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WGD Gas Fired Water-Cooled Throughport Burner

By Ad De Pijper
Eclipse Engineering Manager — High Temper Products Division

Generally, natural gas is injected into regenerative glass furnaces using either underport or side of port neck injectors. Both techniques have proven successful but in both cases there are compromises, in relation to flame position and characteristics. For example, in underport systems the nozzle velocity must be sufficient to inject the gas into the air stream but also low enough to develop luminosity (due to cracking). In side of port injection the flames tend to be vertical giving poor coverage. In both cases it is very difficult to position the flame accurately and obtain consistency.

Compared to traditional burner configurations, the WGD throughport burner offers the following advantages:

- The flame can be positioned very accurately
- The flame develops in the port to maximize heat transfer of the melt
- Mixing of air and gas is optimized because injection of gas is in the center of the air stream. This allows excess air to minimized to reduce NO_x and increase efficiency.
- There is minimum batch carryover because there are no high velocities near the batch
- High luminosity due to impinging jet technology
- High flame coverage
- One burner per port
- Low burner maintenance because the burners are retracted giving highly consistent operation and furnace stability.

In general, the disadvantages of the WGD throughport burner are:

- Water cooling is required
- The nozzles must be changed to alter flame characteristics (i.e, length and width)
- Mechanical equipment under the port may restrict access but takes up relatively small space
- Operating cost of the cooling water system
- Heat loss to water cooled burner (less than 2%, but offset by efficiency)

Burner Description

The flat flame throughport burner produces two ‘fan’ shaped gas streams at a relatively low velocity by means of a special nozzle design. In addition, the two gas streams impinge to promote gas ‘cracking’.

In order to positively control the impingement point and the direction, both nozzles are contained in a single water cooled jacket. This ensures precise location not easily achieved with angle side of port systems.

As the flames impinge in the horizontal plane the impingement tends to produce a wider, flatter flame (rather than a vertical flame) increasing flame coverage across the port width (Figure 1, page 2).

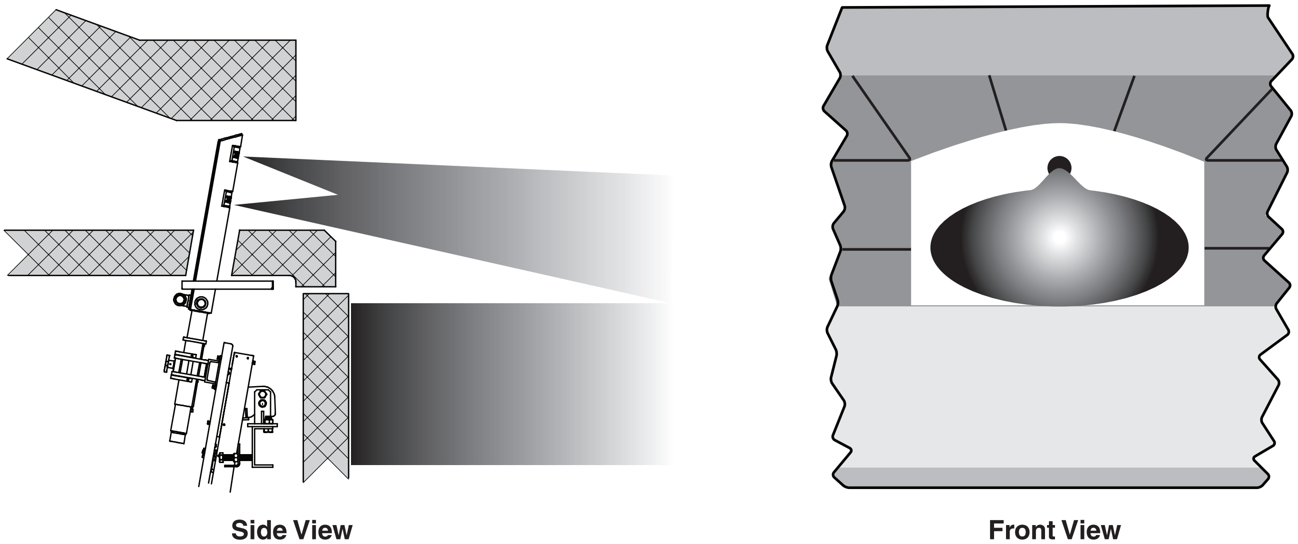

Figure 1: Impinging flames create a wide, flat flame.

<u>Burner Development</u>

An essential requirement of burning natural gas in a glass furnace is that the flame must be luminous in order to transfer maximum heat to the glass. This requires causing the bulk of the gas to be heated to a temperature of above 1,100ºC (2,000ºF) to 'crack' the gas and form carbon particles, which radiate to the glass (Figure 2).

