Nina Buravchuk
Olga Guryanova

ENERGY SCIENCE, ENGINEERING AND TECHNOLOGY

FUEL BRIQUETTES

Made of Carbon-Containing Technogenic Raw Materials

NOVA

Energy Science, Engineering and Technology

Energy Science, Engineering and Technology

Smart Grid Technologies in Electric Systems for Renewable Energy
Eugene Chaikovskaya
2022. ISBN: 979-8-88697-387-7 (Softcover)
2022. ISBN: 979-8-88697-432-4 (eBook)

The Future of Biodiesel
Michael F. Simpson (Editor)
2022. ISBN: 979-8-88697-166-8 (Softcover)
2022. ISBN: 979-8-88697-172-9 (eBook)

Nanotechnology Applications in Green Energy Systems
Rajan Kumar, PhD and Tangellapalli Srinivas, PhD (Editors)
2021. ISBN: 978-1-68507-451-7 (Hardcover)
2022. ISBN: 978-1-68507-479-1 (eBook)

Energy Conversion Systems: An Overview
Sanjeevikumar Padmanaban, PhD
and Saurabh Mani Tripathi, PhD (Editors)
2021. ISBN: 978-1-53619-131-8 (Hardcover)
2021. ISBN: 978-1-53619-200-1 (eBook)

Advanced Power Systems and Security: Computer Aided Design
Muna Hamid Fayyadh and Samir Ibrahim Abood
2020. ISBN: 978-1-53618-785-4 (Hardcover)
2020. ISBN: 978-1-53618-863-9 (eBook)

Energy Storage Systems: An Introduction
Dr. Satyender Singh (Editor)
2020. ISBN: 978-1-53618-873-8 (Hardcover)
2020. ISBN: 978-1-53618-910-0 (eBook)

More information about this series can be found at
https://novapublishers.com/product-category/series/energy -science -engineering -and-technology /.

Nina Buravchuk
and Olga Guryanova

Fuel Briquettes Made of Carbon-Containing Technogenic Raw Materials

nova
science publishers
www.novapublishers.com

https://doi.org/10.52305/LLXH2766

Library of Congress Cataloging-in-Publication Data

ISBN: 979-8-88697-944-2 (eBook)

Published by Nova Science Publishers, Inc. † New York

Contents

Introduction vii

Chapter 1 **Technical Solutions for Briquetting of Carbonaceous Waste** 1
1.1. The Status of the Issue of Briquetting Coals of Small Classes 1
1.2. Experimental Experience on Briquetting of Carbon-Containing Waste (Based on the Materials of the Inventions) 5

Chapter 2 **Technological Aspects of Carbon-Containing Waste Briquetting** 25
2.1. Chemical Nature of Coals 25
2.2. Briquetting of Coals 27
2.3. General Principles of Fuel Briquette Design 28
2.4. Stages of Structure Formation 31
2.5. Hardening of Briquettes 33

Chapter 3 **Technological Solutions for Creating Fuel Composites from Carbon-Containing Waste** 37
3.1. The Main Tasks of Briquetting 37
3.2. Briquetting Components 39
3.3. Humidity of Initial Components and Charge for Pressing 47
3.4. Granulometric Composition 52
3.5. Binder Consumption 56
3.6. The Temperature of the Mixture during Pressing 57
3.7. Pressing Pressure 58
3.8. Binder with Hydrophobizing Additive 60
3.9. Stabilization of Properties of Fuel Briquettes 63
3.10. Multicomponent Fuel Briquettes 77

3.11. Comparison of Binders for Briquetting Carbonaceous Products....87
3.12. Technical Characteristics of Experimental Batches of Fuel Briquettes....91
3.13. Results of Combustion of Fuel Briquettes of Pilot Batches....97
3.14. Technological Schemes of Briquetting....103

Chapter 4 Briquette Structure Formation Mechanism....109

Chapter 5 Formation of the Market for Briquettes....115

Conclusion....121

Financing the Work....125

References....127

Index....135

About the Authors....139

Introduction

The coal industry occupies one of the leading places in the mineral-industrial complex and in the Russian economy. Coal occupies a stable position in the chemical and metallurgical industry and energy.

