The Significance of Carbon Neutrality for Cost Saving and Efficiency Enhancement in the Foundry Industry

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1 Introduction

Foundry is a pivotal part of modern manufacturing, playing a significant role in sectors such as automotive, aerospace, electronics, and home appliances. By injecting molten metal into high-pressure molds and rapidly cooling it to form parts, this technology can produce complex shapes with high precision. The global demand for Foundry products has been on the rise with industrialization and urbanization, and technological innovations continue to emerge. In 2022, the global production of aluminum Foundrys was approximately 30 million tons, while magnesium alloy Foundrys reached around 500,000 tons. However, climate change and greenhouse gas emissions pose significant challenges. According to the Intergovernmental Panel on Climate Change (IPCC), the global average temperature has risen by about 1.1°C compared to pre-industrial levels. Consequently, countries have implemented carbon emission control policies, such as Europe's Green Deal and China's dual carbon goals, aiming for carbon peaking by 2030 and carbon neutrality by 2060.

As an energy-intensive and high-carbon-emission industry, effective carbon management is crucial for the Foundry sector. The production processes of aluminum and magnesium involve substantial electricity consumption and CO_2 emissions, particularly during electrolytic aluminum production. The carbon footprint of aluminum Foundrys is approximately 2.5 tons of CO_2 equivalent per ton, while that of magnesium alloys is around 4.0 tons of CO_2 equivalent per ton. Therefore, the Foundry industry must adopt effective carbon management measures to reduce emissions and achieve sustainable development.

2 Current status of carbon emissions in the foundry industry

In the Foundry process, the main sources of carbon emissions include energy consumption, material production, transportation, etc. To formulate effective carbon management strategies, a detailed analysis of the carbon emissions from each stage is essential.

2.1 Energy consumption

During the Foundry process, energy consumption is a major source of carbon emissions. According to the International Foundry Association, the main energy consumption in the Foundry process occurs during the melting and forming stages. The melting stage requires large amounts of electricity or natural gas to heat and melt metal, while the forming stage maintains mold temperature and drives mechanical equipment.

Melting stage: Research shows that the melting stage accounts for approximately 60%-70% of total energy consumption in the Foundry process. For example, melting one ton of aluminum alloy consumes about 15-18 GJ of energy, generating approximately 0.9-1.2 tons of CO_2 equivalent emissions.

Forming stage: The energy consumption of the forming stage mainly comes from heating the mold and operating the hydraulic system, accounting for approximately 20%-30% of total energy consumption. During the forming process, about 0.3-0.5 tons of CO_2 equivalent emissions are generated per ton of casting.

2.2 Material production

Material production is another significant source of carbon emissions in the Foundry industry. The extraction and processing of raw materials generate considerable amounts of greenhouse gases.

Aluminum alloy production: The production process of aluminum alloys, including bauxite mining, alumina refining, and electrolytic aluminum production, are all high-energy-consumption and high-emission processes. According to the International Aluminum Institute, producing one ton of aluminum alloy generates approximately 8-12 tons of CO_2 equivalent emissions.

Magnesium alloy production: Although magnesium alloy production consumes relatively less energy, due to the chemical reactions involved in the extraction and processing of magnesium resources, its carbon emissions cannot be ignored. Producing one ton of magnesium alloy generates approximately 5-7 tons of CO_2 equivalent emissions.

2.3 Transportation

The carbon emissions from transportation primarily come from the logistics of raw materials and finished products. Foundry companies usually need to procure raw materials from all over the world and transport finished products to customers. The choice of transportation mode (such as sea, land, or air) significantly affects overall carbon emissions.

Sea transport: Although sea transport is a relatively low-carbon mode of transportation, it has a long transportation time, which affects the inventory and capital utilization of enterprises. The carbon emissions from sea transport are approximately 0.01-0.03 tons of CO_2 equivalent per ton of goods.

Land transport: Especially long-distance truck transport, carbon emissions are higher. The carbon emissions from land transport are approximately 0.06-0.15 tons of CO_2 equivalent per ton of goods.

Air transport: The carbon emissions from air transport are the highest, approximately 0.5-1 ton of CO_2 equivalent per ton of goods.

24 Post-processing stage

The post-processing stage includes cleaning, finishing, and surface treatment of the castings. Although these processes consume relatively less energy and generate lower carbon emissions, they still contribute to the overall carbon footprint and require attention.

Cleaning and finishing: These processes mainly rely on machinery driven by electricity, consuming about 5%-10% of the total energy and emitting approximately 0.1-0.2 tons of CO_2 equivalent per ton of casting.

Surface treatment: Surface treatments like painting and electroplating not only consume energy but may also produce volatile organic compounds (VOCs), indirectly increasing carbon emissions. The carbon emissions from surface treatment are approximately 0.2-0.3 tons of CO_2 equivalent per ton of casting.

2.5 Carbon management strategies in the foundry industry

Carbon management is significant in the Foundry industry. Improving energy efficiency and adopting low-carbon energy can significantly reduce carbon emissions; optimizing production processes and material choices, reducing scrap rates and resource waste, helps achieve green manufacturing. Effective carbon management strategies enable Foundry companies to not only reduce carbon emissions but also achieve cost reduction and efficiency enhancement. Here are key strategies for carbon management in the Foundry industry.

2.6 Material selection and management

Use of lightweight materials: Selecting lightweight materials such as aluminum and magnesium alloys can reduce the carbon footprint of products. These materials possess excellent mechanical properties and corrosion resistance and can significantly reduce weight, thereby decreasing energy consumption and carbon emissions during transportation and use.

