ASEAN FEDERATION OF GLASS MANUFACTURERS
glass WORLDWIDE OFFICIAL JOURNAL

Optimum design concept for energy-efficient furnaces

Xuqing Xie discusses the AGCC approach to furnace design to reduce energy costs and CO_2 emissions.

It was in July 2018 that Asahi Glass changed its name to AGC Inc. The group's wholly-owned AGC Ceramics (AGCC) subsidiary started making refractories in 1916 and provides products and services in the fields of glass, aluminium, cement and incineration etc.

Dating from 1976, the AGCC engineering business has built various glass furnace types, including recuperative, side-port, end-port and oxy-fuel combustion furnaces for container, tableware and sodium silicate glasses. Reducing fuel consumption is becoming increasingly important to protect the global environment. The AGCC design concept contributes to the management of these issues.

Energy saving design

Fossil fuel is used as the main energy source to melt containers, tableware and sodium silicate. To reduce fuel consumption, it is necessary to improve the insulation and heat recovery efficiency. These improvements should be realised while considering the balance with glass quality and furnace life. AGCC has addressed this issue for many years and has achieved several successes.

Ecolead is the name of the AGCC design. Figure 1 shows actual energy consumption results for furnaces, when comparing side-port, general end-port and Ecolead furnace designs without electric boosting. The X axis is the furnace pull, while the Y axis shows the unit consumption. As a general rule, the unit consumption of an end-port furnace is better than from a side-port design. Ecolead is better than the general end-port. For example, for a pull of 200 tonnes/day, the unit consumption of the end-port design is over 10% less than a side-port. But the unit consumption of Ecolead is +5% less than the end-port.

Efficiency and cost of electric boost

Electric boosters can heat glass effectively and are widely used. Since the glass is directly heated by electricity, it is efficient and can easily realise pull and glass quality improvements.

The blue line in figure 2 shows the change of total energy consumption against the amount of electricity in a 250 tonnes/day furnace that uses gas combustion and electric boost. Energy consumption is improved by increasing electrical power, because electricity is directly applied to the glass.

On the other hand, the red line in figure 2 shows the change of total energy cost for gas and electricity calculated by equation 1. Gas and electricity costs are calculated using prices in Japan. As the power of the electric boost increases, the amount of gas used can be reduced but the total energy cost increases. This is due to the fact that the efficiency of electrical energy is better than gas combustion and the price of electricity is more expensive than gas. In the Japanese market, therefore, fossil fuel is used as the main energy source and electricity is used as necessary.

CO_2 emissions comparison

Fossil fuels emit CO_2 as shown in equation 2, so the CO_2 emission of

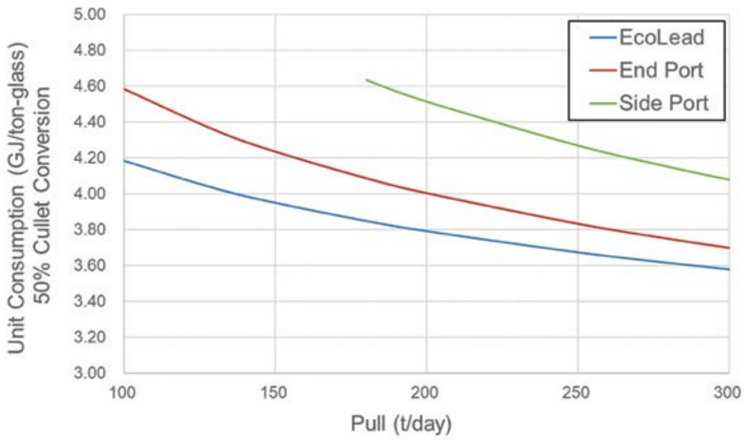

Figure 1: Unit consumption comparison of glass furnaces (without electric boost).

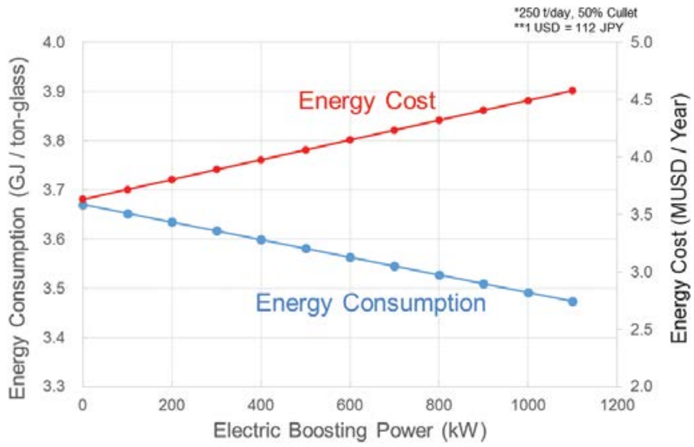

Figure 2: Relationship between energy consumption and cost in Japan.

$$\underset{\text{USD / Year}}{\text{Energy Cost}} = \underbrace{\underset{\text{GJ / Year}}{\text{Gas amount}} \times \underset{\text{USD / GJ}}{\text{Gas price}}}_{\text{Gas}} + \underbrace{\underset{\text{GJ / Year}}{\text{Electric amount}} \times \underset{\text{USD / GJ}}{\text{Electric price}}}_{\text{Electricity}}$$

Equation 1: Cost calculation equation.