On the other hand, the coal industry is an intense source of anthropogenic impact on the environment. Coal regions, due to their specific socio-economic development, experience significant technogenic pressures, as a result of which intensive changes occur in all components of the environment. In the "Energy Strategy of the Russian Federation for the period up to 2035" [1], the tasks of the coal industry are to reduce the negative impact of the activities of enterprises of the fuel and energy complex (FEC) on the environment and climate. One of the measures that contribute to the solution of the tasks set is to stimulate the reduction of the formation of new and disposal of accumulated production waste, and land reclamation. Utilization of technogenic raw materials acquires a comprehensive character and becomes part of the modern economic outlook. The transformation of carbon-containing technogenic raw materials into useful products is the final stage in the extraction and processing of a mineral - natural coal.

In the process of coal mining, enrichment, intra-mine reloading, storage and transportation to the consumer, a large amount of solid coal waste is generated (anthracite fines, coke and coal fines, coal sludge and dust). The scale of formation of solid combustible waste in various industries can range from 30 to 70% of the main production volume [2]. Utilization of combustible technogenic raw materials is a very urgent problem that attracts the attention of many researchers. Coal wastes of small classes are stored in dumps, sludge storages. Significant areas of land suitable for urban planning and agriculture (agriculture) are allotted for such dumps and storages, which have the status of technogenic deposits. Dumps occupy approximately 20% of the area of all disturbed lands and, in addition, pollute the environment with greenhouse gases, toxic and harmful substances, soil and water with

harmful ingredients. The enterprises of the coal and fuel and energy industries spend significant funds on the transportation and storage of solid waste, pay for their disposal and environmental pollution resulting from harmful emissions and discharges at the sites of sludge storage and dumps. Unused waste from the coal mining industry is stored in dumps, sludge storages.

In the mining industry of Russia, the total mass of all non-utilized solid coal waste reaches 45 billion tons, and the total area occupied by their storage occupies more than 250 thousand hectares of land. Such waste contains from 30 to 80 or more percent of combustible substances. However, due to fine grain, high humidity and ash content, their use and marketing are difficult. In Russia, in the coal-industrial regions, a huge amount of such waste has already been accumulated and continues to accumulate.

Long-term storage of significant volumes of fine-grained and finely dispersed fines in the open-air leads to its entry with flood and storm waters into the basins of nearby rivers. At the same time, the study of such qualitative characteristics of carbon-containing materials as: ash content, sulfur content, combustion heat, volatile matter yield, made it possible to establish their prospects for use after appropriate processing as a full-fledged domestic fuel. The reserves of such wastes, which have a certain energy potential, are large. Coal screenings and sludge, being production waste, as a rule, are not inferior to mined coal in terms of quality characteristics. In significant quantities, there is another type of waste that can form the raw material base for the manufacture of additional fuel. These include vegetable waste from agriculture and the woodworking industry. Energy-potential technogenic raw materials can become fuel with qualitative characteristics. By processing waste into lumpy fuel, carbon-containing technogenic raw materials are transferred from low-value and low-grade combustible substances into high-quality solid fuel. Involvement of combustible waste in the heat balance makes it possible to obtain additional fuel and at the same time reduce the level of environmental pollution.

One of the major consumers of solid fuels is furnace devices for industrial power engineering and public utilities. For these purposes, ordinary, fine-grained, or low-grade coals with a high yield of volatile substances are used, which emit a lot of smoke, soot, and dust when burned. The use of such coals does not ensure the completeness of fuel combustion and, accordingly, high thermal performance of power plants. The fuel used in power plants is subject to quality requirements in the direction of reducing environmental pollution with coal dust, harmful oxides of sulfur, nitrogen,

etc. This is especially true for coals intended for combustion in household stoves, small boiler houses and other small power plants, where there is no system of centralized capture of harmful emissions. It is almost impossible to control the quality of emissions from such power plants.

