Midinfrared Temperature Measurement Technique Developed

Infrared thermography is the measuring of the temperature of an object by examining the spectral quantities of light emission. The microgravity combustion experiment Solid Inflammability Boundary at Low-Speeds (SIBAL) calls for full-field temperature measurements of a thin sheet of cellulosic fuel as a flame front moves across the fuel, and infrared thermography is the only technique that can accomplish this task. The thermography is accomplished by imaging the fuel with a midinfrared camera that is sensitive in the 3.0- to 5.0-μm wavelength region in conjunction with a 3.7- to 4.1-μm bandpass filter to eliminate unwanted infrared radiation from components other than the fuel.

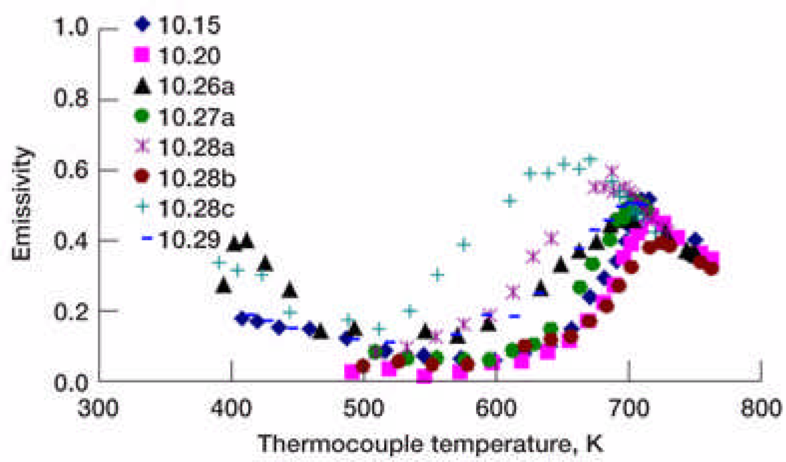
Problems have been encountered with the process of obtaining accurate temperature measurements from the fuel. The first of which is the wide temperature range that requires measurement. SIBAL calls for a temperature range of 420 to 1070 K corresponding to an in-band radiance ratio of 245:1-far too large a span for an infrared camera to cover in one "snapshot" since the entire range of temperatures will be in the field. Another problem encountered is that of the varying emissivity of the fuel as it burns. In typical cases, the emissivity remains constant over the temperature range of interest, allowing for a one-time calibration of the infrared imaging system. Unfortunately, standard calibration will not work for SIBAL thermography, because of the wide variance of emissivity.

A unique, multifaceted approach has been developed at the NASA Glenn Research Center for dealing with all the issues faced and to achieve the ultimate goal of accurate, full-field temperature measurements. First is the issue of the wide temperature span to be measured. This is accomplished by cycling through a series of integration times, each optimized to a specific range of temperatures and radiances. Each integration time must be calibrated beforehand to make sure that the combination of all integration times seamlessly cover the entire temperature range of interest.

Next is the issue of the varying emissivity. This is addressed by instrumenting the fuel surface with a small thermocouple for an in situ point temperature measurement. By comparing the point temperature measurement with the radiance measurement of a corresponding pixel group, temperature can be correlated to radiance, thus the system will be constantly calibrated. While emissivity will not be used in this scheme, it can be calculated from measurements at a later time.

These techniques will be pulled together and applied in image postprocessing. A software package is under development to parse images. This software will extract the optimized data out of an integration time that is within the calibrated range, while retaining the position of the images in the scene. The software will also correlate the temperature data with the measured radiance values and apply the correlation across the scene. Finally, it will bring all relevant and processed data into one composite image of accurate temperature data.

Preliminary testing has been completed and trends are evident in emissivity variance. An experiment rig is being completed to test the technique with higher fidelity instruments.



Preliminary test results showing wide range of emissivity variance and basic trends. Test used ashless filter paper at 4.0 psia with 21 vol% O_2 and upward burning.

Find out more about this research:
Glenn's Engineering Development Division http://www.grc.nasa.gov/WWW/EDD/

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