glass WORLDWIDE

Infrared thermal imaging optimises furnace operations and reduces NO_x

Mark Bennett looks at an innovation that is not only leading to the optimisation of glass furnaces but also the reduction of NO_x.

Over the years, a great deal of research and innovation has gone into developing methods for obtaining live temperature values within glass furnace applications. The AMETEK Land solution uses innovative thermal imaging via a Near Infrared Borescope (NIR-B), which allows for long-term data trending and the enabling of thermal optical profiles to be measured continuously.

Glass manufacturers, therefore, can use this infrared temperature measurement solution to highlight issues within a glass melting tank, make repairs for fuel optimisation and then optimise firing to achieve record pull rates.

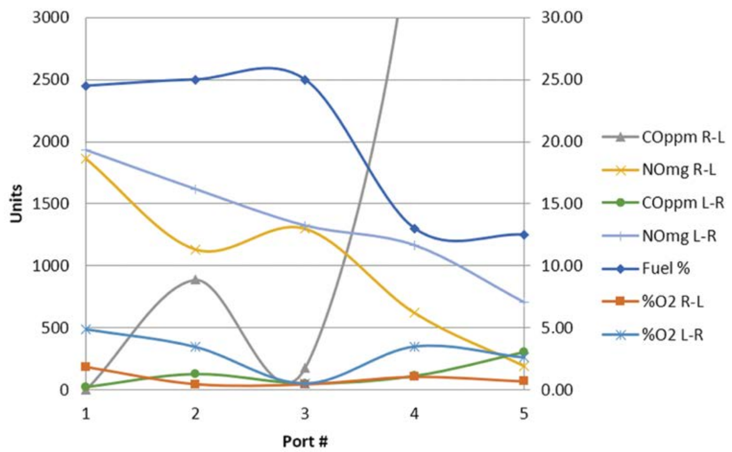
Investigations

Recently, research was carried out into the link between apparent flame intensity and corresponding nitrogen oxide levels within the glass melting process. These investigations were designed to establish whether, by identifying and controlling high temperature levels, this could help reduce emissions in a glass production facility.

NO_x formation is a non-desirable by-product of combustion or the melting process, in which typically - and in a simplistic form - at high temperatures, elemental oxygen reacts with nitrogen. In glass melting applications, a majority of NO_x formation is believed to be by thermal NO_x.

At temperatures exceeding 1600°C, the oxygen molecules in air start to dissociate into elemental atoms. The higher the process or flame temperature, there is greater dissociation and therefore, greater formation of NO_x. In the hottest zone of the flame, a super-equilibrium level of oxygen atoms exists.

The content of NO_x formed in a glass melting furnace is determined mainly by temperature, excess air, residence time above 1500°C and rate of mixing. Previous studies have found equipment and combustion staging methods lower the formation of NO_x. Fundamentally, this is achieved by reducing the rate of mixing and staging fuel and/or excess air to lower the flame temperature.



October 2016 target wall measurements.

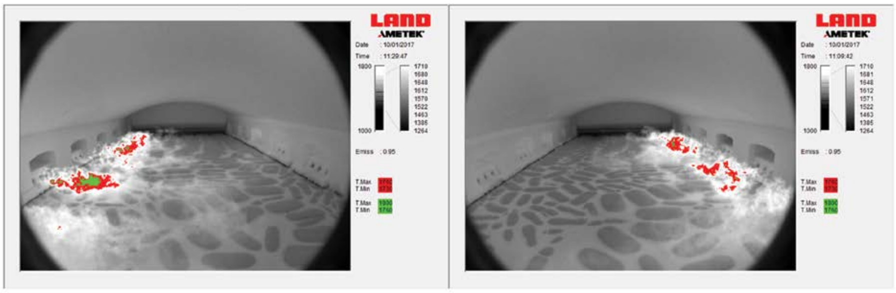
In-furnace installation

A near infrared borescope (NIR-B), in-furnace thermal imaging system was installed in 2014 by UK glass manufacturer Encirc on both its furnaces in Elton, Cheshire, replacing its existing CCTV system. In 2016, AMETEK Land started working with Neil Simpson of Simpson Combustion and Energy Ltd to optimise quality through effective temperature measurement in the glass industry. Together, the businesses worked at the Elton plant to use the temperature data from the NIR-B with additional data to improve the thermal efficiency of the process.

