Thermal Spectrometer Signal Analysis

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Category

Products Used
LabVIEW 7.1
Ocean Optics S 2000-TR Spectrometer

The challenge
Develop a Data acquisition system to acquire data from an Ocean Optics S 2000-TR Spectrometer and analyze the data to determine the correct temperature based upon the light spectrum. This application is needed to check the temperature of a molten vessel of metal used to produce the product as well as verify the calibration of single use thermocouple like devices being produced. The need was to replace a method of using specially calibrated single use thermocouples during the quality testing of samples from a standard production run. By using the spectrometer instead of the older method a savings would accrue by only needing to use two calibrated thermocouples to calibrate the equipment programmatically and use it through out the day with multiple samples from the multiple production runs. This would be extremely helpful when ramping the vessel temperature up and down for each new batch of product that needed tested. The spectrometer provides the raw signal in wavelengths of light. This raw information then needed to be analyzed between 500 and 1000 nanometers of wavelength. All of the temperature values needed to be converted to Kelvin for calculations and returned to a degrees Fahrenheit or Celsius based on the users selection. The integration time for the detectors to establish a good signal-to-noise ratio without saturation needed to be set to an intensity of 3500-3900. The ability to exclude up to three variably-sized bands from analysis was required to eliminate known areas of wavelength that were not indicative of the true temperature. The resulting data would need to be collected in a file form as well as having the ability of taking screen shots and creating a BMP from a Chart.
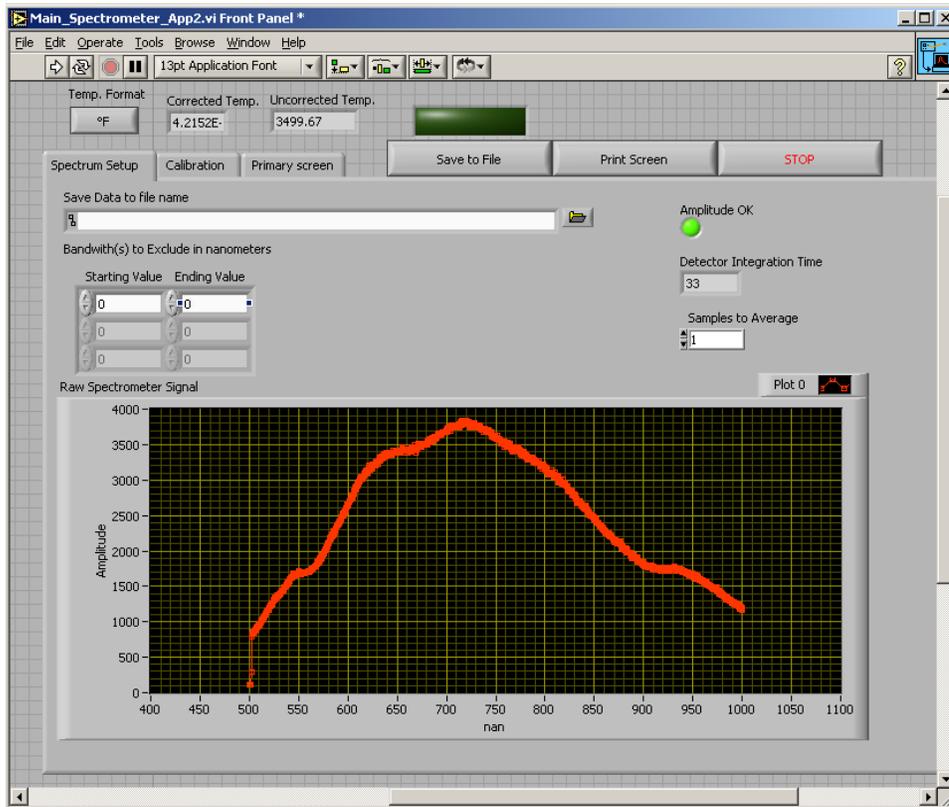
Figure 1

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The solution

Data Science Automation, Inc. (DSA) used National Instruments (NI) LabVIEW software to create the program. The program utilized the math functionality that is already provided in the LV library. The first step in the process was to remove any wavelengths below 500 nanometers and above 1000 nanometers. It was also very important to keep the amplitude between 3500 and 3900 to insure good signal to noise separation as well as not allowing the signal to become saturated. This was achieved by increasing or decreasing the integration time for the spectrometer. See Figure #1 to look at the raw spectrum shown as a red trace on the graph along with the integration time indicator and amplitude ok indicator. The next step was to allow a bandwidth filter to be applied to the incoming spectrum to remove up to three separate bands of the signal. The calibration procedure would take the signal of desired wavelengths and make a comparison to a Planck curve of the temperature being calibrated to. The operator enters 1st calibration temperature. This calibration is preformed on the low end of the anticipated range of temperatures to be read. An emissivity value of one is assumed for this temperature and a correction of emissivity will be calculated after the second calibration is preformed. A Planck curve is then calculated for the entered temperature. This Planck curve is then compared to the raw spectrum at each appropriate wavelength. A correction table (multipliers for each wavelength to transform the raw signal into the Planck curve) is calculated from the comparison of the raw information and the calculated Planck curve. See Figure #2 for the comparison of the calculated Planck curve in the thicker blue trace to the corrected raw spectrum using the multipliers shown by the yellow trace.

