Beyond the visible: Industry 3.91

Neil Simpson discusses the benefits of in-furnace thermal imagers to gain an improved level of understanding of glass furnace operation.

AMETEK Land’s five year development of an in-furnace Near Infrared Borescope (NIR-B) has taken the glass industry to another level of understanding of glass furnace operation. With over 324,000 continuously measured optical temperatures in over 50 end-fired and cross-fired regenerative furnaces, through case studies, it is possible to demonstrate the potential to use this data to further develop furnace controls to meet the needs of Industry 4.0 and optimisation of the furnace process. A picture, or in this case, a single thermal image, really is worth a thousand words and can convey complex and sometimes multiple ideas.

Current standard practice is for operators to take manual infrared pyrometer temperature measurements, often using AMETEK Land’s Cyclops and the frequency is really company and site-specific but at least once per shift. Whenever anything goes wrong on a furnace, one of the first things that operators should do is take an optical temperature reading at a predetermined point and time. Depending on the reading, furnace operating parameters may be changed, or alternative areas investigated.

An in-furnace thermal imager, such as AMETEK Land Near Infrared Borescope (NIR-B Glass), can measure up to 324,000 Cyclops equivalent temperatures continuously, or with its latest model release now nearly three million. Based on the emissivity used and measured temperature, the thermal imaging software generates a pixel of image equivalent to that of the measured temperature. The data collected is significant and the resulting visual images are excellent.

Batch flow focus

Before reviewing the additional thermal capabilities of the NIR-B Glass, it is worth considering that it gives operators the same views as a conventional CCTV system. The primary purpose is looking at the batch pattern. Time-lapse recording can be used for reviewing batch flows as a conventional CCTV. Since the image is based on thermal data, it is possible to add areas and apply alarms if cold batch reaches a certain point(s). Whenever an alarm is triggered, the image is recorded for QA and troubleshooting purposes.

The batch flows are initially impacted by the charging method/control and flames. However, once in free space, the flow patterns are driven by the thermal flows/convection currents. The same way that heat flows from hot to cold, the thermal currents follow the same thermal vectors.

The most important initial benefit of the NIR-B Glass is the ability to obtain a furnace thermal profile every reversal when the flames go out (or continuously in oxy furnaces). To take a thermal profile manually using a portable infrared pyrometer varies between three to six hours. Optimisation of the thermal profile is critical to yield, throughput, energy and hence emissions. In both cross-fired and end-fired regenerative container furnace case studies, the primary objective is to optimise the thermal profile. Once the thermal profile is optimised, burner work can be performed to lower emissions. By utilising a specific thermal palette and adjusting the temperature bands, it is possible to identify which port and which flame is the most intense or hottest, therefore generating the most thermal NOx.

The background to the end-fired case study was that an ageing furnace was struggling to achieve limits of NOx.
emissions. AMETEK Land was invited to propose different technical solutions, including new low NOx burners and in-furnace staging techniques.

As part of the assessment process, a brief NIR-B analysis was suggested to see if there was anything that could be achieved in the short-term. In February 2018, the NIR-B was briefly installed in the existing conventional CCTV location. Simultaneously, regenerator target wall measurements of %O2, ppm CO, ppm NO and ppm NO2 were taken using an AMETEK Land Lancom gas analyser.

The initial analysis unusually highlighted that the NOx was lower on the side with the single doghouse. Using the 'NOx Palette' confirmed that the flames were significantly hotter on the side with the NOx, with corresponding overheating of refractory at the charging end of the furnace (figures 1-5).

The batch pattern at the end of firing was completely different from firing from one side to the other. The Lancom confirmed that there were problems with calibration of the oxygen lambda probes and combustion airflow measurement. Re-alignment of the flow meter and reverting to ratio control brought the combustion closer to normal and gas was removed from the ports as a result.

Typically, it takes significantly longer to initially analyse the data than physically taking the measurements. By reviewing data at the flame-out furnace reversal, it became clear that there was a significant temperature difference between the exhaust port and target wall temperatures firing from one side to the other. By utilising the zoom and isotherm functions, it was possible to show after firing from left to right the target walls and temperatures were almost identical (figures 6 and 7). Firing from right to left, the temperature difference was 100 degrees. Clearly, there was a regenerator issue that was a partial blockage.

A three hour NIR-B thermal survey identified four significant issues that were all interrelated. They had impacted the energy efficiency and resulting NOx emissions. It was important to resolve the issues before trying new technology to lower the NOx emissions. The glass manufacturer increased the firing cycle and cleared the regenerator blockage, had the oxygen probes and annubar flow meter serviced before hiring a NIR-B thermal imager for 30 days.

With the original combustion equipment operational, stable combustion with consistent excess oxygen was achieved. By making an adjustment to the burner angles, the thermal profile was optimised by the customer. Further adjustments to the burner impulse settings were able to lower the NOx. Within 30 days, NOx emissions were within limits and no additional abatement equipment was required.

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