Consumers in the domestic sector need fuel. Demand for coal will increase due to high oil and gas prices. With the current trend of reducing the production of sized coal for domestic needs, there is a need for additional types of solid fuel. Meanwhile, the reserves of coal fine-grained materials are enormous. However, their use is difficult, and often almost impossible: the complexity of transportation, dusting, incomplete combustion, high ash content, sludge–high humidity. There are other unclaimed plant raw materials that are potentially suitable for obtaining thermal energy. Under these conditions, it is necessary to look for opportunities for the rational use of technological fines and low-grade coals, and other energy-bearing waste, to create technologies that replenish the reserves of standard fuel.

Consumers in the domestic sector need fuel. Demand for coal will increase due to high oil and gas prices. With the current trend of reducing the production of sized coal for domestic needs, there is a need for additional types of solid fuel. Meanwhile, the reserves of coal fine-grained materials are enormous. Coal waste of small classes contains from 30 to 80% combustible substances. However, their use is difficult, and often almost impossible: the complexity of transportation, dusting, incomplete combustion, high ash content and high humidity in the slime. There are other unclaimed plant raw materials that are potentially suitable for obtaining thermal energy. Under these conditions, it is necessary to look for opportunities for the rational use of technological fines and low-grade coals, and other energy-bearing waste, to create technologies that replenish the reserves of standard fuel. It is possible to obtain a product with the required properties from substandard, but having a certain energy potential, raw materials by applying the briquetting technology. In the presence of a raw material base to produce fuel briquettes, technology is needed that ensures environmentally efficient production of products with specified quality indicators. The most reasonable technological direction that can provide fuel with satisfactory consumer characteristics is the briquetting of substandard carbonaceous waste with binders. This is a universal way to obtain briquettes from almost any material. The demand for solid fuel is steadily increasing, the fuel market is practically empty. The organization of production facilities to produce conditioned briquetted fuel makes it possible to at least partially

reduce the growing shortage of coal, primarily for furnace devices in the domestic sector and thermal units of industrial energy.

The subject of this study is the carbon-containing waste available in the Rostov region. 6.5 billion tons of coal have been explored in the bowels of the Rostov region. The Rostov region is the main fuel and energy base of the North Caucasus region. This status is ensured by the huge reserves of coal concentrated in the region. The enterprises of the coal industry are located on the territory of one of the oldest coal basins - Eastern Donbass and have a convenient geographical position. Proximity to the ports of the Black and Azov Seas, the territories of other subjects that are part of the Southern Federal District, potentially predetermines the coal industry as one of the main sources of energy resources in the region. Anthracites are mined in the coal basin of the Rostov region. A significant part of coal waste is anthracite fines and waste from coal preparation plants. The largest amount of coal (15–40%) is found in flotation waste. In wastes of gravity enrichment of class 1-13 mm, the amount of coal can reach 15%, and in wastes of class 13-150 mm - 4-7%. The coal content in coal mining waste varies from 0 to 10%. Anthracite fines, coke, coal fines have a certain hardness, and their mixtures are rigid, not plastic. A strong fuel briquette based on such coal components can be obtained with binders. In this regard, the task arises of finding an optimal binder for briquetting hard coal waste, which is both easily accessible for the molding process and, most importantly, inexpensive, since the economic component in any technology is largely decisive. If wastes with suitable physical and chemical properties are used as such substances, then the problem of choosing a binder from the point of view of economics will be solved. In addition, the proposed binder must be transportable and non-deficient so that the production of fuel briquettes is not tied to the places where the waste binder is formed. As such a substance, the use of sugar-beet and starch-treacle products is promising. The resulting fuel can be used as an alternative to natural gas and coal, which will contribute to the resource saving of traditional energy carriers.

