Float glass production

The critical role of industrial gases

By Linde Gases

Although glassmaking dates back to ancient times, in many ways it reflects the same basic processes in today's industry. In the 21st century however, mass production of float glass to comply with modern building standards and changing legislation has become an art that the ancients could not have imagined. Playing key roles in this high-tech production of float glass are nitrogen (N_2) and hydrogen (H_2), along with an array of specialty gases with high levels of purity and extremely precise accuracies corresponding exactly to the application.

Within these pure specialty grades, purity can reach up to 99.99999% (7.0), guaranteeing fewer and lower levels of the impurities that cause problems in such an advanced production process, as well as in the associated analytical instrumentation and emissions monitoring.

Alongside glass for packaging, float glass used for glazing in buildings and housing accounts for one of the biggest single usages of glass in the modern world. Float glass production has been relatively unchanged for more than 60 years, but the final product has changed dramatically from a single equilibrium thickness of 6.8mm, to today's range from sub-millimetre to 25mm – exhibiting almost optical perfection.

Production overview

A commercial float glass manufacturing line comprises a series of steps that begin when a mixture of fine-grained ingredients, typically sand, soda ash, limestone, dolomite and some other minor elements, are combined and melted to form molten glass in furnace at temperatures reaching 1,500°C. The vast majority of float melting furnaces are regenerative furnaces which consume enormous amount of natural gas and air.

The subsequent steps of refining and homogenising occur in separate stages, driven by extremely high temperatures. This continuous melting process can take as long as 50 hours to deliver a quality of float glass free from inclusions and bubbles to the float bath. Here, with the essential employment of N_2 and H_2, the liquid glass floats on a bath of molten tin as it hardens and where its thickness and width are adjusted.

The next step is cooling, after which the glass is lifted out of the liquid tin onto conveyer rolls at a temperature of about 1,100°C and then into the annealing kiln or 'lehr'. The glass comes out of the lehr at about 350°C and is cooled towards room temperature by open air fans. It is then inspected for flaws. Before cutting with diamond wheels, the surface of the glass is treated with various coatings to impart particular properties and to provide separation of the sheets and stain prevention. The oxygen for the furnace can be sourced from air or supplied as pure oxygen. Natural gas is easy to handle and burns cleanly, producing a more favourable emissions footprint than the bunker oil or heater fuel sometimes used in this application.

To operate the burner efficiently, the plant should have various process control measures in place. A burner needs to achieve a precise ratio factor, or 'Lambda' value, of natural gas to oxygen for an optimal combustion process which is normally one-to-one, in terms of the amount of oxygen molecules and fuel coming in. If there is more oxygen than is required, there will also generally be more nitrogen than is required. And this will increase the amount of oxides of nitrogen (NOx) produced, which will have downstream consequences in terms of flue gas treatment or emissions.

Conversely, if there is too little oxygen and a surplus of fuel, the fuel will not be completely burnt, leading to wastage. Since methane is the main constituent of natural gas, the emission of this fuel into the atmosphere will also have global warming implications. The best way to ensure optimal operation of the burner is to measure and control the amount of oxygen in the burner flue gas to ensure there is a small residual amount of oxygen emerging in the escaping flue gases.

Although this is the most economically and environmentally efficient way to run the process, plant operators should guard against having a large excess of oxygen which could impact production costs. To achieve the right balance, oxygen should be measured in the furnace through a feedback process control loop, using instrumentation such as a Zirconia oxygen analyser, which is reliable and robust in this very hot operating environment. The instrument's sensor requires periodic calibration with a specialty gases mixture of typically percentage level oxygen in nitrogen, close to the measurement point, to ensure accuracy of measurement.

Control loops

While a feedback control loop is essential to measure oxygen levels in the melting furnace and make adjustments to the oxygen or natural gas being fed in, the more sophisticated feed forward control loop process control strategy, used in combination with the feedback control loop, measures gas levels coming into the furnace and enables operators to make predictive and proactive adjustments.

Feed forward control loops usually incorporate gas chromatography (GC) in this application to measure the quality of the natural gas coming into the furnace and allow for feed forward adjustments in either oxygen or the natural gas flow rates, based on the calorific or heating value of the natural gases coming in. This is a critical factor, since natural gas is fundamentally a mixture of gases whose composition changes over time, impacting on the total calorific value.

GC is often coupled with a flame ionization detector (FID) or thermal conductivity detector (TCD), both of which are established technologies that incorporate various specialty gases for their operation. All GC instruments

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require some kind of carrier gas, typically nitrogen or helium, to carry the sample through the GC column, while TCDs need a carrier gas such as helium or nitrogen, and FIDs require specialty gases such as hydrogen and synthetic air to operate the flame. Calibration gas mixtures are also required for the periodic validation of the instrument itself.

