Gas heating systems for working ends and forehearths.

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A reliable and efficient heating system for working ends and forehearths is an important factor in the achievement of stable and economic production, and as quality requirements for the final products climb, so the importance of the heating system increases.

Gas heated forehearths have typically been provided with a large number of small burners, installed on both sides of the channel, along the complete length of the forehearth. The burners themselves are relatively simple, and consist of a tube which ends in the so-called burner nozzle.

The burners are supplied with a combustible mixture of air and gas, and some method is provided to maintain the correct ratio of air and gas in the mixture. The amount of heat supplied to the burners is normally varied by using a motorised valve to vary the air pressure, and therefore the air quantity, before the gas is added.

The traditional low pressure system

The traditional system used to provide the air/gas mixture for the burners was based on an injector installed in the air line. The gas supply was passed through a zero governor, which was used to reduce the gas pressure to zero, before it passed on to the injector. The passage of the air through the injector caused a negative pressure to develop in the gas line coming from the zero governor. This drew gas through the governor and into the injector, where it was mixed with the air to form the air/gas mixture.

Any change in the amount of air passing through the injector would change the negative pressure produced, and would therefore also change the amount of gas inspirated.

This system was very simple and robust, and was used successfully for several decades. However, it did suffer from two significant disadvantages.

The injector had a relatively high pressure loss, and so despite a typical combustion air supply pressure of 80 - 100 mbar entering the system, the maximum mixture pressure at the burners was only about 18 mbar. A minimum mixture pressure of about 2.5 mbar is necessary at the burners to prevent the combustible air/gas mixture from back-firing. The range of 2.5 - 18 mbar limited the throughput range of the gas heating (minimum:maximum) to about 1:3.5, which was very limited for efficient control.

This limitation also resulted in significant energy wastage, as the low energy requirements of some forehearths were below the achievable minimum fire, and energy was often used unnecessarily.

The negative pressure produced by the injector and used to induce the gas into the system was only approximately proportional to the amount of air passing through the injector. In the centre of the injector range the relationship was reasonable, but in the outer areas the proportionality was lost and so the actual air/gas ratio produced was not stable throughout the complete operating range of the system.

The first generation of high pressure systems

A significant improvement in the situation was achieved at the beginning of the 1980s, with the introduction of the so-called high pressure heating systems.

The basic design of the new systems was the same as the traditional system, but the method of producing the air/gas mixture was improved. An injector was still used, but the membrane of the zero governor was loaded by a pressure signal taken from the mixture pipework downstream of the point at which the gas entered the system. Thus, the opening of the gas valve was influenced by both the negative pressure from the injector and the pressure signal from the mixture line.

The new type of injector reduced the pressure loss in the air line and made it possible to use a maximum mixture pressure of about 60 mbar. The resulting range of 2.5 - 60 mbar gave an increase in the minimum:maximum throughput ratio to about 1 : 7, thus significantly improving operational flexibility.

The more important improvement, however, concerned the stability of the air/gas ratio. Despite an effective doubling of the operating range this system was capable of providing a stable mixture over most of the range. The only significant divergence occurred at the lower end of the range.

However, the principle of operation of this arrangement relies on stable pressure relationships in the complete system. If there is any change in these relationships, the air/gas ratio will not remain completely constant.

Such pressure variations can occur in the gas line if pressure control equipment is not correctly dimensioned, or well maintained. A further, typical effect which can cause some problems is an effective decrease in burner nozzle diameter over a period, as a result of deposition of dirt.

Operational experience with such systems has shown a definite tendency for the air/gas ratio to drift over a period of time.

The SORG® VMC system

The VMC gas heating system works on the basis of a quantity measurement in both the gas and air lines. The measurement of both gas and air quantities compensates for any variation in the basic pressure relationships.

The VMC gas control valve is installed in the gas supply line and is used to control the amount of gas supplied to the system. A metering orifice unit is installed in both the gas and air supply lines, and the pressure drops across these restrictions are measured.

The pressure drop from the air line is connected to one side of a membrane in the VMC gas control valve, whilst the pressure drop from the gas line is connected to the other side of the same membrane. The membrane, which is connected to the gas control valve, is held in a balanced position by the same pressure drop from the air and gas lines.

As with conventional high pressure heating systems, alteration of the energy quantity is made by variation of the air quantity by means of an air control valve. Any change in the air quantity causes a change in the pressure drop across the air line orifice unit. This results in an imbalance on the membrane in the VMC gas control valve, and causes a movement of the valve until the pressure drops from the air and gas lines are the same again and the membrane is returned to the balanced position.

The air/gas ratio maintained by the system can be varied by adjusting the size of the metering orifice in the gas line to change the pressure drop measured at any given throughput. A simple mixer is installed to provide effective mixing of the gas and the air. A diagram of the VMC system is shown in figure 1.