ASEAN FEDERATION OF GLASS MANUFACTURERS

This article is based on a paper presented by Xuqing Xie at the 42nd ASEAN Glass Conference in Yogyakarta, Indonesia, held in September 2018. **www.aseanglass.org**

Glass Worldwide is the official journal of AFGM

Xuqing Xie addresses the 42nd ASEAN Glass Conference in Yogyakarta, Indonesia, in September 2018.

each energy source should be considered:
$C_xH_y + (x+y/2)\ O_2 \rightarrow x\ CO_2 + y/2\ H_2O$ ... equation 2

Table 1 shows the comparison results of CO_2 generation of each energy source in Japan. The CO_2 emission factor in table 1 is a value indicating the average CO_2 emission from city gas, fuel oil C and electricity in Japan. Results of the three summarised cases show that city gas is the lowest CO_2 generator, while electricity and fuel oil C are almost the same. This means that using electricity does not necessarily lead to CO_2 emission reduction in Japan.

Because most power generation in Japan uses fossil fuel, there is CO_2 emission at the power plant. The loss of electrical transmission gives the effect to energy efficiency. In fact, it must be considered on a case-by-case basis, depending on the country and location where the furnace is constructed.

Electricity has low CO_2 emissions in the furnace. However, it cannot remove CO_2 emissions totally because the fossil fuel is also the energy source for power generation. So, CO_2 is generated in power generation plants and sending loss from the power plant to the furnace increases CO_2 emissions.

Energy source for power generation in Japan and ASEAN

Figure 3 shows the energy source for power generation in Japan and ASEAN. In Japan, almost 75% of power generation is generated from fossil fuel. For Indonesia, the Philippines and Thailand, fossil fuel is also the main energy source for power generation; Indonesia is over 85%, the Philippines is nearly 70% and Thailand is also over 85%. In these countries, the CO_2 emission factor and energy cost appear very similar.

As a general rule, the life of a glass furnace is very long, sometimes more than 15 years. Figure 4 provides a perspective of the world's electricity demand. Energy demand is expected to increase in the future but fossil fuels will still be the main energy source for power generation, at more than 50%. Under this trend, the use of energy saving furnaces is very important. AGCC will continue to create a value through ceramics technology to protect the global environment.

Insulation material and design

AGCC's key material for insulation is called THERMOTECT (TMT). In 2015, this material received the grand prize for excellent energy solutions in Japan. It has many excellent properties such as high thermal insulation at high temperatures, low ageing degradation and human body-friendly (non-refractory ceramic fibre).

AGCC uses TMT for ports, regenerator walls, breast walls and crowns, as shown in figure 5. The material has already been adopted in many furnaces. Customer feedback is that TMT exhibits no degradation compared with conventional insulation materials, as in the example of figure 6 (continued on page 92).

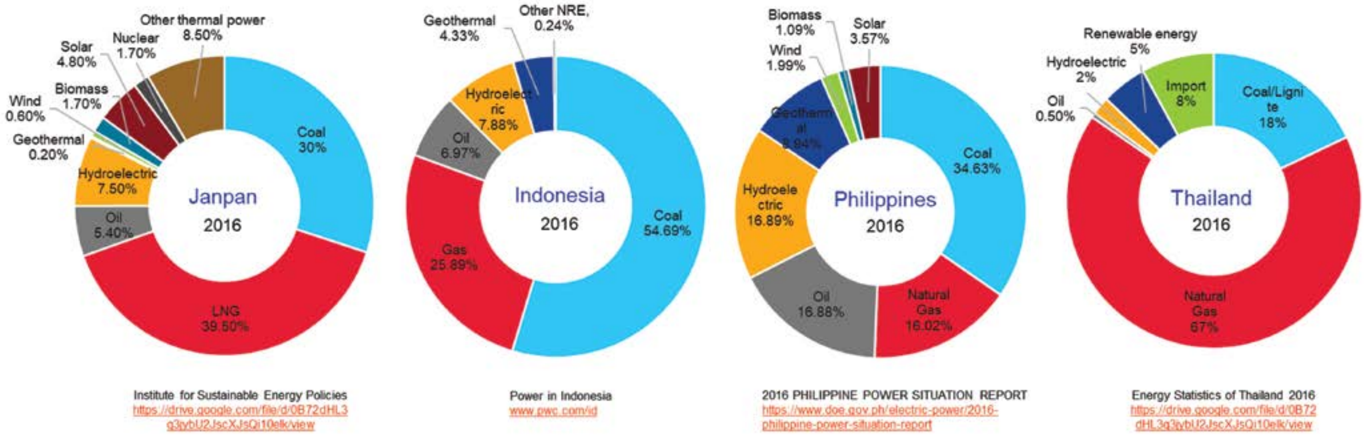

Figure 3: Energy sources for power generation in Japan and ASEAN.