Material recycling and reuse: Material recycling and reuse are important means to reduce carbon emissions. For example, through waste recycling and the use of recycled aluminum, the carbon emissions from the extraction and processing of raw materials can be significantly reduced. According to statistics, the energy consumption for producing recycled aluminum is only 5% of that for primary aluminum, significantly lowering carbon emissions.

Green procurement strategy: Choosing suppliers with low carbon emissions is an important strategy for achieving green procurement. By collaborating with environmentally conscious suppliers who emit low carbon, companies can reduce their carbon footprint at the supply chain level. Additionally, companies can establish green procurement standards to ensure that every link in the procurement process meets low-carbon emission requirements.

2.7 Energy management strategies

Use of low-carbon energy: In terms of energy selection, Foundry companies can prioritize using low-carbon energy sources such as natural gas and electricity instead of traditional coal energy. Natural gas produces less carbon dioxide when burned than coal, thus reducing carbon emissions.

Application of renewable energy: Companies can further reduce carbon emissions through the application of renewable energy sources such as solar and wind power. For example, utilizing photovoltaic power generation systems powered by solar energy to supply electricity to production lines not only reduces reliance on fossil fuels but also lowers energy costs.

Energy efficiency improvement measures: Through equipment upgrades and process optimization, companies can significantly improve energy efficiency. For instance, replacing traditional coal-fired furnaces with efficient electric furnaces can significantly reduce energy consumption. Additionally, optimizing production processes, such as reducing heating times and temperatures, can help lower energy consumption and carbon emissions.

2.8 Production process optimization

Application of advanced casting technologies: Utilizing advanced casting technologies such as high-pressure Foundry and precision casting can increase production efficiency, reduce scrap rates, and lower carbon emissions. These technologies can precisely control various parameters in the casting process, reducing material waste and energy consumption.

Process optimization and automation: Through the introduction of smart manufacturing and Industry 4.0 technologies, companies can achieve comprehensive optimization and automation of production processes. For example, introducing automated equipment and robots can not only enhance production efficiency but also reduce energy consumption and scrap caused by human operations.

Waste management and minimization: Waste management is an important aspect of carbon management. Companies can reduce waste generation through the handling and reuse of foundry sand and slag. For instance, regenerating used sand and reusing it in Foundry production can significantly reduce solid waste emissions.

2.9 Carbon emission monitoring and management system

Establishment of carbon emission monitoring system:

Establishing a real-time carbon emission monitoring system can help companies promptly grasp carbon emissions during the production process. Through data collection and analysis, companies can identify key emission links and take corresponding improvement measures.

Carbon footprint calculation and reporting: Implementing carbon footprint calculations and regularly publishing carbon reports are important measures for transparent management. Through carbon accounting, companies can accurately calculate carbon emissions generated during the production process and report their carbon management performance to stakeholders, enhancing the company's social responsibility image.

Application of carbon emission management software and tools: Using advanced carbon emission management software and tools, companies can more efficiently manage carbon emissions. For example, using professional carbon management platforms can automate the collection and analysis of carbon emission data, generate detailed carbon emission reports, and provide improvement suggestions.

By implementing the above strategies, the Foundry industry can achieve carbon neutrality goals while improving production efficiency, reducing operational costs, and enhancing market competitiveness.

3 Future outlook

In the future, the Foundry industry will witness significant developments and innovations in carbon management technology. Firstly, with the growing global emphasis on controlling carbon emissions, advanced carbon capture and storage technologies (CCS) may find applications in Foundry enterprises. These technologies can not only effectively reduce carbon emissions during production but also convert captured CO_2 into valuable chemicals or materials. Moreover, energy efficiency improvement technologies will continue to develop, especially through the combination of smart manufacturing and Industry 4.0 technologies. Foundry companies can achieve comprehensive digitalization and intelligence of production processes, thus significantly lowering energy consumption and carbon footprints.

Another significant trend is advancements in materials science. In the future, the research and application of lightweight and high-strength materials will become an important direction for the Foundry industry. These new materials can not only reduce product weight and enhance performance but also reduce energy consumption and carbon emissions during production. For instance, the application of aluminum and magnesium alloys will expand further, leveraging their low-carbon advantages to assist Foundry companies in achieving carbon neutrality goals.

To realize these technological advancements, collaboration and coordinated development within the industry are crucial. Foundry companies should actively participate in industry alliances and technology cooperation platforms to jointly promote the research and application of carbon management technologies. For example, companies can share technology outcomes and best practices through joint R&D projects, reducing R&D costs and risks associated with technology application. At the same time, industry associations and government agencies should play guiding and supportive roles, setting industry standards and policies to promote the popularization and application of carbon management technologies.

Furthermore, Foundry companies should strengthen cooperation with the upstream and downstream supply chains to build a green supply chain. By closely cooperating with raw material suppliers, equipment manufacturers, and customers, Foundry companies can implement carbon management measures comprehensively from source to end, achieving cost reduction, efficiency enhancement, and carbon reduction objectives throughout the entire supply chain.

Carbon neutrality holds profound implications for cost reduction and efficiency enhancement in the Foundry industry. By actively adopting advanced carbon management technologies and strengthening cooperation within and outside the industry, Foundry companies can not only effectively reduce carbon emissions and respond to the challenge of global climate change but also enhance their competitiveness and achieve sustainable development. We call upon all companies in the Foundry industry to take action together, jointly promoting the development and application of carbon management technologies, contributing to the achievement of carbon neutrality goals. This is not only a manifestation of corporate social responsibility but also a necessity for future development.