The Future of the Glass Industry is All-electric

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Executive summary

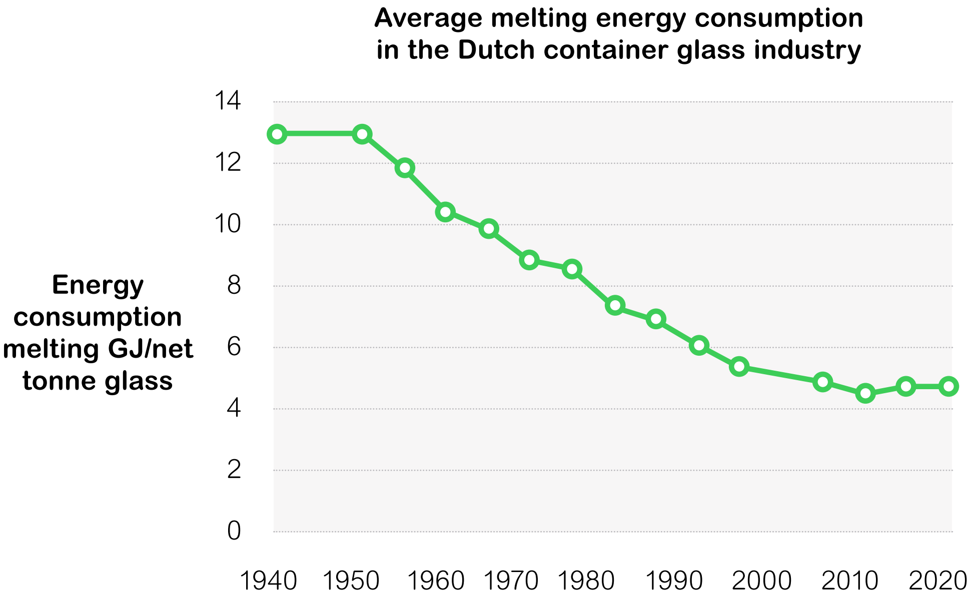
The burning of fossil fuel as an energy source in the glass melting process results in unavoidable carbon emissions, and improvements to traditional technology have reached their efficiency limits. Moving to electrical heating methods has many benefits including improved energy efficiency, more flexible control, and lower combustion-related emissions. The aim of this paper is to stimulate glass manufacturers into rethinking their existing melting technology and considering "all-electric" melting in the near future.

Introduction

Glass melting has been carried out for nearly 6000 years, and for most of that time wood was used as the energy source. It wasn't until around 1880 that the industry began to use fossil fuels like oil and natural gas. At this time, the regenerator had already been invented to improve the efficiency of steel blast furnaces and was soon adapted by the glass industry for early side port furnaces, very similar to how we know them today. During those thousands of years of glass making, less than 150 years' worth of fossil fuels were used and it is possible that they will not be around for another 150 years. Although new fossil fuel resources have recently become available, the world has at last begun to understand that burning them results in unavoidable carbon emissions, and therefore this method must come to an end. Glass melting still needs to continue at this point in time because we have not yet discovered a viable replacement material. It is therefore likely that glass will be around for many centuries to come and that the inevitable future for a carbon-efficient glass industry will be "all-electric".

History

With no disrespect to past furnace design developments and the great achievements that have been made, they are mostly still based on original technology. Traditional side and end port furnaces are proven technology that has been developed and tweaked to a level of efficiency, low emissions, and lifetime that simply cannot be improved any further. Since their efficiency level came down to 2.4 MWh/ton in around 1990, no big improvements have been achieved. Consequently, further CO2 and NOx emission reductions slowed to halt as well. Oxy-fuel firing, batch pre-heating, waste heat recovery, submerged burners, etc. are great advances but the bottom line remains the same: they all increase the complexity of the melting system and CAPEX, do not avoid CO2 emissions, and in most cases cannot reduce NOx emissions any further. The use of fossil fuels has become the fundamental problem and technology cannot overcome these issues sufficiently.



SOURCE: NCNG – CelSian course on glass technology specific energy consumption of dutch container glass furnaces

The fuzziness of politics

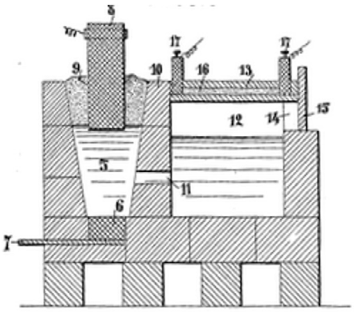
Just like many other raw materials, as soon as we start believing that resources are running out we find new ones. That is also applicable for fossil fuels, so why should we even start considering diverting from fossil fuels? Science has proven that CO2 emissions are related to global warming which will likely lead to serious environmental issues for humanity. Legislation, customers, and common sense will force the industry to step away from fossil fuel firing sooner or later. By 2050, the EU aims to cut greenhouse gas emissions to 80% below 1990 levels. Milestones to achieve this are 40% emissions cuts by 2030 and 60% by 2040. All sectors need to contribute. One famous Dutch beer brewer is putting a lot effort into reducing its carbon footprint and estimates that 53% of this is related to their packaging material. The pressure to reduce emissions comes from many sides. No matter which side we agree or disagree with, it will impact how glass is melted in the future.