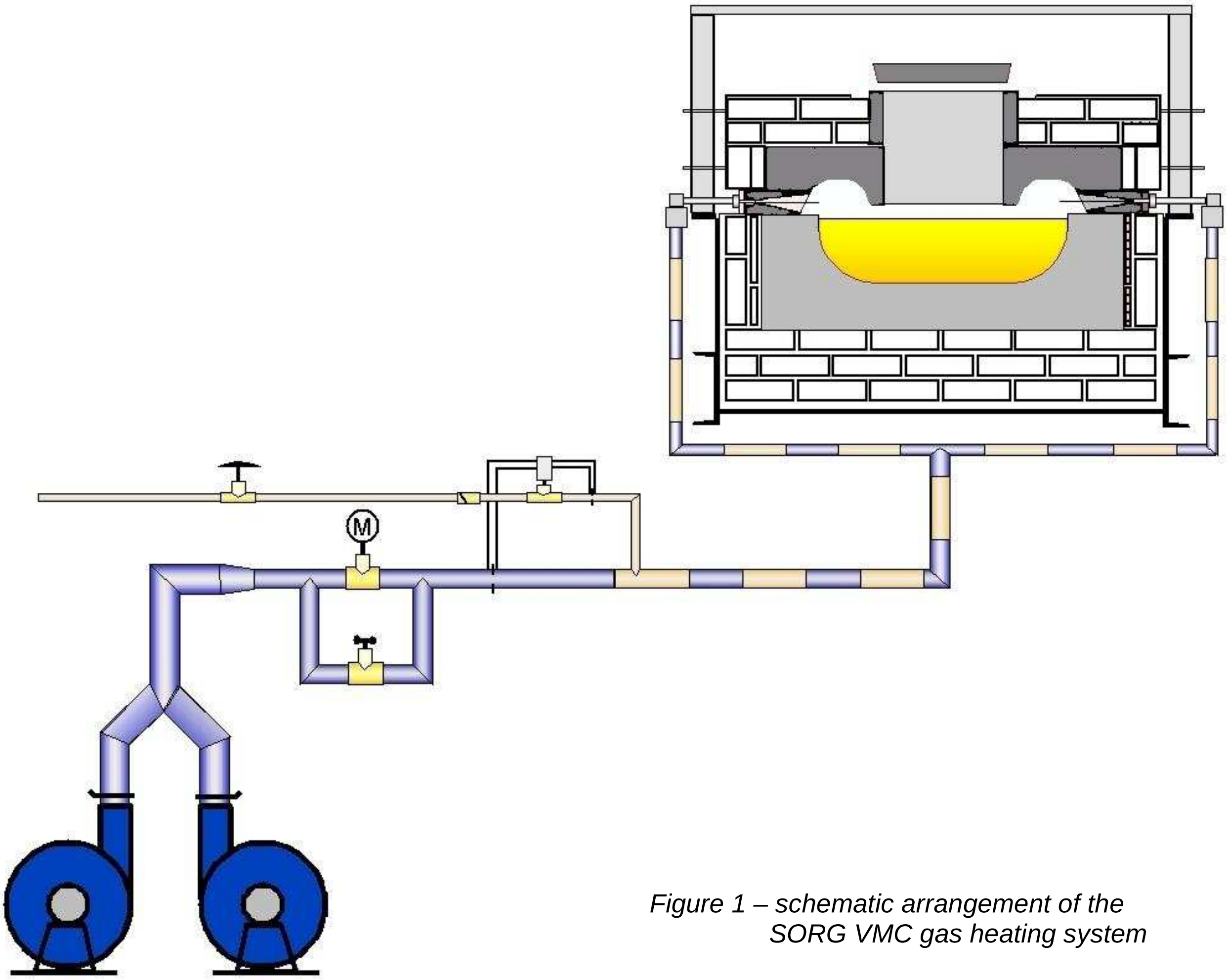

Figure 1 – schematic arrangement of the SORG VMC gas heating system

The VMC system uses most of the same components as conventional high pressure gas heating systems. The air supply and air control valve are retained, as are the burners. In the case of a conversion to the VMC system only the mixer and the gas control valve must be replaced.

SORG® has been using the VMC gas heating system for 7 years, and recently a competitor, who has also been convinced of the advantages of this system, openly and publicly referred to the system as “a touch of genius”. Although this may be an exaggeration, we can understand the enthusiasm.

Figure 2 shows an actual air/gas control station featuring the VMC system.

Figure 2 - 3 SORG air/gas control stations featuring the VMC system

Other recent developments
In addition to the basic change in the way in which the air/gas mixture is produced, as described above, there have been a number of other small but important improvements.

