V.A. Ramazanova
National research
Tomsk Polytechnic University
Tomsk, Russia

Comparison of energy efficiency measures in glass production

Energy Saving is one of the most serious challenges of the 21st century. This problem comes to the fore because natural resources while vast are finite and limited, so we will eventually run out of them sooner or later. Of course, science is moving forward and tries to find the new ways how to get energy.

Let us consider the problem of energy conservation on the example of the glass manufacturing.

Glass manufacturing (Glass production) is highly energy-intensive process and the choice of energy source, methods of heating and heat recovery is crucial for the development of furnace design, energy efficiency and cost-effectiveness of the process. Also those factors define the environmental performance of the process. Energy saving is not only connected to the economic benefits, but to improving environmental performance of process as well, in particular by reducing the specific emissions, including CO_2, NO_X and SO_2, and particulate matter. [4] In accordance with the range of product mix, as well as the climatic conditions, the glass melting consumes up to 60–80 % of the energy consumed by the enterprise. So, we should pay particular attention to reduction of energy consumption in glass melting processes. The thermal efficiency of the best Russian combustion furnaces is 25–28 % compared to 50 % of the best foreign examples. Energy from fuel consumed for heating the furnace is divided into three main flows:

- melting glass (20–25 %),
- heat losses through the surface of the furnace (53–60 %),
- waste heat rejection (20–22 %)

Analysis of information materials, Russian and foreign experience suggests a wide variety of technical tools and solutions that may help in energy saving in the glass industry. [3] Let us consider some of the ways to save energy.

1. Combustion control and choice of energy source:

In recent decades, a liquid fuel was the main for the glass production in the European Union, although the popularity of natural gas continues to grow. Natural gas leads to lower emissions of SOX, but emissions of NOX usually become higher. This is due to the fact that the flame of natural gas has a lower brightness and usually leads to a larger energy consumption, about 7–8 % more. Although, if we use the natural gas, the level of productivity will increase and reach values comparable to those with liquid fuels. Natural gas also has higher hydrogen to carbon ratio and thus leads to lower emissions of CO_2 by 25 % at fixed glass melt. Developing systems with low release of NO_X in combustion also leads to energy savings [4]

2. Use of halides:

The method can reduce the temperature of the liquid phase emergence by 150–200 °C and thus greatly increase productivity of glass furnaces. [3]

An example of halides may be calcium fluoride which contained in the mineral fluorite, which is the main source of fluoride and its compounds. Many fluorine compounds are inflammable and explosive. Fluorine reacts with almost all materials, including metal containers and pipes, if their passivating films have been damaged. Interaction of metal with fluorine may cause release of hydrogen. To prevent local reactions and the risk of fire in the transport systems it is necessary to comply with strict cleanliness requirements.

This method can be considered as one of the most effective, because it increases efficiency of the furnace by 15–20 %. [3] On the other hand, the use of chemical accelerators increases the toxicity of the emissions from melting furnaces, so this method is difficult to call the best.

3. The use of cullet:

Using a third-party cullet (recyclable glass which is obtained from consumers and other industrial sources) in the glass production can significantly reduce energy consumption and can be carried out on all types of furnaces whether they are using fossil fuels, forced oxygen blast or electric heating. Most sub-sectors recycle all internal cullet in the normal mode. Cullet ratio in the feed is typically in the volume range of 10 to 25 %. Cullet has lower requirements for the energy required for melting than batch of raw material because cullet has already undergone endothermic reaction associated with the formation of glass and the mass of cullet is about 20 % less as compared with an equivalent amount of the batch. So, the increase of proportion of cullet in the feed material potentially can save energy; as a general rule you can assume that every additional 10 % cullet lead to a reduction in energy consumption furnace by 2.5–3.0 %. [5] Using cullet also usually leads to a significant reduction in costs because we reduce consumption of energy and raw materials.

4. Also we will save energy if we use gas turbines that recuperate the heat of flue gas from glass furnaces to produce high pressure steam. The generated electricity is used in the production. Depending on the type of glass melting furnaces, electricity costs can be reduced by 25 % if such heat recovery is implemented. [3] The main advantages of the gas turbine plant (gas turbine power plant) is its high electrical and thermal efficiency, which is achieved at the expense of the basic mode of their work on the heat consumption (heating, hot water, supply of heat for industrial purposes), low specific weight, compactness and ease of transportation and installation easy to transport and easy to install that is a very important factor in the dynamics of the modern world. Also the advantages of gas turbine power plant are that it has a short construction period, improves the reliability of heat and electricity supply for consumers, and reduces the thermal inertia of the regulation and heat losses. [2]

Comparing implementation of the above listed methods on an existing plant to reduce energy consumption we may conclude that the most effective method is the use of gas turbines. With this method, energy consumption is reduced by 25 %, thus outweighing 15 % to 20 % increase in furnace capacity given by use of halides, while having much less impact on the environment than that associated with the use of halogen compounds.

References

1. Дресвянникова Е.А., Готулева Ю.В. // Энергосберегающие технологии при производстве строительных материалов. [Электронный ресурс] / URL: http://www.lib.tpu.ru/fulltext/v/Conferences/2012/C2/V3/v3_087.pdf (дата обращения: 10.04.2015).
2. Дьяченко А.С., Абдрафиков Е.Ш. // Негативное влияние ГТУ на окружающую среду. [Электронный ресурс] / URL: http://www.lib.tpu.ru/fulltext/v/Conferences/2012/C2/V3/v3_087.pdf (дата обращения: 15.04.2015).
3. Соколовский Л. // Энергосбережение при производстве строительных материалов. [Электронный ресурс] / URL: http://www.nestor.minsk.by/sn/2001/15/sn11505.html (дата обращения: 29.03.2015).
4. Справочник по наилучшим доступным техническим методам использования энергоресурсов в стекольной промышленности: Производство сортового и тарного стекла. [Сетевое научное издание. 2005.] / URL: http://www.14000.ru/projects/glass/BAT_in_Energy_use.pdf (дата обращения: 03.04.2015).
5. Energy conservation vs. energy efficiency. [Электронныйресурс] / URL: http://www.nrcan.gc.ca/energy/efficiency/buildings/eeb/key/3969 (дата обращения: 03.04.2015).

Scientific supervisor: D.V. Shepetovsky, senior teacher, TPU (Tomsk polytechnic university), Russia