

IR CURING SHOPTALK

Infrared Equipment Division of IHEA

This column is provided to you by members of the Infrared Equipment Division (IRED) of the Industrial Heating Equipment Association (IHEA). The group includes infrared (IR) curing equipment suppliers from throughout North America. We publish the column three times a year to give you the latest information about IR curing techniques and equipment. Contact information is at the end of the column. Most IR manufacturers offer testing for free or for a fee. Any IRED member can assist you in finding solutions to curing problems and best practices for finishing of coatings. This issue's column was submitted by IRED member company Weco International, Clio, Mich., who exclusively represents Ceramicx of Ireland for all of North America.

Choosing an infared emitter for your application

Selecting the correct infrared (IR) emitter is something that is widely overlooked and undervalued. Every material absorbs IR differently. Choosing the correct emitter will ensure the most effective heat work that will, in turn, yield the fastest cycle times. The best wavelength for a specific material will produce test results that show an even heating curve on both sides of the material along with the shortest time needed to get the result.

Planck's Law

The basics of IR need to be understood in order to improve any process. And, at its core, the IR process begins with Planck's Law. So says the Ceramicx Ireland research team, which recently published the technical report titled "Explanatory Notes on Plancks Law," which is authored by Dr. Gerard McGranaghan. Ceramicx is represented in North America by IHEA member Weco International.

Planck's Law describes the electromagnetic radiation emitted by a black body in thermal equilibrium at a definite temperature. The law is named after Max Planck, a theoretical physicist who originally proposed it in 1900 as the basis for quantum mechanics.

According to Planck's Law, as the temperature of any emitting surface increases, more and more energy will be released as IR energy. The higher the object temperature, the greater the amount of IR energy will be produced. As well as becoming more intense in terms of power, the emitted frequencies become wider and the peak wavelength becomes shorter. At very high temperatures, not just IR but also some shorter wavelength visible light will be produced. This is first witnessed as a dull red glow that subsequently turns to orange, yellow, and, finally, white.

Figure 1 shows typical Planck curves for a range of temperatures that have been plotted from 1,050°C to 50°C (approximately 1,922°F to 122°F). The red curve corresponding to 1,050°C exhibits the strongest output. It shows the highest power output and its peak is at around 2.5 microns. This is followed by the curve at 850°C where the peak energy is less than half of that produced at 1,150°C.

FIGURE 1

A depiction of IR distribution for various emitter temperatures from 1,050°C to 50°C.

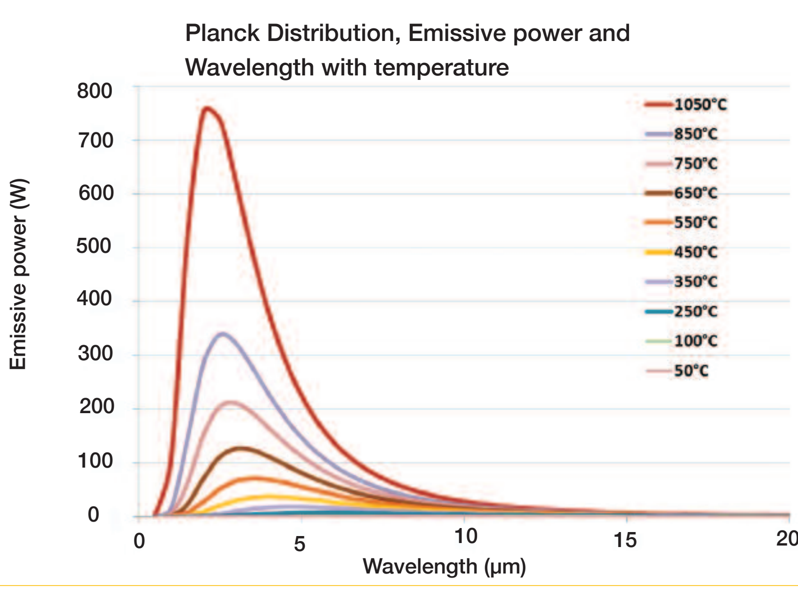
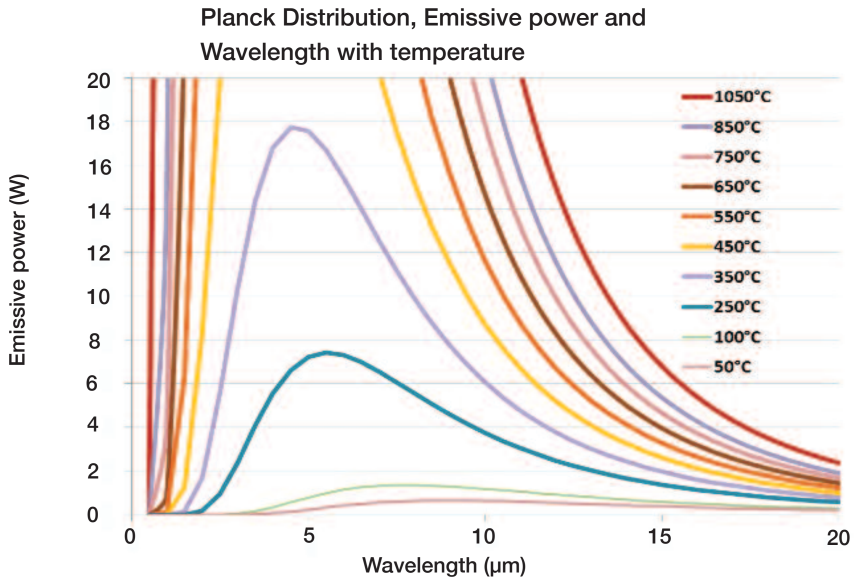


