular structure. But, can change its color respected to rising and decreasing temperatures relatively with time because it is pigment. When color change is happening we should understand that physical changes also appeared. Color change takes place at Different wavelengths of reflected light. (Rupesh, Prakasajothi, Chandrashekhar, Mycherla, & Teja, 2019)

## II. THERMAL-SENSITIVE PAINTS

Thermal paint consists of Luminescent particles that can undergo an excitation process when subjected to photon absorption. When the emission of photons is happening excited particles change into excited particles. Temperature is the parameter that has a higher impact on particles. Whether the particles will go in unexcited without light is dependent

on temperature, This phenomenon is known as Thermal Quenching. Thermal-sensitive paint is working on the Thermal Quenching principle. If the temperature is high then fewer particles will return to an unexcited state when subjected to light emission. When an image is recorded to analyze the temperature it will show a darker image when compared to the previous one. The temperature is measured by using radiation wavelength. Radiation can measure using an RGB camera. By capturing the image we can analyze them using luminescence thermometry.(Jeziorek & Widera, 2018)

### III. THERMAL INDICATING PAINT

It is mostly used to test the Gas Turbine component. It is used to measure the distribution of temperature over Gas Turbine blades to avoid the difficulties faced by electronic sensors. When its subjected to temperature it can undergo a visible color change that is caused by a chemical reaction. The main advantages of using Thermal Indicating paint to measure the temperature is that the TIP can obtain the global temperature profile whereas another instrument such as sensors only gives a point temperature indicator. Thermal indicating paint is very useful for Thermal Mapping of Hypersonic Flight Tests.(Rupesh, Prakasajothi, Chandrashekhar, Mycherla, & Teja, 2019)

### IV. TEMPERATURE MEASUREMENT OF THERMAL PAINT USING COLOR CAMERA CALIBRATION METHOD

#### 4.1 Color Camera Calibration Method:-

The component which applies Thermal Paint take as a sample in this process And later the analysis is done on that component using a color camera. In this process, the RGB values of the sample are taken as a result. The RGB values of the camera would have been different according to its manufacturer that's why it is necessary to find out the complete information about the RGB of that camera according to manufacture and find the relation between RGB values of the color camera and their standard estimate values. There are different types of calibration method used in this process as follow:-

- PAL Algorithm
- Three-dimensional lookup table Algorithm
- LBPNMEF Algorithm

#### 4.2 Calibration Method

##### 4.2.1 Experimental Instrument

- Spectral Radiometer
- SG color card
- NCS color card
- Lightbox
- Camera
- Whiteboard

##### 4.2.2 Experimental Process

- Put the color card in the lightbox
- Put the camera accordingly at a distance
- Turn on the camera imaging software
- Shoot color card with the camera
- Replace SG color card with NCS color card
- Repeat shooting process

##### 4.2.3 Data Processing and Analyzing

The image captured by the camera is processed by image processing software and measured the RGB values of two color cards and then a comparison of color differences between calibration methods.

#### 4.2.4 Temperature Recognition of Thermal Paint

The photograph of thermal paint samples captured by a color camera is a color temperature database and later by using the Temperature Recognition Algorithm the temperature of thermal paint is established.(Hu & Liao, 2022)



Fig.3 SG color box

### V. ADVANTAGES OF THERMAL PAINT

1. It is non-invasive nature
2. Traditional methods of temperature measurement such as thermocouples, and infrared cameras require physical contact with the component that has been tested. On other hand, thermal paint can be applied to any surface and the structure of the component doesn't matter here.
3. It is cost-effective.
4. Easy to use.

### VI. APPLICATION

Thermal paint has numerous applications in various industries including aerospace, automotive, and construction. In the aerospace industry, thermal paint is used to measure the temperature distribution on aircraft surfaces during flight testing.

### VII. CONCLUSION

Temperature measurement using thermal paint is a promising alternative to traditional temperature measurement methods. It offers many advantages, including cost-effectiveness, non-invasiveness, and visual representation of temperature changes. However, it is important to recognize its limitation and use it appropriately in an application where its accuracy and limitation are acceptable. Overall, thermal paint for temperature measurement has the potential to revolutionize temperature measurement in many industries and offers an exciting avenue for future research and development.

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