INCREASED ETHYLENE FURNACE EFFICIENCY AND CONTROL, USING VISION BASED TEMPERATURE MONITORING, AND VISUAL VERIFICATION

Ethylene is one of the most widely used base chemicals in plastic and polymer production, with approximately 150 million tonnes produced each year. One of the first steps in it's production is "cracking" light hydrocarbon gases (typically Ethane or Naptha). This takes place in a cracking furnace where the gas is mixed with steam, and passed through the furnace tubes to heat up to 750-950°C, before rapid quenching. The Ethylene cracking furnace is the single largest CAPEX item, and also the single largest energy consumer with an Ethylene plant (between 30-50% of the plant energy costs), so optimizing it, and avoiding component failures is of critical importance.

The single greatest cause of component failure and furnace downtown, is overheating tubes. If tubes overheat, it can lead to tube rupture, and possible escape of the feed stock into the firebox area of the furnace, which not only is a process issue, but also a safety issue. Constant tube temperature measurement, and process surveillance for any upsets which may lead to overheating tubes, is therefore of the utmost criticality.

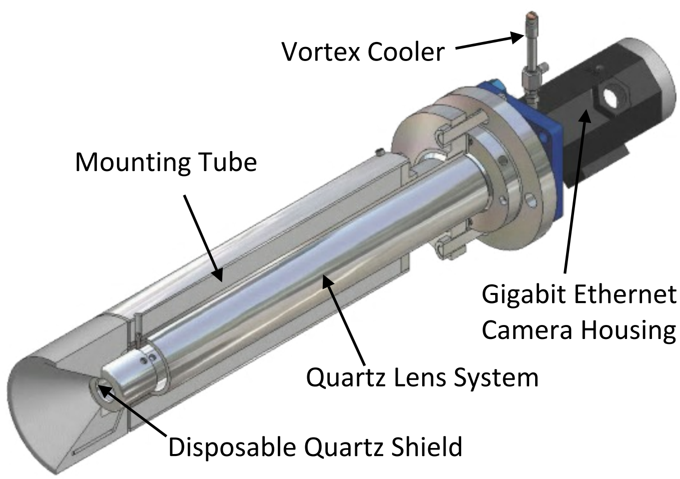
Canty can provide high temperature cameras to constantly monitor the tube temperature, as well as the tube position to detect tube distortion. Depending on where the camera(s) is mounted within the furnace, a view of the burners can also be provided, which will allow for individual optimisation of each burner. This assists in avoiding issues such as flame detachment, smoking burners, or flame impingement onto the furnace tubes.

Equipment & Installation

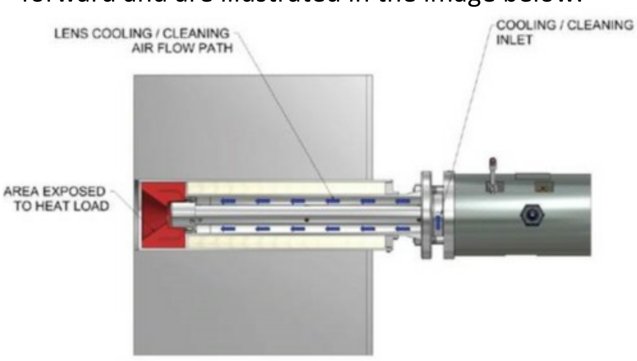
The Canty high temperature camera features high quality quartz optics, with system options for for process temperatures up to 1650°C (3000°F).

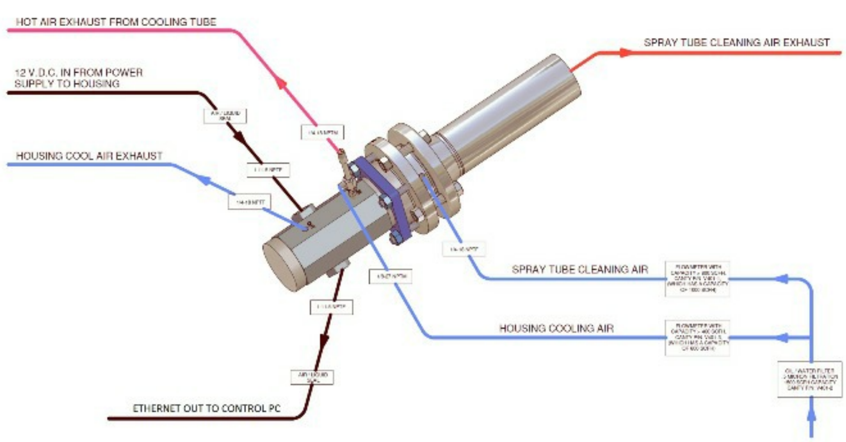
The electronics are cooled through the use of a vortex cooler, while a positive air flow over the lens through the cameras spray tube ensures the view remains clear at all times. A disposable and easily replaceable quartz shield protects the tip of the lens from any abrasion damage.