Technological evidence

Most glass melting furnace technology goes back 160 years or more. Over the years different developments have led to huge energy efficiency and emission improvements, and many furnace suppliers are still working on enhancements, forced by the fact that fossil fuel energy remains cheap. However, that will change, and assumingly much faster than many of us expect. As previously mentioned, most of those improvements employ a more complex technology that results in additional maintenance and CAPEX, the use of non-environmentally friendly chemicals, and limitations to equipment lifespan. Most glass smelters perceive their melting process as complex enough and are not keen on modifying it further. They want to focus on their core business, without the issues of managing and maintaining complex industrial installations requiring high numbers of technical personnel. Keeping the system simple has been a key argument for many decades. Now that the world around us seems to be changing rapidly, our efforts to elongate the lifetime of furnaces up to 15 years is working against us. In fact, most glass manufactures only have one opportunity every 10 to 15 years to introduce a new innovative melting process, so it is not surprising that having to live with that decision for the next 15 years makes them extremely risk averse. Who can blame them? It reminds me of a comment made by one of our customers: “In God we trust, but here you have to come with facts”. Technological research and development needs to provide evidence of improvements, otherwise politics forces us to rely on expectations.

Electrical heating

Electrically heated furnace technology is almost as old as regenerative furnace technology. In fact, the first furnace patent on electrical melting was issued to Sauvageon in France, in 1907. The first successful cold top furnace ran in Norway from 1920 to 1925 using carbon electrodes and Cornelius in Sweden had operating furnaces producing amber and green glass as early as 1925. In 1952 the industry started to use molybdenum electrodes, and in around 1975 high current SCRs (thyristors) became available leading to the principal of solid state furnace boosting systems we know today. Most modern traditional container, fiber, and float furnaces are now equipped with electrical furnace boosting, contributing 10% to 50% of the melting power.

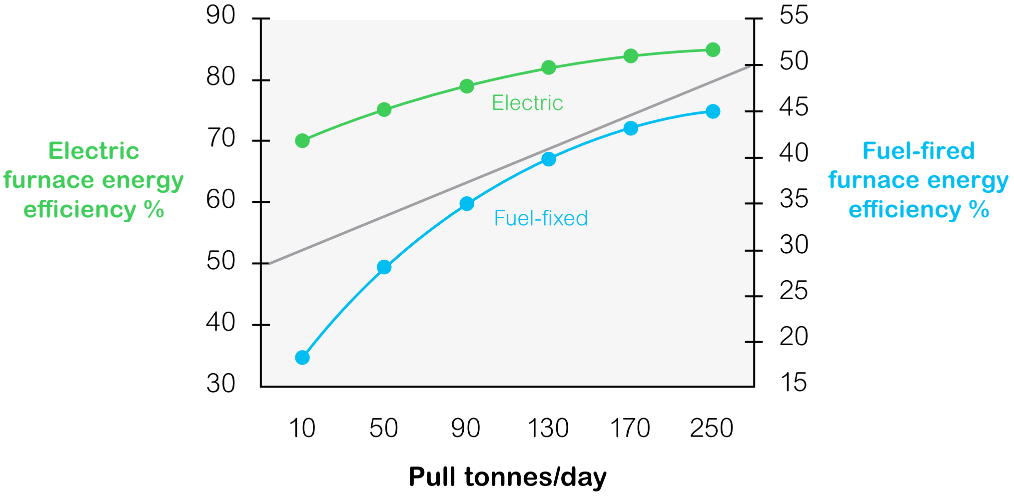


The efficiency of all-electric melting

Even in the early days, all-electric melting efficiency at 4.4GJ/ton4 (1.3MWh/ton) was already close to today's most efficient fossil fuel fired furnaces at 4GJ/ton (1.1MWh/ton). Since the introduction of all-electric furnaces, huge efficiency improvements have been achieved, reducing energy usage levels to 2.8GJ/ton (0.78MWh/ton) (20% cullet) or less. The power consumption is not likely to go below 2.6GJ/ton (0.72MWh/ton). Most of the electrical power ends up in the melting process anyway and only relatively low energy losses come from transformers, busbar, and control efficiency. Compared to traditional fossil fuel heating at 4GJ/ton (1.1MWh/ton), energy use is around 35% less.