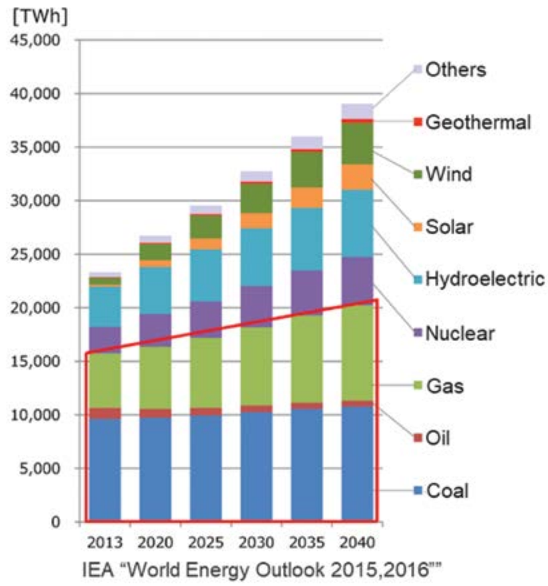

Figure 4: Global electricity demand.

	CO_2 Emission Factor (t-CO2/GJ)	Energy Efficiency	CO_2 Generation (t-CO2/GJ)
City Gas	0.050	40%	0.13
Fuel Oil C	0.072	40%	0.18
Electricity	0.144	85%	0.17

CO_2 Emission Factor / Energy Efficiency = CO_2 Generation

Table 1: CO_2 generation comparison for each energy source in Japan.

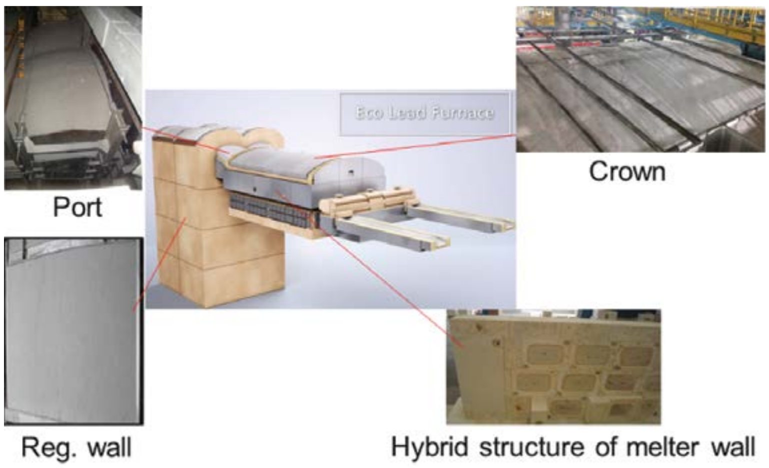

Figure 5: THERMOTECT application for glass furnaces.

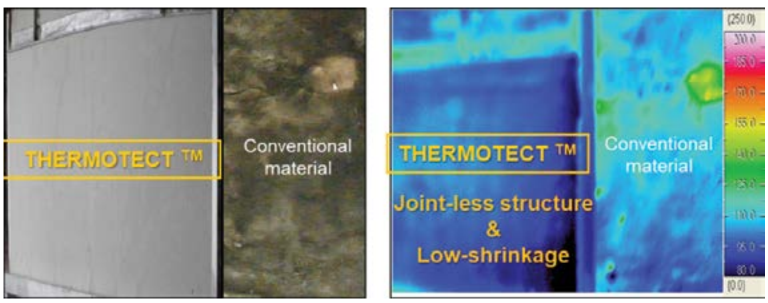

Figure 6: Thermo viewer imager comparison between TMT and conventional insulation materials after 2.5 years' use.

Conclusions

In order to reduce energy costs and CO_2 emissions, it is important to combine optimal energy sources, depending on conditions in every country and location. Reducing fuel consumption is becoming increasingly important to protect the global environment.

In addition, the combination of materials and design technologies must be balanced and energy saving needs must be addressed in the future. ●

About the author:
Xuqing Xie is Manager at AGC Ceramics

Further information:
AGC Ceramics Co Ltd, Takasago City, Hyogo Pre, Japan
tel: +81 79 447 7626
email: kyokusei-sha@agc.com
web: www.agcc.jp