The high resolution Gigabit Ethernet camera captures the images from the process, and transmits them in the real time over a dedicated Ethernet connection to the control room PC running Canty image analysis software.



The camera system mounts through the furnace wall with it's mounting tube welded to the outer shell. The insertion section is tightly packed with refractory / insulation material to limit the thermal exposure to the system tip thus reducing the air requirements, and eliminating the need for any retraction system. The electrical, video and air hookup details are straight forward and are illustrated in the image below.



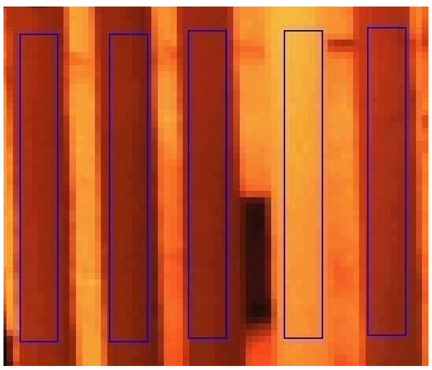


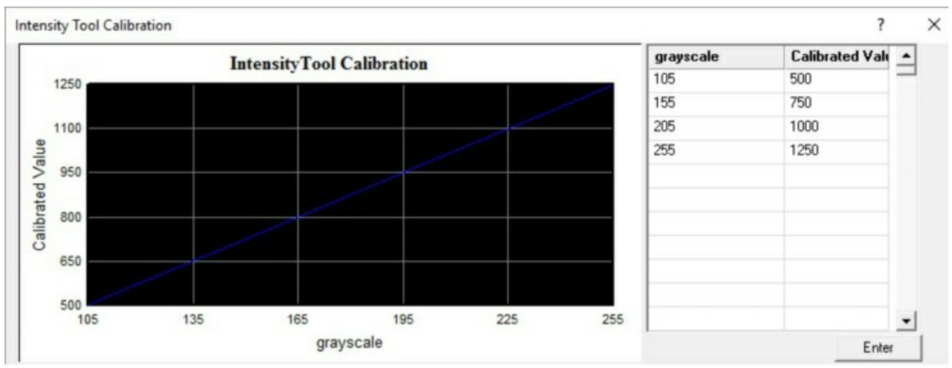
Vision Based Temperature Measurement

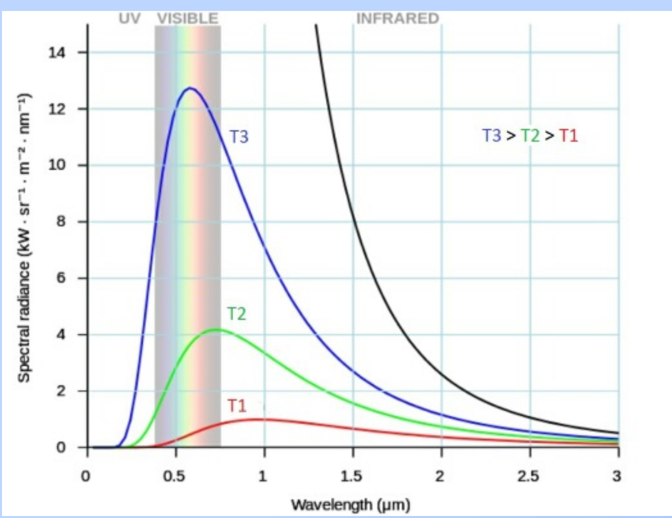
Continuous temperature measurement can be provided by using multi-band wavelength imaging pyrometry. Objects radiate energy across a wide spectrum including the visible band (above ~400°C / 750°F). Measuring the intensity of radiation at any given wavelength reveals the temperature of the object.

A camera system, operating in the visual spectrum, and capable of withstanding elevated process temperatures, is used to capture real time images from within an Ethylene furnace. The images are sent over a Gigabit network connection, to a control PC running Canty's image analysis software. Individual intensity measurement zones are positioned on the image, on each of the tubes within the camera field of view. Wide angle cameras, or multiple cameras may be used to maximize or extend coverage of the measurement area within the process. The raw intensity reading for each measurement zone is the Y component of the YUV colour scale, and is given a grayscale reading between 0-255 (0=black, 255=white).