An electrical furnace is easy to control and maintain but it is important to consider the engineering of the electrical system alongside the furnace design. Like a burner system for a traditional furnace, the electrical system is not a subsystem but should be part of the total design and needs to be fully integrated. Bringing steelwork, refractory, cables, busbars, electrodes, transformers, and control together in one design is essential for the efficiency success of the whole system.

Furnace size and energy efficiency



http://www.aseanglass.org/wp-content/uploads/2017/08/39th-ASEAN-Glass-5.-Electricity-in-Glass-Making-...-often-the-Low-Cost-Option-Electroglass-Ltd-by-Mr.-Richard-Stormont.pdf

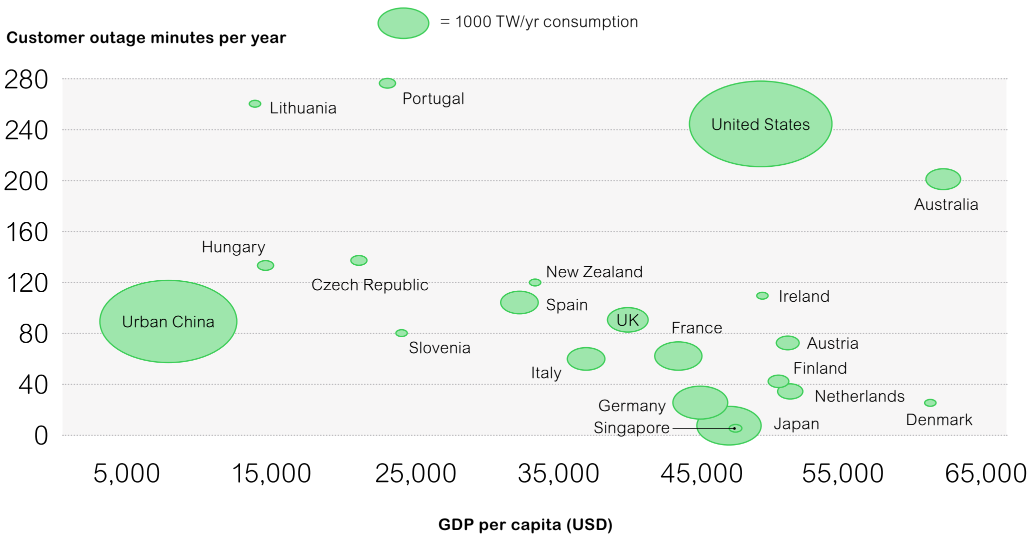
Advantages of all-electric melting

Compared to high-efficiency fossil fuel fired smelter systems, all-electric furnaces are sophisticated but very straightforward in terms of design. Regenerators or burner skids are not required, and expensive high temperature crowns are not necessary. Higher pull rates can be achieved without any problems. No combustion related CO2, thermal NOx or SOx emissions are released. Potentially less evaporation of volatile and expensive raw materials, like boron and lithium, etc. will occur, which makes exhaust filtering much easier. Also, the carry-over problem will almost vanish. Smaller furnaces could be considered (for example, one furnace that feeds one forehearth which feeds one IS-machine), and might become a new concept for bottle manufacturing.

Disadvantages of all-electric melting

Although all-electric furnace concepts are very simple in principle, there are some implications to consider when changing over to this technology. At room temperature glass or glass compositions are electrical insulators. To start the electrical heating process, it needs to run through a pre-heating sequence similar to the method used in container and float furnaces. An all-electric furnace also needs a stable, reliable power grid, and due to different melting and fining behaviors the glass composition needs to be changed. Electrical tariffs need to come down in price, and to lower the carbon footprint electricity would need to come from renewables instead of coal-fired power plants. Electrodes need to be maintained by advancing them in case wear leads to higher resistance. There are new methods to counter electrode wear, which would need to be investigated further. Another issue, especially for the container industry, might be how this kind of furnace would handle extremely high amounts of cullet, which may result in different ways cullet and batch are managed.