Final stages

Towards the end of the float glass production process, molten glass is 'fed' through metal rollers in order to smooth and 'iron out' any defects on the surface of the glass. In this extremely reactive environment, measures must be taken to prevent the glass from reacting with the rollers and other materials handling equipment, in order to mitigate damage to the final glass product and to extend the life of costly capital equipment.

This is achieved by injecting an atmosphere of sulfur dioxide (SO_2) around the equipment, so that the rollers and the sheets of glass are never actually in contact with each other. Instead, a very thin film of SO_2 gas reacts with the surface of the glass to produce desirable chemicals that prevent the glass, which is now at a temperature slightly above or below transformation temperature, from reacting with metals that would damage the rollers and compromise the quality of the glass. The dosage of SO_2 is critically important – too little or too much SO_2 can detrimentally impact the glass quality or the rollers. The gas supply system used to deliver the SO_2 is as important as the quality of the gas itself. The plant operator responsible for SO_2 delivery needs to ensure correct dosing under variable conditions, including an increase in production or a change to ambient conditions – particularly when changes in humidity become a factor, because more

SO_2 will react to a wetter atmosphere.

Linde is heavily involved in the supply of SO_2 for this application. The gas is usually supplied in 50kg quantities in cylinders or 500kg quantities in drum tanks where it is stored in liquid form until utilised in the production process in gaseous form. In addition, cylinders containing SO_2 need to be of robust construction, and there must be no ingress of moisture into supply lines creating a corrosive reaction. The demands made on regulators and valves in this environment are extremely high and components must be capable of handling such a corrosive and toxic gas.

Coatings for performance glass

The role of industrial gases continues to the final stages of float glass manufacture. The rare gas krypton can be used in a technology known as 'sputtering deposition' to coat the surface of the glass with a thin film of metal. This surface treatment maximises its energy efficiency and reduces the requirement for electrical heating in a building. This is often strictly specified for buildings in the US and in Europe to ensure these structures comply with energy efficiency regulations.

In a similar application, the specialty gas hydrogen fluoride is used to etch the surface of the finished glass. This highly aggressive gas produces a non-reflective surface on float glass and enhances other surface treatments. The etching process is particularly important for window glass used in buildings located in hot climates to minimise building refrigeration costs and deflect UV rays, which can be harmful to human skin. Additionally, silane (SiH_4) has proved itself to be a highly effective glass coating in reducing the ability of ultraviolet (UV) light to penetrate glass – particularly that which is destined for use in window manufacture. Silane helps to mitigate the adverse effects of UV rays on human health, including both short-term issues such as sunburn and potentially longer-term issues including skin cancer. These are of concern to health authorities, particularly in countries where intense sunlight and heat are unrelenting, such as in the Middle East region.

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Finally, the inert specialty gas argon or the much rarer krypton is injected between sheets of float glass when double or triple glazing is produced, to achieve superior sound and heat insulation properties that deliver significant energy efficiency benefits, while reducing condensation, dampness and noise levels inside the building.

Emissions monitoring

Glass manufacturing is a high-temperature, energy-intensive undertaking associated with the release of pollutants to air and water and emissions of greenhouse gases. Although an increased use of recycled glass reduces the consumption of energy and raw materials, recycling still requires extensive sorting and cleaning prior to batch treatment to remove impurities. Float glass production facilities are therefore obliged to monitor and control their emissions profile in order to manage the associated gaseous environmental pollutants such as carbon dioxide, oxides of nitrogen (NOx) and SO_2. Even when emission mitigating activities are in place, emissions still need to be monitored and controlled.

Typical stages in flue gas clean-up from the burner are DeNOx and desulfurisation via an SO_2 scrubber, occasionally with carbon dioxide knock-down, before gas is emitted to the atmosphere. In some technologies, as emissions gases flow through the DeNOx unit, ammonia is added to the flue gas to reduce the NOx back to their molecular nitrogen, while in the SO_2 stripper, various chemicals absorb the SO_2.

The glass industry in the US has long been regulated by the US Environmental Protection Agency (EPA) and European Union (EU) legislation is soon to follow and will impact large emitters of chemicals typically associated with glass production, as well as the emissions generated in producing recycled glass. The tighter controls will see glass furnaces in future being controlled and monitored in a similar manner to power generating operations, based on large-scale burning processes. gw

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