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THE IMPORTANCE OF USING INDUSTRIAL WASTE AS A BINDER

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Abstract
This study explores the use of industrial waste as a cost-effective, eco-friendly binder for briquetting low-grade iron- and carbon-bearing fines from blast-furnace and related metallurgical processes. Modified organo-mineral systems—combining mineral residues (e.g., slag, fly ash, and dust fines) with small amounts of organic additives—were prepared and evaluated. Laboratory briquettes were produced and tested for cold compressive strength, drop/shatter resistance, abrasion loss, water resistance, and thermal stability. The results show that organo-mineral binders derived from waste streams can generate briquettes with sufficient mechanical integrity for handling, storage, and pre-reduction, while reducing reliance on commercial binders. In addition, partial substitution of virgin materials with waste lowers binder cost and diverts significant volumes of by-products from landfill, supporting circular-economy goals. Process observations indicate that modest curing at ambient conditions is adequate, and that performance can be tuned by adjusting waste-to-additive ratios. Overall, using modified industrial waste as a binder offers a practical route to upgrade low-grade fines into a valuable feedstock for ironmaking and energy applications, with simultaneous economic and environmental benefits.

Keywords: Briquetting; organo-mineral binder; industrial waste; blast-furnace fines; circular economy; cold compressive strength.

Introduction

Waste generated by large industrial enterprises located in the territory of our republic through the production of products in various directions from chemical, food, construction materials, and similar enterprises occurs in various states. All waste generated during human life is divided into consumer waste and production waste based on their origin type. The second is a large quantity of unusable raw materials, formed as a by-product of the production cycle in combination with the thermal or chemical processing of various natural raw materials, some substances or their mixtures [1].

Such waste (garbage, packaging waste, scrap, etc.) has no value at this stage of the production process, but can be recycled for further use.

As of collection, there are small and large-tonnage industrial waste:

- in a rigid state;
- liquid;
- in the form of gases.

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Liquid industrial waste. Liquid industrial waste generated as a result of processing various types of raw materials includes:

– liquids containing radioactive impurities;
– oils and lubricants;
– emulsions;
– oils.

Among them, the least harmful are oil refining products, and the most dangerous is explosive sulfuric acid [2.3].

Let's consider solid waste of production materials. Solid industrial waste is represented by the following groups:

– waste rock extracted during the processing of minerals;
– obsolete machines and mechanisms with an expired production period;
– solid fraction compounds obtained as a result of chemical, physical, or mechanical processing of industrial raw materials.

Solid waste generated during production:

– as substances in various physical states in the chemical and petrochemical industries;
– in metallurgy in the form of coke, slag and remnants of metal molds;
– as slag and ash at power plants;
– sawdust, branches, mixed and shavings generated during planing from wood processing industry waste.

Solid waste is classified according to four main characteristics:

– by the nature of toxicity to the environment and human health;
– as a source of their origin by industry sectors (wood processing, chemical, coal);
– by general physical qualities - density, composition;
– by fractional state - gas, solid, liquid.

Toxic industrial waste. According to the generally accepted classifier of industrial waste in the state, they are divided into five hazardous classes based on their physicochemical properties, as well as the conditions necessary for their subsequent disposal:

– highly toxic (mercury);
– highly toxic;
– moderately toxic (oils);
– low-harm;
– almost safe, inert (chalk, aluminum, gypsum).

For each type of waste, a type of passport is drawn up, indicating its hazard class, accumulation in production, and volume of destruction by the environment. Many industrial wastes are highly toxic compounds. For example, anhydrous aluminum chloride, which is a toxic waste in titanium production, must be treated with calcium carbonate to neutralize it before being disposed of at the landfill [4.5.6]. All hazardous production waste is characterized by the following features:

– the presence of substances harmful to the survival of humans, animals, and plants;
– the presence of causative agents of infectious diseases, compounds that lead to poisoning of living organisms or corrosion of natural materials;
– explosion and fire hazard, presence of toxicity or radiation.

Primarily, large-tonnage waste, produced by industry in the millions of tons per year, is used for further processing.

These seemingly unnecessary substances are successfully processed into combustible briquettes, biogas, and building materials.

Large quantities of solid industrial waste are directed to:

– repair of road surfaces, destruction of pits and filling of dams;
– restoration of excavated lands in the mining industry;
– for various needs of agriculture [7.8].

Recycling and utilization of industrial waste. Theoretically, any waste, including production, can be subsequently processed as a necessary product for obtaining secondary raw materials for industrial needs. However, the decisive factor in this case is the economic feasibility of further processing (financial and labor costs of the processing process) and the hardness of the waste (the more difficult the waste is to process, the more difficult it is to process)[9.140.11].

A certain part of secondary production waste, taking into account the loss of consumer quality, provides the possibility of recycling. Each type of production waste is collected separately and disposed of according to the processing technology adopted for a specific fraction.Nevertheless, the collection of all industrial waste, their transportation to the disposal site, and disposal are carried out by specialized organizations licensed by type and are regulated by the requirements of the relevant ministry.

