Using Infrared Cameras to Examine Tanks and Vessels

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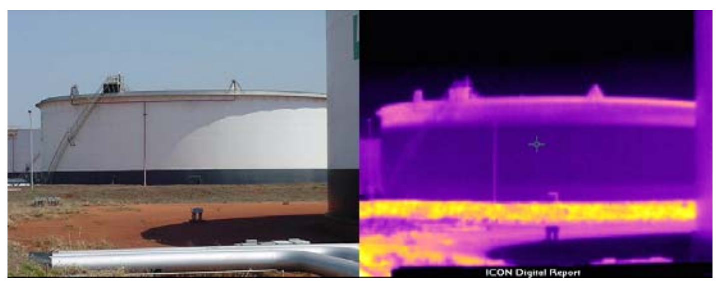
In industry, it is common to use infrared cameras to examine tanks and vessels, but why is there so much interest in this when the tanks usually already have level indicators to tell how much product is inside a tank? People who have worked in a manufacturing process area can likely tell horror stories of past experiences when the level gauge gave a false indication, resulting in either running out of product or worse, overfilling a tank that was supposed to be empty. As former President Reagan was noted for saying: “Trust, but Verify”.

Typical illustrative images from infrared cameras appear to exhibit “x-ray vision,” showing the contents of the container, giving quantifiable verification of the material inside. Infrared cameras however do not empower the user with x-ray vision. Infrared cameras do an excellent job of showing apparent thermal differences. When users apply their knowledge of materials and physics to the image of thermal differences that infrared cameras so easily produce, they are often able to deduce the level of fluid in the tanks.



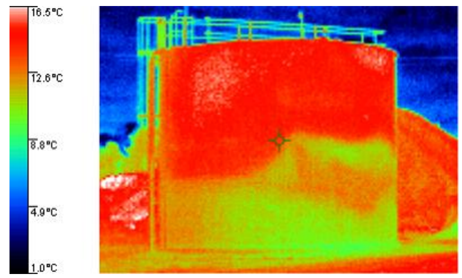
[IR image of a tank farm, showing how the liquid level is apparent in each tank]

Tanks, whether they are petroleum storage tank farms or the myriad assortment of tanks and vessels in a chemical processing plant, can be examined with infrared cameras. The meaningfulness of results of the examination are highly dependent on the knowledge of the person using the equipment and the type of result they desire. In the illustration of the tank farm, we clearly see the liquid level inside the tanks. We are able to see the level because the tank contains two different materials. In this case one is liquid petroleum, and the other is air in the headspace. Since these tanks are located outside, the tanks and their contents undergo thermal cycling. During the daylight hours the tank and contents absorb heat from the sun and the air, and also from whatever processing might be taking place. During the nighttime, the tank and the contents are giving up heat to the night sky. This thermal cycle and the varying thermal capacities of the various materials involved all contribute to the ability of the infrared camera to “see” the interior product level.

During the day the tank and contents absorb heat. These tanks which are constructed of metal, are un-insulated and are highly thermally conductive. As night falls, the headspace begins to cool quickly while the liquid volume cools much more slowly. As a result, one can observe the outside surface of the tank with the infrared camera and easily “see” the thermal gradient between the liquid and the headspace. There are typically two times of day when the thermal difference is at its maximum – once during the morning and once during the evening.

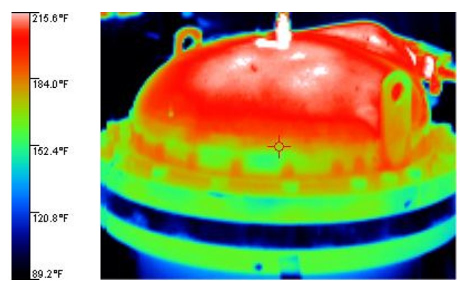
At other times of day, it may not be possible to clearly identify the liquid level with the infrared camera because the contents and the air in the headspace may approach the same temperature. Reflections from the sunlight during daylight hours can also make it difficult to observe thermal differences.

Tanks hold materials other than liquids, too. Dry bulk materials tend to pile up against the sides and have very uneven levels. Infrared cameras enable you to see these irregularities in level (see IR image at right). Also, many liquids contain particulate that may settle out inside the tank, forming a sediment layer. These layers can often be identified as sub straights by the thermal differences they produce.



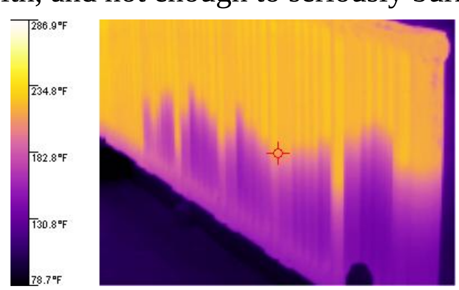
Understanding the materials of construction is also important. Many tanks have shiny metal surfaces and/or insulated walls. Low emissivity surfaces from shiny metals or insulated walls can make it difficult or impossible to observe the internal thermal differences. These factors are crucial for understanding what your infrared camera appears to be telling you. One must use caution and apply their knowledge to the information that the IR camera produces.

[IR image of a process reaction vessel]



As an illustration, let’s look at a process reactor vessel (pictured at right). The color temperature bar indicates that dark blue is approximately 95°F and the top of the scale indicates red at over 200°F. We see the dark blue band where the lid sits on the vessel, and this band appears to be cool. What we are actually seeing is a very low emissivity band of stainless steel around the top of this otherwise painted vessel. The painted portion has a much higher emissivity, so in contrast it appears the bare stainless steel is cool while it is actually the same temperature (over 160°F) as the painted portions that it is in contact with, and hot enough to seriously burn skin. Industrial processes often involve tanks that we do not necessarily think of as “tanks”. In process terms, we often refer to these vessels as “heat exchangers”. The most common heat exchanger tank is a steam radiator.