Chapter 1

Technical Solutions for Briquetting of Carbonaceous Waste

1.1. The Status of the Issue of Briquetting Coals of Small Classes

During the extraction and processing of coal, the formation of waste is inevitable. These are mainly anthracite fines, coke, coal fines and coal dust, coal sludge. These wastes are generated at the enterprises of the fuel and energy complex during the classification of coal and the separation of fractions suitable for combustion in boilers. Coal slimes are high-ash and fine particles, which are wastes of technological processes of coal mining and its enrichment. Large-tonnage coal technological waste is generated during the activities of coal mining enterprises–mines, cuts, as well as coal preparation plants. Coal waste is stored in dumps and sludge storages and most often remain unclaimed in the future. Such waste contains from 30 to 80% (or more) of combustible substances. However, due to their fine grain, high humidity and ash content, their disposal and marketing are difficult. In Russia, a huge amount of such waste has already been accumulated and continues to accumulate, occupying large areas and polluting the air basin, water bodies, land, thereby deteriorating the quality of the human and animal environment. Such waste is an important energy resource that can be used in the organization of the production of new types of fuel. for example, fuel briquettes. The problem of utilization of finely dispersed coal waste has existed for a long time and has not lost its relevance at the present time. The briquetting of coals of small classes and energy-bearing fine-grained waste is a process of mechanical processing of waste into lumpy fuel - briquettes with certain technical characteristics, shape, size, and weight. By turning into briquettes of anthracite fines, coal fines, sludge, they are transferred from low-grade and low-value fuels to more conditioned solid fuels.

Fuel briquettes are rightfully considered the fuel of the 21st century, the number of its consumers in various countries of the world is growing every year. Abroad actively engaged in waste briquetting. Europe has already appreciated the advantages of briquetted fuel. In developed countries,

briquetting is constantly given the closest attention. Significant funds are invested in scientific and technological developments, in the construction of new and improvement of existing briquette facilities, especially those using waste or low-grade raw materials. It should be noted that foreign briquette production, using not even waste, but high-grade raw materials, is highly profitable. Processing of coal waste using various briquetting technologies is widely carried out in most European countries. So, in Germany, England, France, the Czech Republic, Poland, Turkey, the USA, Australia, China, Japan and other countries, briquettes based on coal fines are produced using various technologies in large volumes of various quality, composition and properties [3, 4]. The development of binders and briquetting methods is actively carried out by Germany, Great Britain, the USA, and Japan. Germany occupies a leading position in the field of briquetting. In Germany, brown coal briquetting has been mastered for the first time, thermal briquettes of increased strength and calorific value based on sintered coal as a binder have been developed. In another group of technical solutions, polyvinyl alcohol is used as a binder. Some firms in Germany, Great Britain, France use coal tar pitch for briquetting. Abroad, a bituminous binder is often used. The most common binder for briquetting remains products of coal and petroleum origin. However, these binders are substances with increased carcinogenic properties. To increase the permeability of fuel briquettes, surfactants are introduced. Increasing the water resistance of fuel briquettes, especially during long-term storage, is achieved by using polyacrylamide, vinyl acetate polymers and thermoplastic resins based on polyethylene. Briquetting technologies include, as a rule, preparation of initial components and a binder, mixing of ingredients, pressing, drying, heat treatment for strengthening and imparting stability of properties to fuel briquettes. In recent years, in the development of briquetting technologies, molasses, polyvinyl alcohol and other substances are more often used as a binder, which are environmentally friendly and provide the necessary strength characteristics of briquettes. Such binders are used in the development of firms in Germany, Great Britain, Poland, etc.

From a brief analysis of foreign inventions, it follows that the most common binder for briquetting remains products of coal and oil origin. There is a trend towards the use of more environmentally friendly binders.

According to some data, up to 1.5 million tons of coal briquettes are produced annually in France, up to 1 million tons in Belgium, England, in the USA, Sweden, Austria and in several other countries the volume of production and use of fuel briquettes is from 0.5 to 2.0 million tons per year.

In general, in all of Europe–up to 4 million tons of coal briquettes. In Japan, the process of partial briquetting of coal charge has received wide industrial application. This process has been implemented at five coke plants in this country. Briquetting technologies make it possible to obtain briquettes of various quality, composition and properties. At the same time, an increase in the operational characteristics of the fuel is achieved, namely, transportability, storage stability, it becomes possible to increase the calorific value.

