Heat oxy-combustion to contribute to COP21 ambitions

Air Liquide's energy-efficient technology was awarded at the recent conference on climate change in Paris. Luc Jarry* and Taekyu Kang** report on how heat oxy-combustion technology can be used to meet environmental needs.

Last December, the United Nations Conference of the Parties, better known as COP21, reached an agreement[1] to combat climate change. Together, the EU along with 185 nations pledged to limit the global average temperature to a rise 'well below' 2°C (3.6°F) compared to pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C.

Such an ambitious goal will require not only the immediate halt of greenhouse-gas emission increases, but also a serious effort to decrease emissions throughout the rest of the century. This global agreement will put immediate pressure on industrial processes, which account for one-third of global energy use and 40% of CO_2 emissions worldwide.

Meaningful change

Decarbonisation for fossil fuel-based industries has proven to be difficult.

Although industrial intensity (energy consumption per unit of value added) has fallen in developed countries since the 1990s, there still aren't enough alternative energy sources or innovation-based solutions available.

Therefore, the development of new technologies is crucial.

On the occasion of the COP21, the France-China Committee awarded heat oxy-combustion technology its 2015 Innovation Award focused on 'Climate Solutions'[2].

Heat oxy-combustion, based on oxy-combustion, is a technology that aims to reduce the environmental impact of the glass-melting process. It is recognised as one of the best available technologies for reducing CO_2 through fuel savings, while also reducing NOx and dust emissions.

Oxy-combustion is widely used within glass and metallurgical industries to improve the combustion process, reduce air-pollutant emissions and save fuel. The main principle of heat oxy-combustion is that heat extracted from the combustion fumes is used to heat oxygen and fuel, thereby improving oxy-combustion performance by 10%. Compared to air combustion, this technology provides up to 50% energy savings and up to 50% CO_2 emission reduction (excluding emissions generated for oxygen production).

Unlike current oxy-fuel technologies, which don't take advantage of wasted energy recovery from combustion fumes, heat oxy-combustion recovers a substantial portion of the heat lost through flue gases by indirectly preheating fuel and oxygen (***Fig. 1***).

To develop this patented technology, safe and reliable equipment is designed and fully integrated with glass-melting furnaces. This equipment is made of specific materials suited for hot reactants.

For more than 10 years, various materials had to be tested for cyclic oxidation, ignition and flame propagation with hot oxygen, as there was no industrial standard for hot oxygen-compatible materials (>200°C)[3].

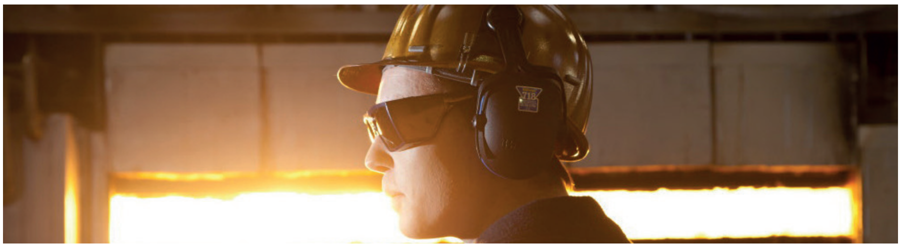
Safety studies and analyses of oxygen hazards have been extensively performed with top-notch institutes and experts from Germany and the United States to build know-how in hot-oxygen handling.

Three glass manufacturers – Pasabahçe Bulgaria EAD, AGC France and AGC Czech Republic – have validated the concept of preheating oxygen to 550°C and natural gas to 450°C for oxy-fuel combustion[4].

Heat oxy-combustion consists of the following technological components:

- Oxygen supply: Liquid Oxygen storage (LOx), or low pressure gaseous state through floxal oxygen, an on-site oxygen-production solution that provides the required quantity of oxygen supply.
- Glass melting technologies: A unique and patented combination of heat exchangers: one recovers heat from hot fumes to air; others transfer heat from air to fuel and oxygen.
- Burners: non water-cooled oxy-fuel burners made of specific materials to accommodate high-temperature fuel and oxygen.
- Valve trains: are automated control systems to monitor oxy-fuel burners and their fuel and oxygen supply systems.

Compatible with many types of fuel, all types of glass and a variety of furnaces, the technology can also operate with air, cold oxygen or cold fuel in backup mode. Such flexibility helps to reduce energy-sourcing dependency and associated risks.



Proven

As a new technology, heat oxy-combustion is improving in efficiency gains and competitive equipment cost.

In the near future, manufacturers can expect higher preheating temperatures, enhanced design and materials, and greater cost-efficiency.

