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Technology of breakage of coal for the coal-water fuel production

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Summary. The search for new solutions in the direction of producing fuels from coal that are more efficient and more usable of energyresources with a relatively low cost, objectively led to the creation of coal-water fuel (CWF). The significantly greater economic efficiency of coal compared to gas and oil allows to reduce running costs and to provide enterprises with the maximum profit in the energy sector. Technology of production CWF requires finding alternative plants for crushing coal, which are more effective in many performances.

Based on these requirements, the construction of a vertical roller mill equipped with a high-dynamic separator is the proposed in the paper. This mill provides grinding of any rank of coal to the required fraction and it is a very cost-effective solution when it comes to specific energy consumption. There was also a scheme of arrangement grinding of coal working in non-inert and considered the principle mode of operation of the mill.

It is known a number of technologies of processing coal into the so-called ecological, convenient operating kinds of fuel – gaseous and liquid. However, in the vast majority of them the complex processes of heat or chemical processing with a large capital investment and increased requirements for operation are used. A considerable amount of coal fuel reserves in Ukraine and the high price of oil and gas dictate clearly a necessity of the massive use of coal-water fuel in the nearest future, but today it is made only a search for optimal solutions for using WCF as the main fuel. There are a lot of technologies and components of preparation CWF nowadays. For the preparation of CWF different ranks of black and brown coal, coal slack consisting of a mixture of various components: coal slurry, sludge tank products, waste dumps heaps, fine-dispersed coal, low-grade coal.

Key words. technology, coal, breakage of coal, mills, economic efficiency, energetic.

INTRODUCTION

The current state of the fuel and power potential of many European countries dictates the conditions of the selection of the most promising fuels according to all indicators.

Nowadays the energy supply of developed countries is mainly based on these energy-carriers:

- Combustible Fuels (oil, gas, coal);
- Nuclear fuel;
- Renewable energy sources (biomass, solar and wind energy, etc.);
- Industrial hydrocarbonaceous products / waste (petroleum coke, blast furnace gas, synthetic gas, etc.)

The diagram below presents the main world reserves of primary energy in the form of a script, "past-future" for the period from 1930 to 2090 from the perspective of today. The amount of energy reserves are in millions of tonnes (Fig. 1.).

We can clearly see that in future of the fossil fuels, in the world economy in decent volumes only coal will be available [13].

Following these forecasts one can raise the question of searching the best technologies for the use of coal fuels in the energy sector.

A sustainable development of the global fuel-energy complex is closely connected with the use of alternative fuels, which are the most appropriate and cost-effective energy for many countries in terms of modern conditions.

It is known a number of technologies of processing coal into the so-called ecological, convenient operating kinds of fuel – gaseous and liquid. However, in the vast majority of them the complex processes of heat or chemical processing with a large capital investment and increased requirements for operation are used [14].

The searches for new solutions in the direction of producing fuels from coal fuel which are more usable energy resource with a relatively low cost, objectively led to the creation of fuel disperse systems water –fine-dispersed coal – chemical additives [9,24].

A considerable amount of coal fuel reserves in Ukraine and the high price of oil and gas dictate clearly a necessity of the massive use of coal-water fuel (CWF) in the nearest future, but today it is made only a search for optimal solutions for using WCF as the main fuel.

There are a lot of technologies and components of preparation CWF nowadays. For the preparation of CWF different ranks of black and brown coal, coal slack consisting of a mixture of various components: coal slurry, sludge tank products, waste dumps heaps, fine-dispersed coal, low-grade coal.

THE ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

New directions have activated in the coal energy recently. Technological solutions for the coal gasification, the production of coal-water fuel and special equipment for burning it are widespread in many countries [19]. All these new technologies require a higher quality of coal fuel, a minimal ash content, a sufficiently narrow grain-size composition and a sufficiently fine breakage of coal – not larger than 50 microns, and more preferably less than 30 microns [13].