Utilization of industrial waste. All non-recyclable waste is placed in large, technically equipped areas to prevent environmental pollution[12.13].

In addition to dumping in landfills to protect agriculture from waste, energy-producing waste is sometimes disposed of by burning at thermal power plants and polluting the air with flammable products (gases, ash, and ash) [14].

Before waste disposal, the following is carried out:

– burning in fuel furnaces or reactors;
– neutralization with chemical compounds;
– concentration of liquid waste by mixing it with soil.

Waste transportation. Waste removal from enterprises and organizations is carried out by various methods.

A specific method of waste disposal affects their physical condition:

– solid household waste is transported in specially designated containers;
– liquid - in hermetically sealed containers.

Recycling and sale of industrial waste. Processing of industrial waste is not only environmental protection, but also a source of additional income.

Organizing the processing and sale of production waste serves to increase the profitability of the enterprise. Of course, not all raw materials or waste materials and semi-finished products can become secondary raw materials. As a material for recycling, only recyclable waste is processed in plants specially equipped for recycling. As one example, let's consider briquette products made using coal waste and industrial waste as a binder for waste processing and transferring them to consumption in the form of a high-quality product [15.16]. Coal dust makes up approximately 60% of the coal mined during mining and transportation operations at the Angren coal mines. This hinders the full use of extracted solid fuels. To eliminate these problems, 2 different methods of briquetting waste were studied. Organic and inorganic waste generated by industrial enterprises was used as a binder. The two samples obtained as binders show that the briquette sample obtained by adding an inorganic binder has high strength but low flammability, while the organic binder has lower strength but higher flammability compared to the inorganic binder [17]. Therefore, the use of an aqueous solution of sodium silicate (liquid glass) as a binder in the preparation of briquettes from coal powders allows comparing the effectiveness of the selected local binders with the standard (control). Figure 1 shows the change in the mechanical strength of the obtained briquettes when adding the recommended binders. An aqueous mixture of sodium silicate at a concentration of 5% was used as the controlled binder[18]. As can be seen from Figure 1, with the addition of up to 15% of the binder - gossypol resin and up to 20% of the beer bar, high-strength coal briquettes are formed. Under the influence of the mechanical strength of the binders, the coal briquettes change in the following order of decrease: 5% sodium silicate mixture in water > gossypol resin > beer bar.

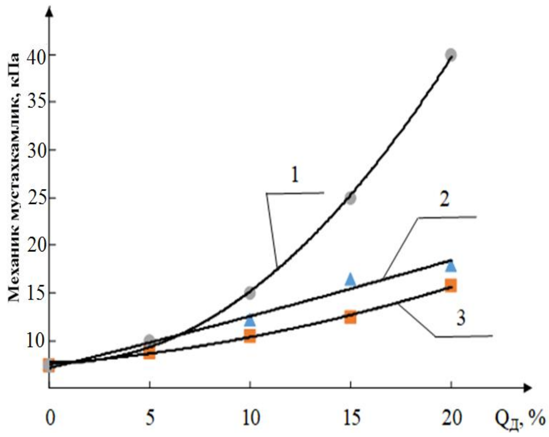

Figure 1. Changes in the mechanical strength of the obtained coal briquettes depending on the amount of binders: 1 - a mixture of sodium silicate in 5% water; 2 - gossypol resin; 3 - beer bar

We studied the influence of the obtained coal briquettes on the combustion temperature depending on the amount of binder (Fig. 2).

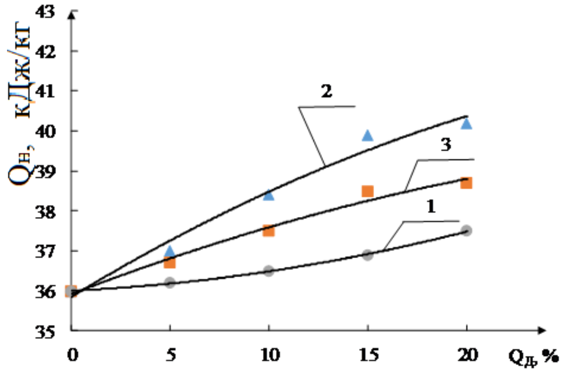

Figure 2. Change in the caloric value of the obtained coal briquettes depending on the amount of binding agents: 1-5% aqueous solution of sodium silicate; 2-gossypol resin; 3 - beer bar

As can be seen from Figure 2, the highest caloric value of the obtained coal briquettes was obtained by adding up to 15% gossypol resin and up to 20% beer bar. Using a 5% aqueous solution of sodium silicate, the control sample practically does not change the caloric value of the resulting coal briquettes [19.20.21].

In conclusion, it can be said that high color values were achieved in coal briquettes obtained using organic binders. It was established that the amount of ash released after the combustion process is lower than in coal briquettes obtained using inorganic binders.

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