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Utilization of aspiration dust and fine waste in foundry production

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Abstract: Foundry production inevitably generates significant volumes of waste, such as aspiration dust, sludge, and shavings. These materials present both environmental risks and economic potential due to their content of valuable metals. This paper examines traditional methods of recycling these wastes, their limitations, and innovative approaches utilizing rotary tilting furnaces (RTFs). The study includes research findings and practical case studies that confirm the effectiveness of RTFs in processing complex wastes and integrating them into production processes.

Keywords: Aspiration dust, fine waste, rotary tilting furnaces, recycling, environmental sustainability.

Introduction: Foundry production plays a vital role in the metallurgical industry, providing materials and components for machinery, construction, and other sectors. However, it is inevitably accompanied by the generation of wastes, such as aspiration dust, sludge, and shavings. These wastes are produced during grinding, drilling, and processing of metals. On one hand, they pose significant environmental risks due to toxic components. On the other hand, they contain valuable metals, such as iron, zinc, and lead, making them an important source of secondary raw materials.

Modern challenges, including stricter environmental standards and rising raw material costs, demand the implementation of efficient waste recycling methods. Traditional approaches, such as briquetting or direct use of fine waste in smelting furnaces, demonstrate insufficient effectiveness due to high metal losses, low energy efficiency, and significant slag generation [1-3]. In this context, rotary tilting furnaces (RTFs) offer an innovative solution, providing higher energy efficiency, reduced operational costs, and improved metal recovery rates [4-6].

MATERIALS AND RESEARCHES

Issues with Traditional Recycling Methods

Briquetting is a process where fine waste materials are compressed into compact forms for subsequent smelting. Despite its popularity, this method has significant limitations. It requires a considerable amount of energy for drying and compressing fine waste. The resulting briquettes are fragile and prone to breakage during transportation and storage. Moreover, impurities in the briquettes often degrade the quality of the final product, reducing its commercial value [7].

Direct use of fine waste in smelting furnaces, though seemingly straightforward, leads to significant metal losses due to oxidation. Under these conditions, fine waste particles quickly turn into slag, reducing overall metal recovery. Additionally, the uneven heating of fine materials results in defects in the final products, making them less suitable for industrial applications [8].

These methods, besides being energy-intensive, have a significant environmental impact, making them less attractive under modern sustainability requirements.

Innovative Approaches Using Rotary Tilting Furnaces

Rotary tilting furnaces (RTFs) represent a modern technology that overcomes the limitations of traditional methods. The main advantage of RTFs lies in the creation of a dynamic layer where particles are evenly heated, ensuring complete melting and minimizing metal losses.

Another key feature of RTFs is their ability to create a reducing atmosphere within the furnace. This prevents further oxidation of metals and enhances the quality of the final product. For example, during the processing of oxidized waste at the Belarusian Metallurgical Plant, the use of RTFs achieved an iron recovery rate of 90%, which is significantly higher than that of traditional methods [4].

RTFs also effectively handle waste containing oils and other contaminants. The heat released during the combustion of these substances is utilized to reduce energy consumption, making the process more cost-effective.

Method	Thermal Efficiency (%)	Energy Consumption (kWh/t)	Metal Losses (%)	Fuel Usage (m^3/t)
Traditional Furnaces	25	1500	20	20
Rotary Tilting Furnaces	55	800	5	8

Table 1. Comparison of Thermal Efficiency Between Rotary and Traditional Furnaces

The data presented in the table highlight the significant advantages of rotary tilting furnaces over traditional ones. The high thermal efficiency (55% versus 25%) indicates more effective energy utilization in RTFs, attributed to uniform heating of materials and minimized heat loss. This is particularly critical for enterprises aiming to reduce energy costs and their carbon footprint.

RTFs exhibit nearly twice the energy efficiency of traditional furnaces (800 kWh/t versus 1500 kWh/t). This advantage stems from the ability to utilize heat generated during the combustion of impurities and the optimized heat transfer processes.

Metal losses in RTFs amount to only 5%, compared to 20% in traditional furnaces. This is due to the creation of a reducing atmosphere, which prevents further oxidation of metals. Specific fuel consumption is also significantly lower (8 m^3/t versus 20 m^3/t), reducing overall production costs.

However, it should be noted that implementing RTFs requires substantial initial investments in equipment and the adaptation of technological processes. Despite this, long-term benefits, such as reduced operational costs, minimized environmental risks, and improved product quality, make these furnaces an economically viable and environmentally sustainable solution for recycling fine waste in foundry production.

CONCLUSION

Rotary tilting furnaces represent a promising solution for recycling fine waste generated in foundry production. They provide high metal recovery rates, reduced energy consumption, and minimized environmental risks. In the context of stricter environmental regulations and rising raw material costs, the adoption of RTFs becomes a critical element of sustainable development in the metallurgical industry.

These technologies not only address the challenges of recycling complex wastes but also contribute to the circular economy by ensuring the efficient use of resources. By integrating RTFs, enterprises can achieve significant economic and environmental benefits, paving the way for a more sustainable future in metallurgy.

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