According to the classical scheme the production of SWF consists of three main stages: breakage, wet milling, homogenization. The wet milling is the key step when the coal is ground to the required fraction (usually less than 100…150mkm) [11, 16].

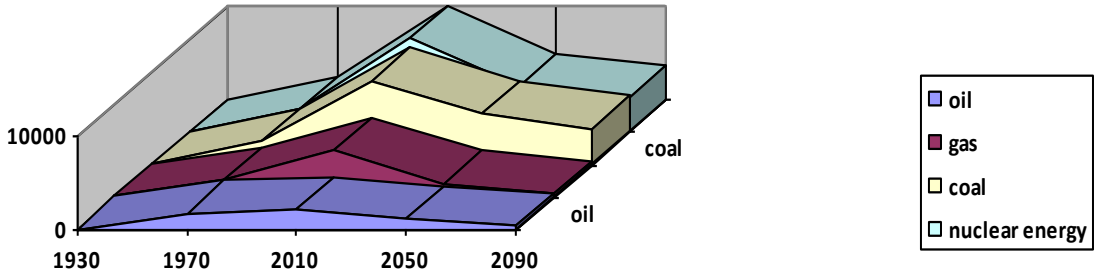

Fig. 1. World energy reserves (calculations from 2014

Currently, the most widespread equipment for breakage coal is different types of grinding mills. Depending on the shape and form of the driven element and speed of his motion, the mills can be divided into five groups:

I – Barrel including ball, rod, pebble autogenously grinding.

II – roll, circular, roller, frictional-ball runners.

II – hammer (mine), finger (disintegrators).

IV – vibrational with a swinging body.

V – Jet, aerodynamic, without crushing bodies.

In the early 2000s, it was also proposed to use the cavitational devices for the wet milling step and homogenization. Today, we are exploring the new electrophysical ways of grinding coal with the electrical currents of high frequency electric pulse, electrohydraulic beat and others.

The main disadvantage of barrel and vibrating mills is a high energy consumption for the production of CWF that constitute not less than 55 kWh / t. Grinding material that passed the last stage can include particles to scatter on-graded. Elimination of this disadvantage requires a fairly long time of coal grinding, which greatly increases the costs of energy and does not ensure a high quality of grinding [21].

The main disadvantage of hammer mills is a rapid wear of the impactor and the rotor, which reduces the performance and reliability of the systems. An advantage of the hammer mills is the possibility of jet mills superfine (1-5 microns up to 95%) milling with a high purity product. The draw back isahigh energy milling.

OBJECTIVES

On the basis of these requirements, it is necessary to implement the efficient technologies and equipment for grinding raw coal. This is due to the tendency to reduce energy consumption for the production of CWF and to increase productivity.

THE MAIN RESULTS OF THE RESEARCH

Recently the most promising solution of organization grinding coal plants has been the vertical roller mill, the principle of which is based on the use of cyclone airflow. At this stage of the development of equipment for grinding all ranks of coal installation of container type that satisfy the safety requirements are the most widespread [7,13]. A modern compact design coal mill that is made in the result of continuous improvement differs with a high reliability and the ability to create on its basis the mills of different sizes.

The vertical roller mill that is proposed in this paper grinds and dries all ranks of coal and it is a very cost-effective solution when it comes to specific energy consumption. This mill is suitable for manufacturing plants of various types: inert and non-inert, with direct and indirect fuel supply system [15].

Coal grinding mill provides grinding of any ranks of coal to the required fraction; it isequipped with high-dynamic separator system RAKM. If there is a set with engine with adjustable speed at the mill, it can grind petroleum coke and anthracite residue on sieve of up to 5% of the material of size more than 90 microns.

Separator and nozzle ring are sized independent of the mill. It makes possible to select the size according to the amount of gas required for drying and transporting material. During one operation this mill is able to grind and dry the coal containing more than 20% moisture.