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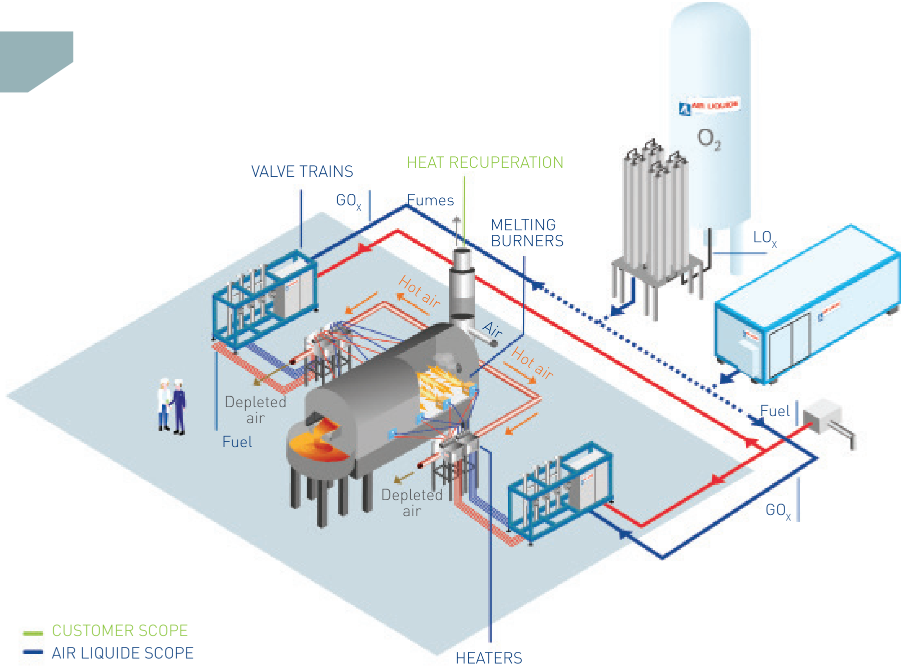

Heat oxy-combustion technology can also be implemented with energy-recovery systems, such as a compact Organic Rankine Cycle (ORC), which will be implemented on the discharged hot-air line after the oxygen/natural gas heaters to produce electricity.

The remaining hot air can be used for other purposes such as drying fibres or heating buildings of the plant and warehouse. Heat oxy-combustion equipment is then sized to maximise heat extraction from the fumes to supply hot air accordingly.

Many new greenhouse gas-reduction technologies were developed to recover the energy contained in the flue gas of industrial furnaces, such as steam boilers, electric generators, steam/ORC and synthesis gas CO-H_2 production by thermal or catalytic decomposition or load preheating.

For glass furnaces, most heat-recovery solutions have the major drawback of a lengthy pay-back time, sometimes equalling the full life of the installation. They also lack flexibility.

For example, a power-generation unit with an ORC cycle, installed to a glass furnace, reaches a maximum efficiency (20%) at a full-furnace pull rate, but decreases rapidly (15%) as soon as the furnace reduces capacity.

Others, such as syngas or load preheating, lead to changes in furnace operation. For broader deployment, heat-recovery technologies will need to manage capital-investment costs to achieve ROI in less than three years. Among these technologies, heat oxy-combustion helps to reduce Capex thanks to its way of transforming wasted energy into value.

The equipment needed to preheat lower volumes of combustion oxygen and fuel is less expensive than what is needed to preheat larger volumes of combustion air. Unlike other combustion-related technologies, heat oxy-combustion requires no DeNOx system to treat combustion fumes in the majority of cases, so manufacturers avoid all the extra investment, operating costs and waste associated with such a system.

Making strides

Taking into account the main cross-media effect of oxy-fuel combustion, represented by the upstream emissions of a power plant using electrical energy to produce oxygen, on average the reduced CO_2 emissions with oxy-combustion outweigh the emissions associated with the oxygen production itself.

CO_2 from oxygen production is extremely difficult to quantify and varies greatly depending on the case. The environmental impact of oxygen production is mostly due to the emissions associated with electricity generation. Estimating it requires taking into account the oxygen consumption, the method of oxygen production and the average emissions from electricity production as reported by national statistics.

▲ By heating pure oxygen and fuel with fumes, combustion performance is increased by 50%.

In addition to CO_2 reduction in proportion to energy savings, by preheating the natural gas and oxygen CO_2 emissions from combustion are reduced by an additional 10%, and CO_2 for oxygen production (compared to traditional oxy-combustion) adds another 10% reduction on top of that.

Global carbon footprint must be evaluated on a case-by-case basis. However, for every heat oxy-combustion reference, it has been demonstrated that the technology reduces CO_2 emissions.

In conclusion, heat oxy-combustion will enable the glass industry to comply with environmental regulations.

Its energy improvements have been validated by three industry references. A large reduction in NOx and particulate emissions was also reported.

This new technology is universal in that it can be applied to any type of glass or glass furnace. In addition, thanks to the simple concept of preheating oxygen and fuel with wasted energy from flue gas, the ease of operation makes the solution more attractive practically.

Combining this concept with patented process and component technologies from 10 years of R&D, heat oxy-combustion is safe, robust, flexible and affordable, and is expected to be rapidly deployed. ■

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www.airliquide.com/

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