For each new raw signal set brought in the multipliers will fit the wavelength values to the Planck function and calculate a new temperature. The operator enters 2nd calibration temperature. The second calibration is taken at the upper limit of the expected range and a new emissivity value it calculated for the second calibration temperature. Once the new emissivity value is calculated a new emissivity value for every temperature between first calibration temperature (where the emissivity is assumed to be 1.0) and second calibration temperature (where the emissivity is calculated) is created. This calculation assumes a linear change between the values takes place. Values are also calculated for the range that continue both above and below the calibration points. The new emissivity factor applied to the uncorrected temperatures will provide the corrected temperature. The corrected temperature is then applied to a VI that allow for the operator to select smoothing for the temperature. This is an average of last 1-50 calculated temperatures. Once the smoothing is completed the corrected temperature is sent to the chart and the digital indicator. Temperature display starts out red before any of the calibrations have taken place. The temperature changes to yellow after first calibration. Finally the temperature turns green after second calibration has been completed. During the operation if any readings were desired to be recorded the operator only needs to depress the save to file button to have the data written to an Excel formatted spread sheet. This would allow the user to record the temperatures for attaching to passed or failed samples as needed. As an alternative the print screen could used to add the graphic representation to the information needed for documentation for quality prepossess.
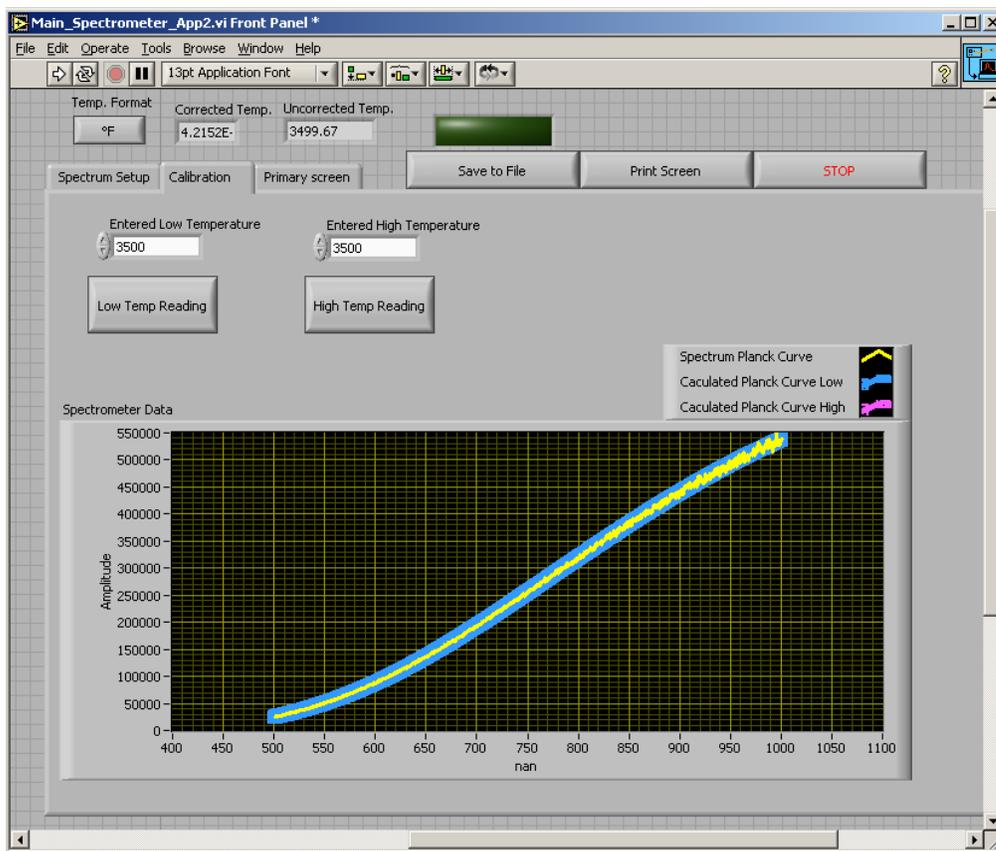

Figure 2

Summary

Data Science Automation, Inc. was able to construct the test application using National Instruments LabVIEW software in a timely and cost effective manner for our costumer. The end result was a more flexible application that could be easily maintained and provided a cost effective resource for checking the calibration of the produced product.