Since the plant has a continuously operating Selective Catalytic Reaction De-NO_x (SCR), an investigation of NO_x was not part of the original scope. However, as part of the initial survey, a Land Lancom gas analyser from AMETEK Land was used at the port target wall and common flue to check emissions prior to secondary abatement.

The Lancom analysers took port flue gas measurements and the data was analysed simultaneously with the in-furnace thermal images generated by the NIR-B. Comparing that information with historical data from 2014, it was determined that specific regenerators now


The Encirc Elton plant control room.



Fuel %	22.5	23.5	22.5	18	13.5	
	# 1 L-R	# 2 L-R	# 3 L-R	# 4 L-R	# 5 L-R	
% O2	1.87	1.15	1.21	0.82	0.43	
CO ppm	0	0	0	0	0	
NO ppm	865	1236	1385	1004	1036	
NO2 ppm	0	0	0	0	0	
NOx mg	1202.0	1655.0	1860.1	1322.3	1338.4	
	270.4602	388.9223	418.5334	238.005	180.6838	1496.605
	18%	26%	28%	16%	12%	

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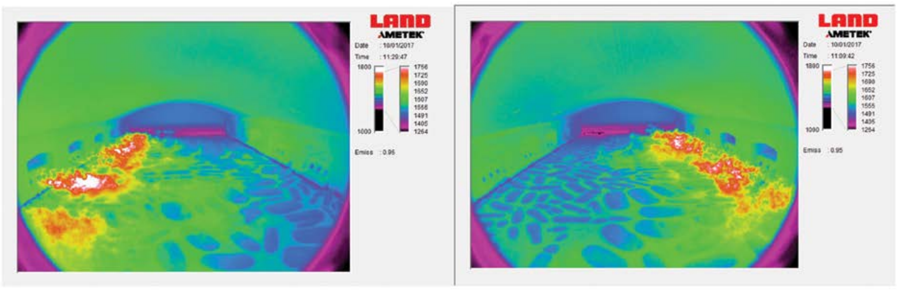
	# 1 R-L	# 2 R-L	# 3 R-L	# 4 R-L	# 5 R-L	
% O2	1.22	0.45	0.89	1.79	1.45	
CO ppm	0	128	0	0	835	
NO ppm	922.4	863	1269	806	634	
NO2 ppm	0	0	0	0	0	
NOx mg	1239.5	1116.0	1677.1	1115.4	862.0	
	278.8819	262.2581	377.3468	200.7661	116.3716	1235.624
	19%	18%	25%	13%	8%	

Flame temperatures V NO_x (1).



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Flame temperatures V NO_x (2).

had restrictions (cold temperatures) with overheating in clear ports that indicated higher than design port volume flow.

While the most accurate point in the process to measure and optimise the furnace thermal profile is at the end point of the firing cycle when flames are extinguished, data was obtained throughout the full firing cycle. During the analysis of the NIR-B thermal data, different filters generated different images, which highlighted different effects. One example was a monochrome negative, which highlighted areas of excessive cooling, air ingress and/or an undesirable hole in refractory.

By utilising one of the alternative colour palettes, apparent flame temperatures or intensities in excess of 1800°C, ie full-scale deflection, were highlighted in white. By adjusting the range limits to increase contrast, it was possible to determine what parts of the flame are the hottest and thereby, assess the generation of thermal NO_x. This temperature is not absolute, since it is beyond the range of the instrument and the emissivity of the flame is unknown.

By comparing the Lancom data for the NO_x in the flue gas with the NIR-B images, it became evident that the side with larger areas of temperature intensity had higher NO_x. The same phenomenon could be seen at an individual port level.

At this stage, the indication was not a quantifiable measurement of NO_x. However, it appeared to be a clear qualitative indication in which ports the highest NO_x was being formed. Based on the theory of thermal NO_x that with a higher flame temperature of the flame, there is a higher NO_x level. Therefore, the higher the indicated area of temperature above 1600°C, there is a larger reaction zone.

The data from the NIR-B revealed some compelling findings relating to NO_x production at higher levels. ●

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