[IR image and photograph of a steam radiator]



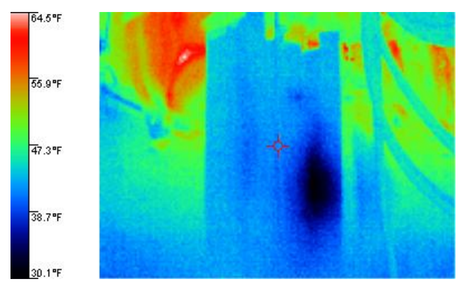
In this image you can clearly see where water is condensed in this radiator. This simple piece of process equipment illustrates how infrared thermal cameras can help diagnose problems in processes.

In another process example, there was a thermocouple installed in a stainless steel process line for monitoring the temperature of the process fluid. The process was not functioning properly and the process engineer was having difficulty determining why the temperature of the process stream was lower than expected even though the process fluid was being sampled and measured externally and observed having the proper temperature.

Since the piping was all stainless steel, the material surface was too reflective to directly observe the fluid level with the infrared camera. The process engineer applied some black electrical tape around the area of the pipe where the thermocouple was installed, and was able to then see with the IR camera that the pipe was less than 1/3 filled with the process fluid, and the thermocouple was barely making contact with the fluid, resulting in erroneous temperature measurements of the process. A vapor lock had produced the errant headspace, which the IR camera was able to reveal.

While furnaces and ovens are often thought of as vessels and are examined for heat loss, another interesting industrial vessel is a process freezer. This freezer was constructed to flash freeze meat patties. The freezer interior contains a custom spiral conveyor system that continuously inputs hot cooked meat patties from the oven, into a -40°F chamber to quickly remove the heat from the product.

Upon delivery, this industrial freezer exhibited numerous areas of condensation on the exterior surface. The condensation indicated areas where there were voids in the insulation system in the walls. The manufacturer had tried drilling holes in the metal side walls of the freezer where the condensation was located, to find the insulation voids, but everywhere they drilled the insulation was present.



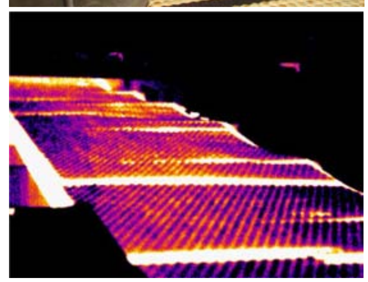
The exterior freezer walls are polished stainless steel, and so are very highly reflective. The areas of condensation were dried and black tape placed over the area. This allowed the exact location of the coldest spot to be identified with the infrared camera. When we drilled a 2 inch hole to observe the interior of the freezer wall, we found the exact location of the insulation void.

As these examples illustrate, tanks and vessels come in a wide assortment of styles and configurations from familiar looking tanks, to reactor vessels, to heat exchangers, and to ovens, furnaces and freezers. Even the piping connecting vessels is a vessel, although rather than being a storage container it is usually process paths.

Infrared cameras are extremely valuable tools for analyzing a great many more things than simply measuring temperature. While many people think infrared cameras are simply devices for making thermal measurements. Instead of merely thinking thermally, you should allow your mind to embrace the spectral and thermal dynamics of your materials and processes.

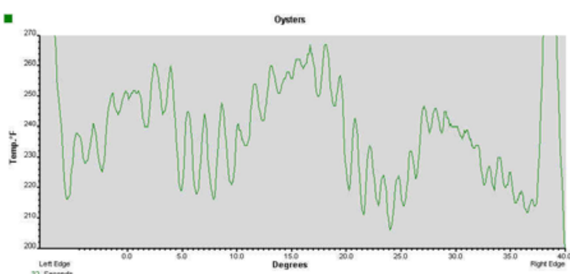
In applying infrared cameras to industrial processes, one should consider how the thermal properties of materials are exhibited in different ways to allow us to make measurements that are not simply thermal.

You can see how thermal gradients allow us to identify liquid levels in a variety of tanks. Products do not need to be liquid, as the same principle applies to vessels containing bulk materials such as plastic resin or grain, et al, where the level of the product can build up and be irregular instead of level.



Also, vessels for infrared thermal analysis can be the product itself. For example, we have a cookie/cracker production facility where crackers are being produced.

Moisture content in the finished product is critical. Think of the moisture content of the cracker in a similar fashion to the liquid level in a tank. In both cases, we want to know how much is inside. In this case, we have a fairly uniform mass of product that is passing through an oven. As the product emerges from the oven, the product that contains more moisture appears warmer and the product that contains less moisture appears cooler. This occurs because as the product emerges from the oven, it begins rapidly cooling towards ambient. Where it contains more moisture, it cools more slowly.



Using an infrared camera, we are able to observe the thermal zones of the oven, as well as a map of the moisture distribution of the product being produced.

Moisture content is a most interesting parameter because moisture can be measured directly using infrared analyzers. When light hits a surface that contains moisture, the moisture absorbs infrared radiation in the region of 1.8 microns. By measuring infrared absorbance, actual surface moisture can be measured. This moisture measurement is similarly reproduced by observing the differences in thermal cooling. So you can see how the spectral characteristics of materials can overlap and be indicative of one another.

The application of infrared cameras is limited only by the knowledge of the person using the equipment. IR cameras are rapidly becoming more economical and easy to use, but the camera is only as good as the person using it. Take time to examine your processes, understand your materials, and think about how the properties you wish to understand are related to the thermal characteristics. Infrared cameras produce useful maps of equipment and processes, as long as one takes time to understand the language.

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