Burner nozzles

Burner nozzles operate in what can be a relatively hostile environment. They are surrounded by the refractory of the burner block, where the temperatures can be quite high. The only cooling available is that provided by the continuous passage of the cold air/gas mixture.

Although heat resistant steels are used for burner nozzles, some problems do occur, especially if the combustion air is not entirely clean. Any dust or oily contamination in the air will tend to lead to deposits on the inside of the nozzles.

In addition to reducing the actual heating capacity of the system, the deposits also limit the amount of air/gas mixture passing through the nozzle, which reduces the cooling.

This spiral may continue until the nozzle is almost completely blocked, when there is no longer any cooling available, and the nozzle will be destroyed by the temperature in the block.

This problem can be completely eliminated by regular preventive maintenance on the system.

However, it has been found that ceramic burner nozzles also offer a solution to this problem. The burner head has to be modified a little to accept the ceramic nozzle, but no other changes are necessary.

The ceramic is not subject to degradation at the temperatures found in the burner block, and there are indications that there is less tendency for dirt to be deposited on this material. SORG® have had ceramic burner nozzles in operation now for more than 2 years.

The only disadvantage of the ceramic nozzles is the lower resistance to mechanical damage which results from the basic properties of the material.

Oxygen trim

As indicated above, the SORG® VMC gas heating system is capable of maintaining a stable air/gas ratio over the complete operating range. However, there are some situations where it may be necessary, or at least advantageous, to be able to adjust the actual value of the air/gas ratio to specific values.

This might occur, for example, in the case of a colouring forehearth, where some of the colours produced may require a specific and carefully controlled atmosphere in the combustion space.

For such applications SORG® can supply an oxygen trim system. The core of the system is a reference burner which is fitted with a highly accurate zirconia oxygen sensor. The mixture from each zone is fed to the burner in turn, burnt under controlled conditions, and the oxygen content is determined.

The result of the analysis is displayed for operating personnel, and can also be coupled to the air/gas mixture control to provide an automatic trim function.

Safety

As already indicated the use of premix burners for this application has been common for more than 60 years, and the systems used are normally perceived to be safe.

Whilst this view is basically correct, we should not lose sight of the fact that the air/gas mixture used is inflammable, and there are a number of regulations which apply. At the present time safety regulations in all areas are being harmonised throughout the EU, and the European EN regulations which currently apply to the gas heating systems are contained in EN746, part 2.

There are some points contained in these regulations which are applicable, but are not always understood or implemented in the glass industry.

The gas supply must be provided with quick-acting safety valves, that will cut off the supply immediately a problem occurs. Such safety valves must be certified for this application by a competent authority. In most applications, and certainly in the case of working ends and forehearths in the glass industry, the regulations require that two such valves are installed in series, whereby the control of the valves must be linked so that they will close at the same time. In addition, the pipework between the two valves must be provided with a certified leak detector system.

Control of the valves has to be connected to both the air and gas pressures so that the valves can only be opened when both supplies are at the correct pressure levels. It is not sufficient to detect only the combustion air pressure.

A final subject which is relevant to operation of this type of system, as anyone involved will have noticed at some time, is the question of blow-backs. These can take two forms :

- A definite and very loud explosion within the pipework
- More or less stable combustion of the mixture at a particular location in the supply pipework

A blow-back can occur if the flame propagation velocity of the gas being used exceeds the forward velocity of the air/gas mixture. It is important that this condition does not occur at the burner nozzle, which is why a minimum pressure (typically about 2.5 mbar) must always be present at the burner. If a system is badly set up or maintained, then this pressure value may not be reached at minimum fire and a blow-back may occur. A similar effect will be obtained if there is leakage in the mixture supply pipe effectively reducing the pressure available at the burner itself. Finally, if burner nozzles become too hot and exceed the ignition temperature of the gas, there may be some combustion in the pipework, and in individual cases this can result in a blow-back.

So-called safety heads are used on some installations. These are spring loaded valves which are designed to open if the pressure in the pipework rises above normal levels, as it does in the case of a blow-back.

It should be mentioned that these valves often do not have the necessary certification for use as blow-off valves. We have also noted that these valves are often installed incorrectly, which reduces or eliminates their function. However, as it is simple to avoid blow backs, we believe that the use of safety heads is not justified.

A good example of this are installations heated with sassol gas, which is used in some parts of the world.

These are not provided with safety heads, and there are no problems with blow-backs, even though this is a well known problem with this type of gas.

Blow-backs will be avoided if the following conditions are met and maintained :

- Correct design and dimensioning of the system
- Correct setting up of the system
- Regular maintenance

It is a compliment to the foresight of those engineers who created the first forehearth heating systems, that we are still using very similar systems today, more than 60 years later. Modern developments have increased both the flexibility and the stability of the system, and numerous detail improvements have produced a system which is still more than capable of meeting current requirements.