International electricity grid reliability

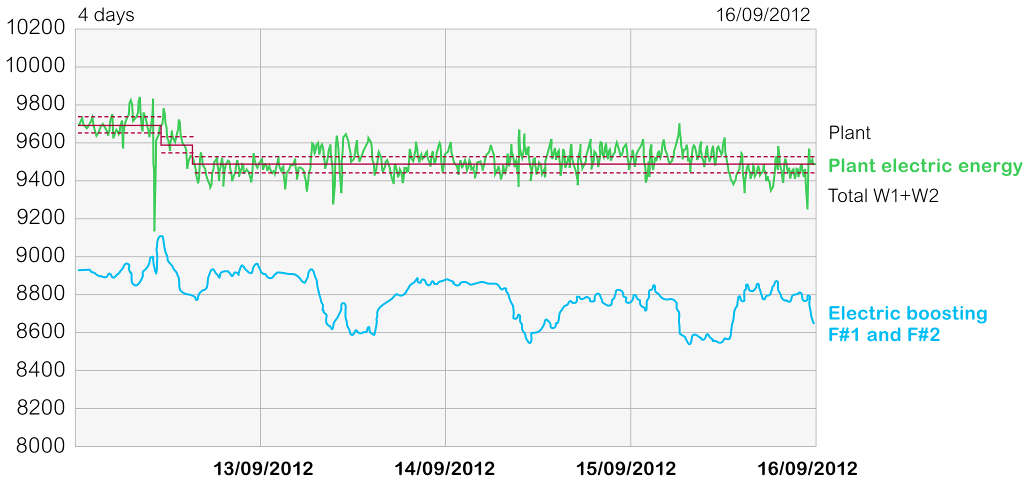


Source: The Brattle Group, Galvin Power Institute, Council of European Energy Regulators, China Southern Power Grid

Flexibility is required

Electrical power tariffs are closely related to availability, and the electrical energy market is changing rapidly. Suppliers and utilities subsidized by government grants are investing in wind, bio-mass, and solar power generation. Citizens also invest in solar panels instead of keeping their money at zero interest in banks. Buzz words such as "smart grid", "tariff tweaking", "peak shaving", and "frequency control" have become familiar terms, and it is recognized that money can be saved if our electrical energy consuming system becomes more flexible. To lower the risk of total grid failure, some utilities offer money to be in control of huge industrial loads to be able to temporarily switch them off when needed. More refined is the method of controlling the network's frequency (Dynamic Fractional Frequency Reuse) by tweaking the power consumption of some massive power consumers. Basically, electrical power consumers are financially rewarded if they make part of their electrical power consuming system available for remote power control. Lower peak power demand can lead to lower tariffs. In that case, a dynamic load management system capable of controlling parts of the electrical system to ensure that agreed peak power levels are not exceeded will lower the overall cost of electrical energy.

Total energy consumption plant (kW)



Source: Glass Service

A glass furnace containing a huge amount of molten glass can or should be able to accommodate the flexibility needed to profit from these rewards, grants, and lower electrical tariffs. Glass manufacturing, being part of the high energy consumer community and rapidly changing energy market, needs to look for furnace designs that better fit both today's and tomorrow's requirements. Sophisticated data analysis and model-based control strategies should help operators to calculate the available freedom of control, allowable melting energy fluctuations, and allowable fossil to electric ratio fluctuations as well as predict the impact on glass quality. The bottom line is that there is no escape from thinking "outside the box" and stepping away from tradition.

Conclusion

As a supplier of process and electrical power supply control systems in this business for over 50 years, we consider ourselves to have a strong understanding of the glass industry's requirements and concerns. For several years now we have been promoting the efficiency, financial, and environmental benefits of moving to electric heating and have recently witnessed high levels of interest and growth in our SCR-controlled power supply systems. The move to all-electric will not occur overnight, however the industry is beginning to listen and accept the implications of not starting. We still stick to our intuition that the efficient future for the glass industry will be all-electric, and we are thinking ahead about what needs to be done to eventually achieve that conceptual change. Let us have your feedback and perhaps involve us in your internal discussions on electrical heating power supplies and control systems with other enablers and innovators to make this happen. Remember, all-electric has been around for over 100 years already.

References:

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About the author

René Meuleman studied electrical engineering, then started his career in the paper industry as a technical assistant, before switching to the glass industry as an employee of Vereenigde Glasfabrieken. During his early years, he built his broad knowledge and experience through the design and development of electronic quality equipment for container glass manufacturing. He was involved in the implementation of the company's first-generation PLC and DCS systems as well as electronic timing systems for IS-machines. René worked on several model based predictive control (MPC) projects and was involved in object-oriented engineering method developments. He became responsible for process control inside the BSN group and finally was responsible for the European plant process control and forming electronics inside the Owens-Illinois group. Sixteen years ago, he left O-I and joined the Eurotherm by Schneider Electric, where he is responsible for technical and commercial glass business development. Based on the Schneider Electric portfolio and his global glass business team, he now works on the development of innovative, pragmatic, and competitive glass manufacturing process and power control systems.

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