CH_4 ! $C + 2H_2$

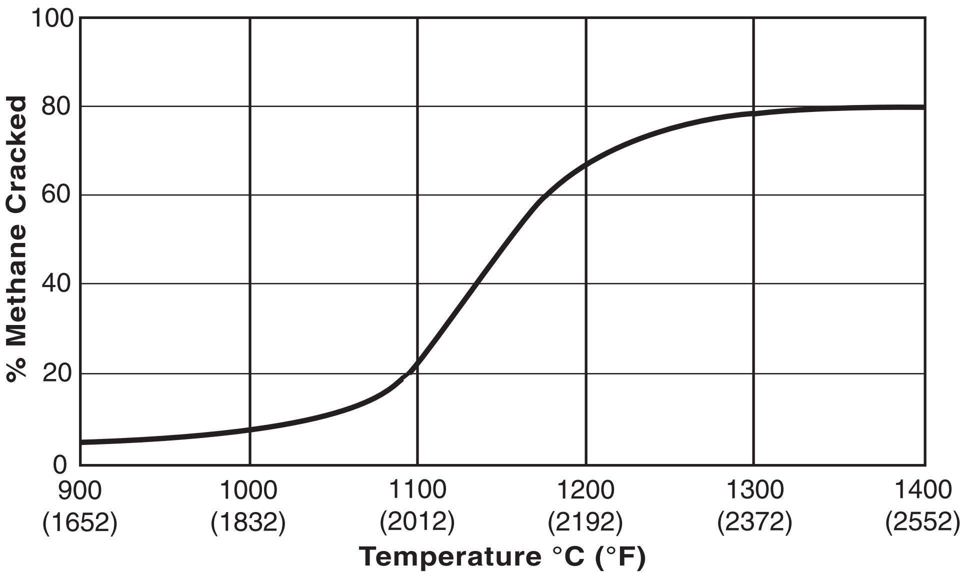

Figure 2: Methane cracking as a function of gas temperature.

One way of achieving this is to inject the gas at a low enough velocity that at least part of the gas stream is heated to 'cracking' temperature before mixing with air for complete oxidation.

Another method of promoting 'cracking' is to cause the gas to mix rapidly with a sub-stoichiometric amount of preheated air thus heating the bulk of the gas to cracking temperature. This occurs in side of port necks impinging jet systems, however, these are limited by large port widths requiring very high injection velocities and the tendency to produce "vertical flames" giving poor flame coverage thus reducing heat transfer area, and hence heat to the melt.

Initial tests with a single flat flame nozzle in a float furnace having an average heat flux of 150 kW/m^2 (47,500 BTU/hr.ft^2) demonstrated that there was insufficient heat transfer due to lack of luminosity but demonstrated the ability of the nozzle to produce a wide flat gas stream in the furnace so that only one burner port would be required even if ports were 2 m (6.5 ft) wide.

Subsequently a double nozzle burner was produced with two impinging flat flame nozzles having a spray angle in the horizontal plane of 80º (Figure 3).

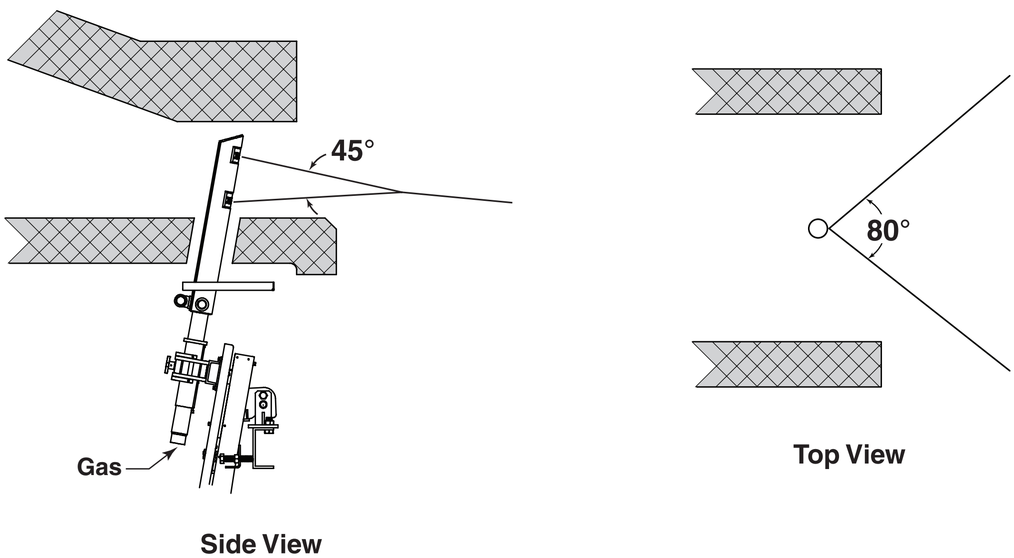

Figure 3: Nozzle spray patterns.

