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The Path to Carbon Neutrality in the Glass Industry

Bingxi CHEN

Hainan University, Haikou, Hainan, China, 570228

Email: chen_bingxi_icnt@iexchange.world

***Corresponding author**

Abstract

This article mainly studies how to achieve carbon neutrality in the field of glass. Currently, global climate change has become a common challenge faced by countries around the world, and the construction industry is one of the main sources of global greenhouse gas emissions. As one of the widely used materials in the construction industry, the greenhouse gas emissions such as carbon dioxide generated during its production and use cannot be ignored. Therefore, how to achieve carbon neutrality in the glass industry has become an important research direction.

This article adopts a lifecycle assessment based approach to comprehensively analyze the production, transportation, use, and disposal of glass, and proposes corresponding emission reduction measures. Specifically, we will focus on the following aspects: firstly, optimizing production processes to reduce energy consumption and waste generation; Secondly, promote the concept of green buildings and improve building energy efficiency; The third is to strengthen the recycling and utilization of waste and reduce environmental pollution. Through the comprehensive application of these measures, carbon emissions during glass production and use can be effectively reduced, achieving the goal of carbon neutrality.

The focus of this study is to explore effective ways to achieve carbon neutrality in the glass industry and provide feasible emission reduction solutions for relevant enterprises. I hope this study can provide useful reference and inspiration for carbon reduction in the glass industry.

Keywords: Carbon neutrality; glass; architecture; industry.

1. Introduction

The global energy, environment, and climate change issues are becoming increasingly prominent, and countries have already or are facing serious environmental crises. Alleviating the sharp contradiction between economic growth and ecological protection has become an urgent practical problem that countries need to solve.

The carbon emissions in the glass industry mainly come from three aspects: fossil fuel combustion emissions, production process emissions, and emissions generated by purchasing and exporting electricity and heat. Among them, fossil fuel combustion emissions account for more than 60% of carbon emissions in glass production, carbon

dioxide formed by raw material decomposition or carbon oxidation accounts for 25% -27%, and electricity emissions account for about 13%.

In 2020, China's flat glass carbon dioxide emissions were about 34 million tons, accounting for 0.33% of the country's carbon emissions. Although it is relatively low compared to high carbon emitting enterprises such as steel and cement, the glass industry still has overcapacity and strong demand for "energy conservation and emission reduction"

In order to accelerate the pace of carbon neutrality in the glass industry, conducting carbon emission analysis from the entire process of the glass industry chain and taking corresponding measures is an effective path to reduce carbon emissions in the glass industry.

2. Method

2.1. Explain search strategy

(1) Keyword selection: We have selected a series of keywords related to glass, carbon neutrality, and the construction field, such as "carbon neutrality glass", "sustainable glass production", etc.
(2) Literature database: We have used multiple academic databases, including Web of Science, Scopus, and Google Scholar.
(3) Retrieval strategy: We have used appropriate retrieval strategies for each database, combined with keyword searches. We have limited the time frame of the literature and usually choose literature from the past decade to ensure the freshness of the information.
(4) Literature screening: We conduct a preliminary screening of the search results based on the title and abstract to determine whether they are suitable for the topic of our research field.

2.2. Outline of source selection criteria

(1) Academic authority: We prioritize literature published in academic journals, conference proceedings, and reports published by industry authoritative organizations.
(2) Credibility and reliability: We only select literature that has undergone peer review to ensure its quality and accuracy.
(3) Accessibility: We prioritize literature that can be obtained for free or subscribed to through our institution to ensure that we can obtain complete literature content.

2.3. Describe literature analysis process

(1) Literature reading: We carefully read the selected literature and fully understand the information contained in it regarding glass in the field of carbon neutrality.
(2) Data extraction: We extracted data, viewpoints, and research methods related to our research topic from each literature.
(3) Comprehensive analysis: We conducted a comprehensive analysis of the extracted data, comparing the view points and results of different literature to obtain a comprehensive understanding.

2.4. Discuss development of recommendations

Based on literature analysis and comprehensive evaluation, we have put forward suggestions on the relevant issues of glass in the field of carbon neutrality. We will combine the viewpoints in the literature with our own analysis to provide feasible solutions and improvement measures.

3. Result

This article adopts a lifecycle assessment based approach to comprehensively analyze the production, transportation, use, and disposal of glass, and proposes corresponding emission reduction measures. Specifically, we will focus on the following aspects:

3.1. Firstly, optimizing production processes to reduce energy consumption and waste generation;

Starting from the production of raw materials,In the reaction process of glass, various carbonates, sulfates, and nitrates decompose at their respective decomposition temperatures, releasing gases and participating in solid-phase reactions. The thermal decomposition of carbonates and the oxidation of carbon powder are the main sources of CO_2, accounting for about 20% of the entire process emissions. Therefore, optimizing the raw material structure can effectively reduce CO_2 emissions in the glass production process. If nepheline silicate raw materials (intermediate products of Na [$AlSiO_4$] 4-K [$AlSiO_4$] 4 series) are used instead of carbonates, it can reduce the CO_2 emissions generated by thermal decomposition, reduce the erosion of refractory materials in kilns, and avoid the emission of toxic gases such as NO. In addition, the amount of broken glass can be increased as a carbon free raw material in the raw material. Generally speaking, for every 10% increase in broken glass usage, it will correspondingly reduce energy consumption by 2.5% to 3%.