In Ukraine, the use of innovative briquetting technologies by several companies ("Vostok-Coal"; "RovnoEnergoAlliance"; "Coal-Sintez"; KT "Ecoresurs", etc.) makes it possible to obtain a competitive type of fuel with good quality indicators. At the initiative of coal enterprises, installations for briquetting coal fines, lines for the production of briquettes "Nestro" have been built and are operating; plant for the production of fuel briquettes "Pini & Kay", etc. In the city of Rovenky, Luhansk region, VERETEX™ coal briquettes are made from high-quality coal of the Donetsk coal basin of the "Anthracite" brand using environmentally friendly substances: sugar beet syrup and lime. Molasses is a binder, and lime is involved in strengthening the strength of fuel briquettes.

In Kazakhstan, there is a coal briquetting plant "Al-Maktub" [5].

The world's two leading manufacturers of briquetting systems, RUF and C. F. Nielsen, joined forces in 2018. The merger allows the companies to provide a full range of briquetting technologies for the production of briquettes, which are suitable for most types of organic and inorganic raw materials [6].

Briquetted fuel has the following advantages: when burning coal briquettes, compared with burning ordinary coal, the efficiency of combustion devices increases by 25–35%, emissions of sulfur dioxide are reduced by 15–20%, emissions of solid substances with flue gases are more than halved, and, underburning of combustible components is reduced by 15–20% [3]. In the context of rising energy prices, the use of this type of fuel is becoming more and more relevant every year. In Russia, interest in briquetting of charcoal and coal waste arose in the mid 30-s of the 19th century. One of the founders of the Soviet school of briquetting is A. T. Elishevich. A number of technological solutions are proposed for obtaining fuel briquettes from various types of unclaimed carbon-containing materials. Briquetting technologies were developed and studied in the works of Alexandrov B. M., Afanasiev A. E., Bazin E. T., Gamayunov N. I., Grevtsev N. V., Kegel K., Kosov V. I., Krokhin V. N., Lishtvana I. I., Lurie L. A.,

Nifontova Yu. A., Ravicha B. M., Churaeva N. V. and many other researchers. However, the briquetting process in Russia has not been developed on a large industrial scale. In Soviet times, the Donetsk briquette factory was innovative. The briquetting technology adopted at the factory originally used coal tar pitch. Due to the carcinogenic properties of this binder, over time it was replaced with petroleum bitumen. A brief review of technologies for the production of fuel briquettes is given in an analytical note [7]. A number of firms and companies ("Unitech" LLC, "ZHASKO" CJSC, "Briquetting Technologies" LLC, etc.) are developing technological equipment and lines for briquetting carbon-containing waste. Successfully and dynamically developing PC "Briquette-Press" in the Republic of Adygea, Maykop [8]. This is a manufacturer of equipment for the disposal of various types of waste, such as sawdust, sunflower husks, straw, as well as screenings of natural coal - coal and lignite and charcoal.

In Soviet times, Donetsk was innovative. Most of the developments related to the theory and practice of briquetting were carried out in scientific organizations. For example, the Institute of Combustible Fossils (IOTT, Moscow) has developed [9–12] advanced technologies for producing smokeless high-calorie agglomerated fuel–thermal briquettes and modular plants for coal briquetting in automated roller complexes (ABVK-10, ABVK-50). Samples of an automated briquette roller complex with a capacity of 50 t/h (ABVK-50) were manufactured at the Krasnoyarsk enterprise CJSC "Spetstechnomash" and operated by "Sibirsky Briket" LLC, located at the industrial site of the Krasnoyarsk State District Power Plant-2 (Zelenogorsk). The object of briquetting is coal grade 2B of the "Borodinsky" open pit. The total design capacity of the enterprise is 1 million tons, the installed capacity is 500 thousand tons. The resulting fuel in the form of briquettes has improved characteristics compared to the original coal.

Research on briquetting of brown coals of the Kansk-Achinsk energy complex is carried out at JSC "KATEKNIIugol" [13]. Several technologies have been developed for obtaining low-smoke and smokeless fuel from brown coals of the Kansk-Achinsk energy complex.

At St. Petersburg Mining University (SPGU), research was carried out [14] on the development of a recipe, technology and equipment for the manufacture of fuel briquettes ignited by a match. By-products of other industries are used as binders. In the works [15, 16], a fundamentally new method of coal fines briquetting with the use of active finely dispersed binders was developed and scientifically substantiated. The mechanism of