This burner was fitted into a float glass furnace having a width of 11.7 m (38.4 ft) and an average heat flux of 120 kW/m^2 (38,000 BTU/hr.ft^2) at the time of testing. The furnace was normally fired with oil using a throughport flat flame burner system so was easily adapted.

During the tests the furnace temperature (crown and breastwall) and regenerator top temperatures were carefully monitored. The difference between the furnace crown temperature and the regenerator top temperature indicates the relative amount of heat entering the regenerator and hence not entering the glass so that the larger the difference the better the heat transfer to the glass. Fuel consumption, airflow, excess O_2, CO_2, CO and NO_x were also measured.

A summary of these results is shown below (Table 1), where it can be seen that temperature differences almost equivalent to oil can be achieved. These tests also indicated that the melting rate could be maintained with heat input from the gas equivalent to oil.

Fuel	Crown to Regenerator Temperature difference, ºC (ºF)
Oil	160 – 180 (288 – 324)
Gas	155 – 170 (279– 306)

Table 1: Comparison of throughtport oil and gas firing

NO_x levels with the WGD burner were approximately 20% higher than oil, although relatively low compared with more conventional gas firing systems.

The tests showed that there are clearly optimum impingement angles and nozzle velocities to achieve maximum heat transfer. It was also shown that changing the relative amount of gas to each nozzle would move the flame up or down.

Tests over a period of several months showed that water jacket and nozzle have excellent durability. It was also shown that it is possible to accurately predict the flame length from any nozzle configuration and that this is largely independent of gas flow rate over a range of 500 to 1,000 Nm^3/h (17,660 to 35,320 scfh).

Burner design considerations

The following factors need to be considered when designing the WGD through port burner (Figure 4).

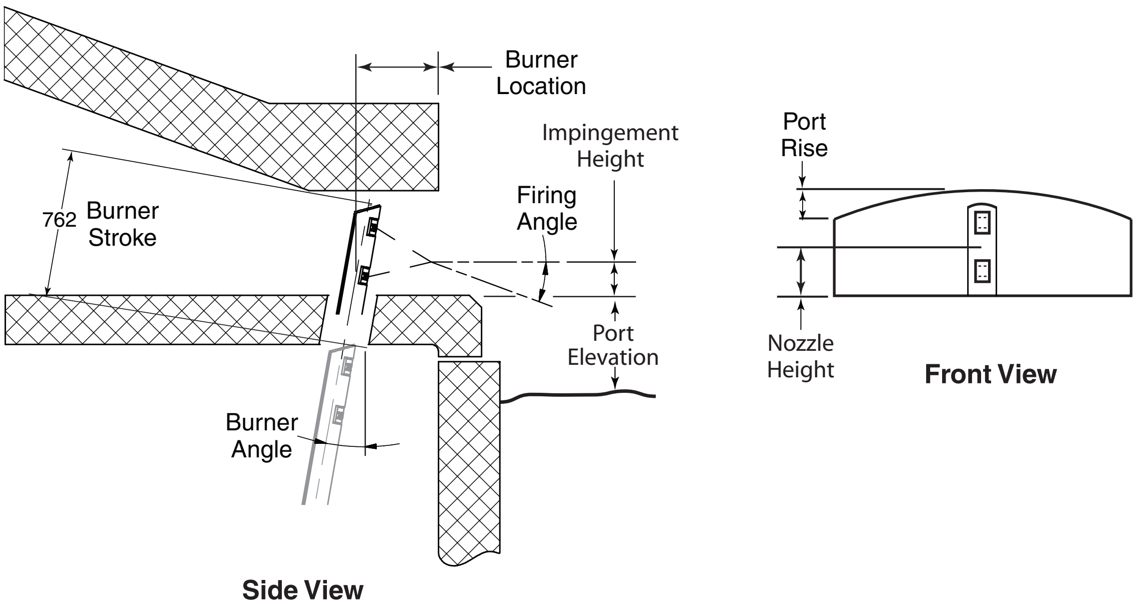

Figure 4: WGD burner design parameters.

- Burner angle
  The typical burner angle is 10 to 15º, and is determined by the port steelwork and furnace structural supports. The burner and retraction mechanism need to be located such that there are no interferences with the steelwork.

- Burner location
  The recommended burner location from the port mouth is about 350 to 400mm (1.2 to 1.3 ft), but should not be more than 600mm (2 ft). Prior to selecting the burner location, it will be necessary to review if there are restrictions on where the burner hole can be positioned in the refractory.

- Firing angle:
  The standard burner firing angle for gas fired burners is 10º down. If the port elevation exceeds 450mm (1.5 ft), the firing angle will have to be increased to prevent flame 'lift' (i.e., the flame is too far above the glass level).

- Nozzle height
  To optimize the way the gas is injected into the combustion air stream, the centerline of the burner nozzles should be located at approximately 50% of the port mean height (port area divided by the port width). With the standard burner firing angle of 10º down, the nozzle impingement height is approximately 40% of the port mean height.