Revolutionizing Glass Manufacturing: The GIFFT Concept Based on Sustainable and Cost-Efficient Solutions.

Raminta Skvorčinskienė[1] and Nerijus Striūgas[1]

[1] Combustion processes laboratory, Lithuanian Energy Institute, Breslaujos st. 3, Kaunas, LITHUANIA

1. Introduction

The EU's glass industry consumes 4.5 billion cubic meters of natural gas yearly, constituting 4% of industrial consumption in Europe [1]. Most of the energy consumed in glass manufacturing is used to generate process heat at high temperatures (1400 -1650 °C) for melting raw materials. The dependence on natural gas presents environmental challenges, especially regarding CO_2 emissions, predominantly stemming from fossil fuel combustion [2]. During the past almost 100 years, the glass manufacturing process has undergone significant evolution thanks to innovations and technologies aimed at reducing carbon dioxide emissions into the environment. These improvements have significantly reduced energy consumption and CO_2 emissions by up to 75% [2]. However, these technologies are approaching their limits, making it increasingly difficult to expect further reductions in CO_2 emissions from burning fossil fuels. *The Future Flexible Hybrid Furnace* is the vision of the European glass industry aimed at achieving the goals of the European Green Deal in order to reach climate neutrality.

This work presents the latest results of the Horizon Europe project GIFFT, which aims to develop a sustainable, hybrid, and flexible heat production technology using biomass fuel, integrating plasma-assisted combustion and gasification systems into the glass manufacturing process.

2. Materials and methods

The GIFFT project aims to create and test a universal hybrid furnace that maximally uses readily available electricity generated from renewable energy sources and eco-friendly biofuels. This initiative seeks to facilitate the transition from reliance on natural gas to a new, low-carbon approach to heat production, aiming to reduce carbon dioxide emissions into the environment. The study proposes an innovative low-CAPEX approach to heat generation in processes for the glass industry by applying different aspects:

- ✓ Biomass E-Gasification;
- ✓ Plasma-Assisted Combustion;
- ✓ Renewable energy resources;
- ✓ Ash Material Utilization.

3. Results and discussion

Innovative components aside, a standout feature of the GIFFT concept lies in its operational flexibility. By seamlessly integrating traditional gasification-combustion processes with e-boosting via plasma technology, GIFFT offers a dynamic approach to heat generation. Designed for uninterrupted operation, GIFFT ensures glass manufacturing plants can run seamlessly year-round, maximizing operational hours. This hybrid approach to operation and fuel flexibility encompasses four distinct modes, allowing for smooth transitions as needed.

"Base Case"

At the core of the glass production facility lies the melting unit, where raw materials are converted into glass, generating excess heat in the process. Due to the high energy demands of melting, natural gas is commonly used as the primary energy source.

To reduce reliance on fossil fuels and contribute to decarbonization, an integrated approach would be adopted. This involves diversifying energy sources by selecting the most cost-effective option (*case 1, case 2, case 3*) from the green energy market and dynamically transitioning between them as needed.

1. *"Biomass case"*

The biomass-derived gas production is facilitated via plasma-assisted gasification. Various biomass residues are gasified, producing hot raw gas directed into a flexible plasma-assisted burner. Continuously operating plasma torches distinguish this process. Gasification biomass ash serves as a substitute for natural ores in glassmaking, minimizing NG use and potentially reducing CO_2 emissions by up to 30% overall or up to 73% of fossil CO_2 per ton of glass produced.

2. *"Green Electricity Case"*

During periods of low-cost electricity, the plant prioritizes green electricity usage. Biomass feeding and syngas production are scaled down and optimized for plasma-assisted EFG operation. Simultaneously, the plasma-assisted burner boosts thermal energy output by up to 25-50%. Cheap hydrogen availability may prompt a switch to electric-hydrogen operation, depending on its price. Gasification biomass ash is repurposed for raw feedstock. With minimal NG use, CO_2 emissions could decrease by up to 55%.

3. *"Green Hydrogen Case"*

The plant transitions to maximum hydrogen fuel operation, halting biomass-derived gas production and minimizing plasma torch output. In this scenario reliant on hydrogen, there is no production of biomass gasification ash, therefore additional biomass ash would be sourced from regional combustion or gasification plants. With minimal NG use, a reduction of up to 67% in both total and fossil CO_2 emissions per ton of glass produced is anticipated.

4. Conclusions

Scientific research highlights energy efficiency measures and renewable energy substitution as key pathways for decarbonizing the glass industry. The proposed technology represents a groundbreaking innovation in the glass-making sector, empowering manufacturers to break free from fossil fuel dependency. It will be offered as a product to enhance energy efficiency for glass manufacturers, minimizing costs, boosting profits, and enhancing their competitive edge in the market.

5. References

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