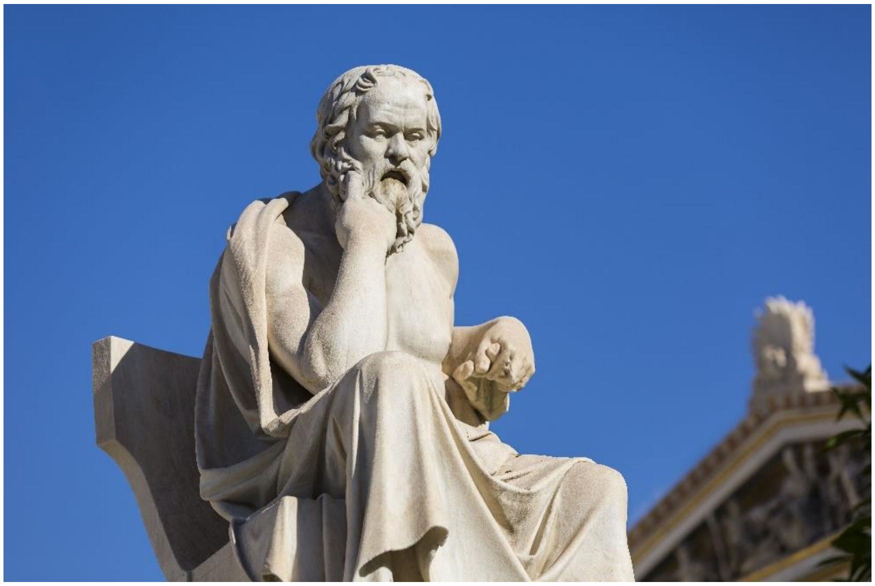
Socrates Helps Us Answer the Question: Can Emissivity Be Measured in Real Time?

By
Mark Ritzheimer
Senior Product Marketing Manager, Advanced Energy



In a previous post by my colleague Simon Wheeler, we called emissivity the "Achilles heel" of pyrometers. Why? Pyrometers are formidable industrial temperature measurement tools, but they have one weakness – emissivity is their Achilles heel.

At about the same time in history that the tale of Achilles was written, Socrates established the Socratic Method, a methodology for critical thinking that is based on asking questions to help determine what you do and do not know.

See, sometimes, you do know what you don't know. Just ask process and quality engineers using two-color (also called dual wavelength) pyrometers to monitor and control their processes. They know that the temperature of the product is changing because the material emissivity is changing. The problem is that they don't know *exactly* how much the temperature is changing, which is a very important question.

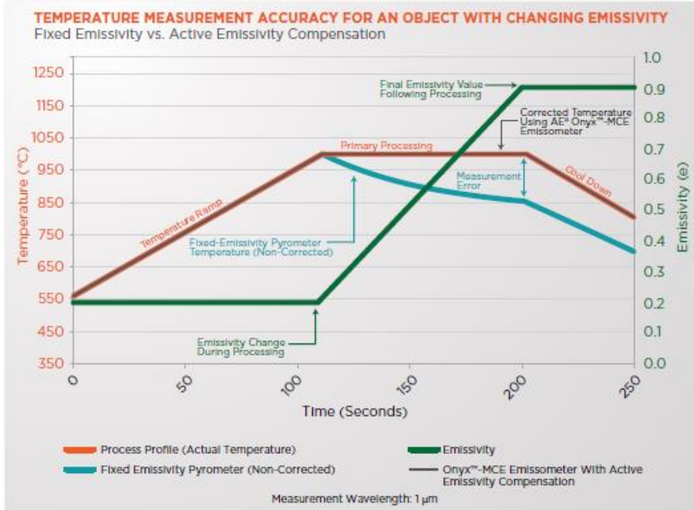
Why settle for average?
Two-color ratio pyrometers have been the solution of choice for decades. That's because calculating the average change in emissivity gave them a better answer to the question of how much the temperature was changing than earlier pyrometers, which analyze just one wavelength.

However, as capable as two-color pyrometers are, if the change in emissivity of one of the measured wavelengths is not consistent with change in the other measured wavelength, significant process errors can occur. Also, since the material surface properties of a material often change during the process, due to oxidation or introduction of coatings, the emissivity changes.

Advanced Energy recently pose this question: Instead of settling for an average, what if we could analyze emissivity in real-time, even under varying conditions, so that the pyrometer can measure temperature accurately even when the emissivity is changing?

I’m not sure that the Socratic Method was the inspiration behind the question, but I am sure that we’ve found an answer. Advanced Energy’s Onyx Series of pyrometers includes optical temperature measurement solutions that include two-color measurement as well as “active-emissivity compensation.” Active-emissivity compensation not only provides accurate temperature correction, but it is also able to report the exact change in reflectance (and corresponding emissivity, E=1-R) as a substrate is processed.

Take a look at the chart I’ve included, which tracks a process and measurement pyrometer accuracy for a fixed-emissivity and a pyrometer with active-compensation. You’ll see that the emissivity starts changing at about 110 seconds into the process. Shortly thereafter, the measurement error for the fixed emissivity pyrometer starts, while the Onyx MCE Emissometer measures precisely throughout the process – and enables steady temperature during the primary and cool down stages.



Next question: Is active compensation always the right answer?

This is an easy one. Obviously, “no.” A two-color ratio pyrometer can be the best solution, for example when there is something physically intervening in the view path between the pyrometer and the substrate, such as steam, smoke, particulate, or some type of contaminate on a window viewport. There are some situations where a two-color ratio pyrometer will help compensate for changing substrate emissivity, but it is more subject to errors (compared to active emissivity systems) and it is only a “passive” measurement. At no time can a two-color ratio pyrometer actually report the emissivity of the material; it is only trying to measure despite any suspected emissivity errors.

By comparison, active-emissivity compensation not only provides accurate temperature correction, but it also delivers more information about the substrate. The true emissivity value is also being reported at all times, which can open visibility into a process. For instance, a specific change in emissivity can be used to determine the progress of a thermal deposition process or be used for “end-pointing” where it’s possible to determine completion of a process. Because a two-color ratio pyrometer is passive, it can never report any specific information about the surface of the substrate.

Your turn. Any questions?

So, have I raised any questions for you? I hope so. As a supplier of both two-color and active correction pyrometers, we’re ready to discuss your process, the challenges you are up against in your processes and what we can do to better help you better understand and control them.