Next is to optimize the fuel structure,Compared to raw materials, fuel has a greater impact on the quality of glass. Currently, the main fuels include heavy oil, petroleum coke, coal to gas, natural gas, coal tar, etc. Developing clean energy, reducing fossil fuel supply, and replacing high carbon fuels with clean fuels are effective ways to improve energy utilization efficiency and reduce carbon emissions before decarbonization of energy.

Finally, optimize the structural design of the glass furnace,Glass kilns are the equipment with the highest energy consumption in glass production lines. The melting of raw materials consumes more than half of the energy used in glass production. The energy used in the glass industry in Europe and the United States is mainly natural gas, which usually accounts for 75% to 85%, followed by electricity, which accounts for 10% to 15%, and the remaining 5% to 10% is composed of fossil fuels. In fact, from 1960 to 2010, energy efficiency increased by more than 50%, and since 2010, progress in energy efficiency has significantly slowed down due to perhaps the kiln structure design and insulation measures are unreasonable, and the quality grade of the refractory materials used is low. Therefore, optimizing the structure of glass kilns is one of the important measures to reduce furnace heat loss, reduce fuel consumption, and improve furnace thermal efficiency.

3.2. Secondly, promote the concept of green buildings and improve building energy efficiency.

Low E glass is coated on the surface of the glass, and the emissivity E of the glass can be reduced from 0.84 to below 0.15. Low-E glass can directly reflect far-infrared thermal radiation, with high infrared reflectivity, low surface emissivity, and low ability to absorb external energy. It can maintain relative stability of heat on both sides of the glass, and can also control the amount of solar radiation transmission as needed to adapt to different needs. Low-E glass can still allow solar radiation from the outdoor environment to enter the building, and this energy is absorbed by indoor objects and then converted into far-infrared thermal radiation, which is left indoors. In summer, the opposite is true. The insulation layer of Low-E glass not only helps to reduce heat loss, but also helps to maintain stable indoor temperature, thereby improving the thermal comfort of residents, reducing the electricity cost of air conditioning, and reducing carbon emissions. Against the backdrop of the “dual carbon” goal, green and energy-saving buildings have become the mainstream of domestic construction. The use of glass will make a huge contribution to achieving carbon neutrality.

3.3. The third is to strengthen the recycling and utilization of waste and reduce environmental pollution

The radiative forced convection heat transfer technology inside the tempering furnace has the characteristics of uniform heating and short time consumption, which can significantly improve the convective heat transfer ratio inside the furnace. The hot gas discharged from the tempering furnace can also preheat the compressed air before entering the furnace, saving 34% of electricity compared to ordinary furnaces. In addition, the waste heat recovery and utilization technology during the glass tempering process is also an important measure to improve energy utilization efficiency and reduce energy consumption. The flue gas temperature from the storage chamber and heat exchanger of the tank kiln is generally above 300 ℃, and the emissions are large, which has high recovery value. The use of waste heat recovery equipment to treat flue gas can be used for steam power generation or direct drive equipment, as well as for preheating air, flame retardant air, drying heat sources, or workshop heating after the heat recovery of flue gas, all of which can achieve good energy-saving and emission reduction effects.

4. Discussion

Firstly, we need to optimize the glass production process to reduce energy consumption and waste generation, thereby reducing carbon emissions. This can be achieved through the use of efficient glass manufacturing technology, the use of renewable energy, improved raw material selection, and recycling methods. This can not only reduce carbon emissions and resource consumption, but also improve production efficiency and sustainability.

Secondly, we need to promote the concept of green buildings and improve their energy efficiency to reduce glass usage and energy consumption. The use of efficient thermal insulation glass, optimized lighting design, and automated systems in buildings can achieve this goal. This can reduce the energy demand and carbon emissions of buildings, while providing a more comfortable and sustainable indoor environment.

Thirdly, we should strengthen the recycling and utilization of waste and reduce environmental pollution to achieve carbon neutrality. Establishing a comprehensive recycling system, promoting awareness and technology of glass recycling, and promoting circular economy can achieve this goal. This can reduce the negative impact of waste glass landfill and incineration on the environment, while improving the sustainable utilization rate of resources.

The impact and suggestions for future research are that we need to further study new glass manufacturing technologies and explore more efficient and energy-saving production methods. At the same time, research and development of new glass raw materials and substitutes should also be carried out to reduce dependence on limited resources. In the field of green building, further research is needed on green building technology and materials to improve building energy efficiency and the effectiveness of glass use. In addition, efficient recycling and reuse technologies for waste glass can be studied, and new glass recycling and utilization models can be explored. At the same time, it is necessary to study the environmental impact of discarded glass and methods to reduce waste generation, in order to improve the sustainability of the glass industry.

In summary, these measures have a significant impact on achieving carbon neutrality in the glass industry. Future research should further explore and develop relevant technologies and policies to promote the sustainable development of the glass industry and the achievement of carbon neutrality goals. In addition, interdisciplinary and global cooperation will be crucial to promote knowledge sharing and experience exchange, and to advance the carbon neutrality process in the glass industry.

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