FIGURE 2

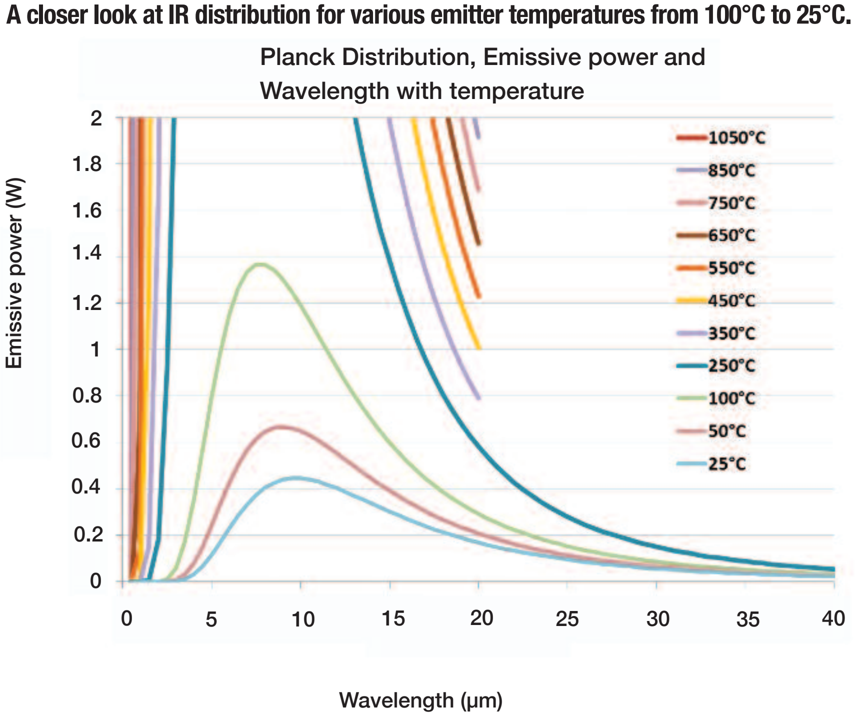
A close up of IR distribution for various emitter temperatures from 350°C to 50°C.



Every material absorbs IR differently. Choosing the correct emitter will ensure the most effective heat work that will, in turn, yield the fastest cycle times.

FIGURE 3

A closer look at IR distribution for various emitter temperatures from 100°C to 25°C.



As the temperature decreases, the energy levels also drop, and the peak energy wavelength shifts to the longer wavelengths. The lowest temperatures from the 250°C, 100°C, and 50°C curves cannot be seen in the graph. When the graph is enlarged to see the lower temperature curves, this shift to the longer wavelengths is more apparent. However, the power intensity drops significantly.

This shift in power intensity is shown in Figure 2. At 250°C, the blue curve can be seen to have an approximate peak around 6 microns, whereas at 100°C, the peak wavelength is around 7.5 microns. Note also that the extent of wavelength is more evenly distributed and doesn't exhibit the concentrated narrow peak seen at higher temperatures.

If we enlarge the same graph again and focus only on the lower temperatures as shown in Figure 3, we see that temperatures of 50°C and 25°C have peak wavelengths of around 9 and 10 microns respectively.

In the final graph shown in Figure 4, a curve showing the peak wavelength against temperature is shown. This is plotted from Wien's Law, which states that the black body radiation curve for different temperatures peaks at a wavelength inversely proportional to the temperature. The increase in peak wavelength as temperature drops is clearly seen.

In summary

As we've established, Planck's Law describes the electromagnetic radiation emitted by a black body in thermal equilibrium at a definite temperature. When plotted for various heater (emitter) temperatures, the law predicts both the range of frequencies across which IR heating energy will be produced as well as the emissive power for a given wavelength.

When selecting an IR emitter for a particular heating task, the target material absorption characteristics are of high importance. Ideally, the emitted IR frequencies and the target material absorption frequencies should match to allow the most efficient heat transfer. However, as depicted in the graphs, at longer wavelengths, the amount of energy transferred will be lower due to the lower emitter temperatures; therefore, heating times will usually take longer. To sum up, the shorter the wavelength, the higher the emitter temperature and the available infrared power increases rapidly. **PC**

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FIGURE 4

Wien's Law allows peak wavelength to be predicted from temperature.