This 0-255 value can be directly calibrated against a Degree Celsius or Degree Fahrenheit value. Once this is done the software operator screen will provide a graphical trend over time of the temperature in each measurement zone, along with the continuous real time process view. The temperature measurements can be outputted to the control system via OPC, 4-20mA or Modbus TCP/IP so that alarm condition triggers can be set to react automatically to any user defined process upsets such as an overheating tube)







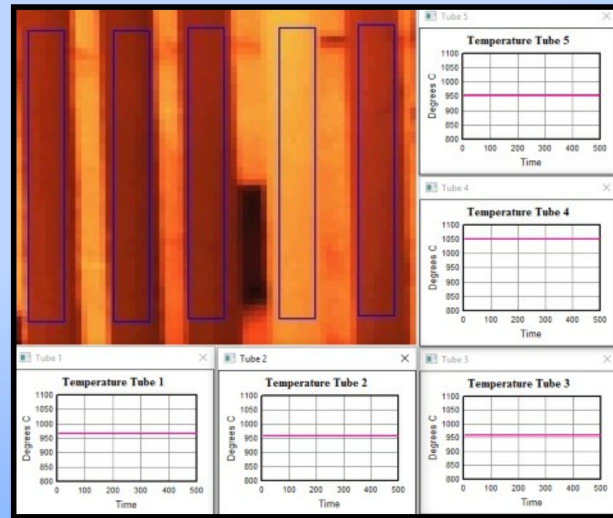
Emissivity Considerations

As seen in the graph opposite, the difference in thermal radiation or spectral radiance for various temperatures is greatest in the visible range. Also, the higher the temperature the more the power curve shifts left toward the shorter wavelengths eg. T3 vs T1. The intensity of thermal radiation coming from an object, is also dependent upon the object's emissivity (ability to emit radiant energy in comparison to a black body at any given temperature). Emissivity is also wavelength dependent and has a larger value at the shorter wavelengths. Therefore if the emissivity of an object changes over time due to surface changes, it is more accurate to use short wavelength instrumentation in order to minimize the error.

With the advancements in CCD technology, multi-band measurement has a number of advantages over 2 colour (2 wavelength) pyrometers;

- Target temperature measurement is integrated over a broader range of wavelengths, which minimizes variance in Emissivity.
- VIS (Visible Spectrum) 0.4-0.7µm allows a wide range of materials to be measured without recalibration or adjustment to emissivity.

Field Study - Tube Temperature



A Canty high temperature camera was mounted to a cracking furnace, through the refractory wall, and positioned to monitor an array of tubes. Intensity zones were set up on sections of the 5 tubes within the camera view and continuous real time scans were initiated.

After a period of time, the intensity reading for tube 4 increased significantly, which correlated to a temperature increase in the region of 100°C / 215°F. The increased temperature reading as measured and outputted to the DCS could be easily verified by looking at the camera image, where it is very clear to see that tube 4 is overheating.

The early detection of this temperature rise allowed to operator to rectify the issue with minimal disruption to the process, and get back to normal operating conditions as efficiently as possible.

Visual Verification & Other Measurement Possibilities

While the primary function of the system may be to provide multiple tube temperature measurement, the fact the system is imaging based an therefore supplies a constant remote visual from the process cannot be underestimated.

If using traditional instrumentation, the user receives a measurement value, but has no means to check exactly where the measurement was taken (instrument may become offset over time), and how it was calculated. In contrast, when using an imaging based system, the multiple measurement zones are displayed on the real-time image so the user can see exactly where the measurement has been taken (ensure it is measuring directly onto the tubes and eliminate the possibility of error due to an operator incorrectly directing their hand held pyrometer).

The software can also be programmed to monitor the position of the tubes, which can be used to detect any tube movement or tube distortion which can lead to measurement inaccuracies, and also be an early warning sign of a larger tube issue.

Depending on where the camera is mounted on the furnace, and the selected view angle of the system, it can also be used to provide surveillance of other features within the furnace eg. burners / flames. This allows the user to measure the flame size / shape, and also monitor for burner issues such as flame detachment, flame impingement on tubes, smoking burners etc. Monitoring for such issues allows the user to individually optimise each burner flame and therefore increase the process efficiency as a whole.