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EMISSIVITY ROBUSTNESS THROUGH GLASS TEMPERATURE CONTROL

HP INC

Emissivity robustness through glass temperature control

Abstract

Temperature control is fundamental for MultiJet Fusion technology and MetalJet technology. When monitoring temperature using a thermographic camera (or any other noncontact thermometry technology) it is important to set the camera emissivity setting to match the optical emissivity of the build material, otherwise the camera readings will not be correct. In some materials emissivity may vary from lot to lot and with recycling, it is therefore advantageous to make the printmode robust to powder emissivity variations. This can be achieved by controlling the temperature of the top lamps glass via pyrometer measurements.

Problems Solved

In some materials the optical emissivity changes between lots and with the recycling of the material. Process temperature control is done via thermographic camera, therefore the emissivity setting set digitally in the thermal camera may not match with the physical emissivity of the build material. A printmode which is robust to emissivity variations of the build material would bypass this issue.

Description

Basic concepts

- Every object emits radiation depending on its temperature. The spectral distribution of the emitted radiation is described by the Planck curve. An object that emits exactly as the Planck curve describes is called a **Black Body.**
- Most objects emit less radiation than a Black Body. If they emit 60% of the Black Body radiation, it is said that the **emissivity** of the object is 0.6.

Emissivity depends on the material an object is made of and on the surface quality (oxidized/pristine, clean/dirty, roughness, coating).

- Due to energy conservation, the emissivity of an object is equal to its **absorptivity**.
- Also due to energy conservation, **emissivity + reflectivity = 1**, (for non-transmitting materials) therefore low emissivity object are good reflectors.

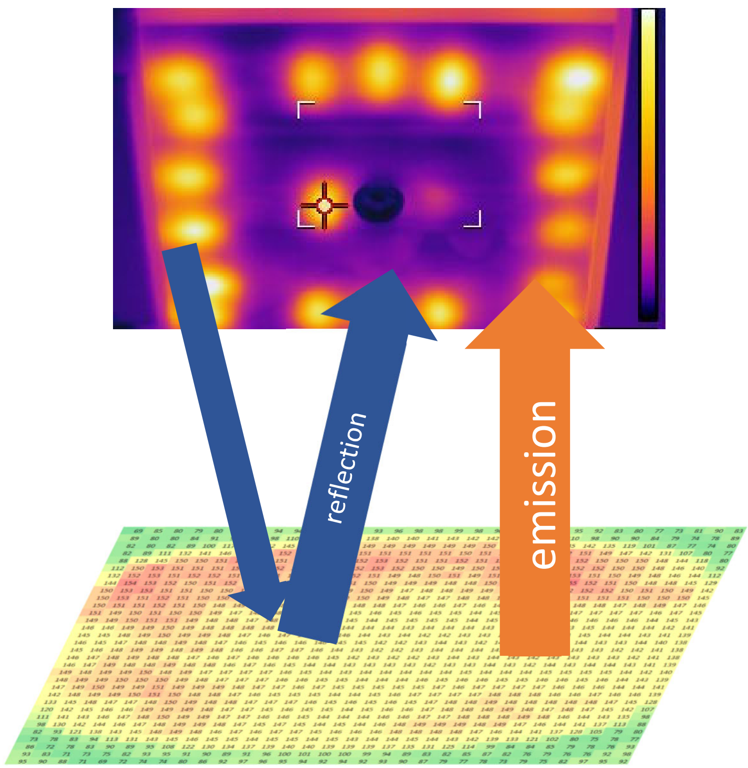

Figure 1: schematic of radiation thermally emitted VS reflected from a surface. Reflected radiation is measured by the thermal camera and contaminates the measurement.

When discussing the apparent temperature of low emissivity objects, it is essential to characterize what an object is reflecting. A low emissivity object at 100˚C emits far less radiation than a high emissivity object, but if they are reflecting a very hot object (at 200˚C for example), then the apparent temperature of the low emissivity object will be higher than that of the high emissivity object.

We rely on this phenomenon to remove the dependency of the thermographic reading on the material emissivity by controlling the temperature that is reflected.

Let us consider printing with a metallic powder of unknown emissivity and according to printmode setting we want to keep it at 60˚C during printing. Due to the print chamber geometry, the object that is reflected by the build material is the glass that covers the top lamps (see Figure 1), it has a large area, and its temperature can be controlled by the airflow flowing in the enclosure of the top lamps. We set the glass temperature to 60˚C. When the powder is at 60˚C, if it has low emissivity it gains in reflected energy the same radiation flux that is loses in emission. Therefore, when the powder is at 60˚C the thermal camera has no measurement error regardless of the powder emissivity (illustrated in Figure 2 There is a small error when the temperature fluctuates away from 60˚C, but the temperature control system will keep the powder to the 60˚C point.

The glass temperature can be measured directly and in real time with a pyrometer aimed at the glass and controlled by varying the PWM of the fans blowing air across the backside of the glass. This way the glass temperature is controlled without affecting the thermal conditions in the printing chamber.

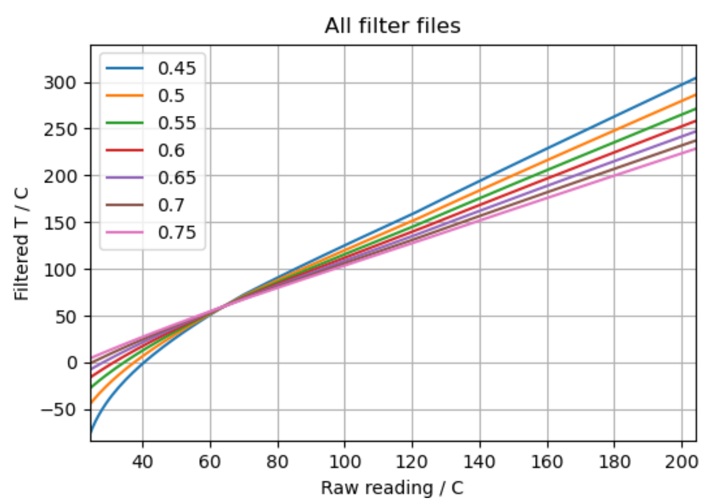

Figure 2: Thermal correction for materials with different emissivities, assuming a reflected temperature of 60C. At the intersection point all the curves the emissivity of the material makes no difference.

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