Consider the principle of operation of the mill. Lump coal is fed into the mill through a sealed screw-feeder and into the center of the rotating milling table (Figure 3.). Rotation of the table accelerates the coal in the grinding zone where the process of grinding between the table and the three rollers. Then, the milled material passes over the ring into the flow of hot air which penetrates into the grinding chamber through the nozzle ring. Air raises the coarse particles of coal on the milling table, and fine particles get into the separator through which the final product should be output from the mill, and coarse particles are returned to the table for further grinding. After leaving the mill at the top, the final product is carried away by the air flow in a cyclone or a bag filter where it deposits [7,5].

During grinding most ranks of coal which are suitable for production of CWF the system can operate in an inert and non-inert mode. Non-inert mode allows to excess air of the clinker cooler for drying and transport.

In this case it does not require a recirculation or water supply to the mill, because for the maintain the required flow an atmospheric air can be used, regardless of the amount of hot air required for drying. Inert mode of operation of coal mill involves the use of water injection system into the grinding chamber to compensate for the low water content in raw coal.

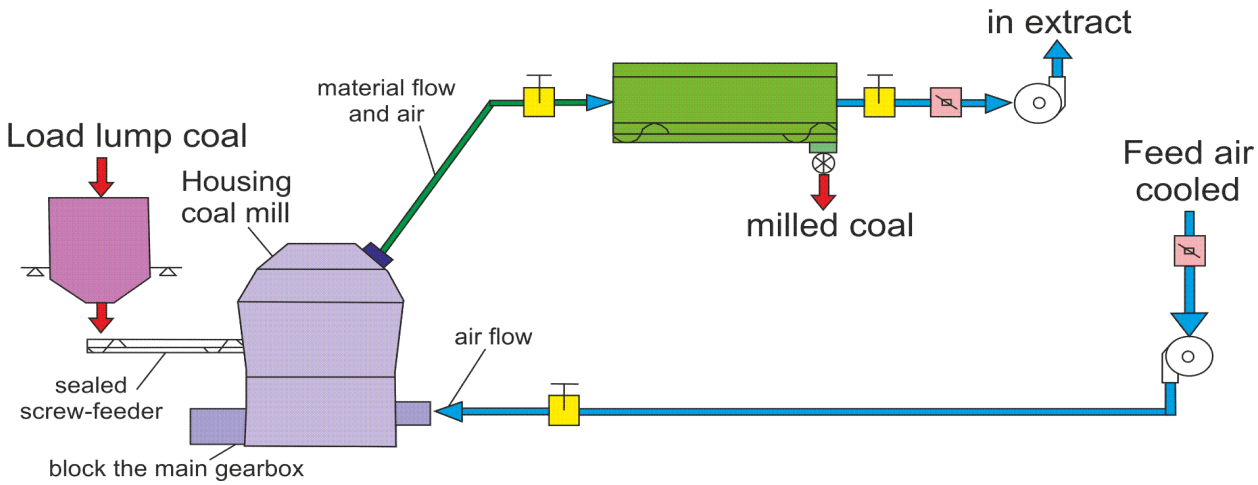

Fig. 2. Arrangement of coal grinding system operating in the non-inert mode

Fig. 3. General view of the grinding table and rollers with the replaceable segments

Grinding table and rollers equipped with segmented replaceable elements. Segmentation allows the use of very hard and wear-resistant material, negating the risk of thermal cracking of the segment undergoing wear. The cylindrical shape allows turning the roller segments. It ensures a high degree of material utilization, even in case of irregular wear.

The use of wear-resistant high-chromium iron provides a long service life of grinding segments.

Hydraulic cylinders that are fixed in the foundation block create the grinding force for the individual rollers. The hydraulic force is transmitted to the ends of the roller shaft through the traction rods. Coupling of these rods are designed as bolted flanges, which providesthehigh resistance to breakage due to fatigue mechanisms.

The roller assembly is fixed in a concentric position relative to the table by means of horizontal torsion bars connecting the end of the shaft of each roll with the housing of the buffer is placed in the mill housing through special dampers [22].

Before starting the engine mill grinding rolls rise above the grinding zone. After a short work of working fan (3-5 min.) the material feedstarts, and grinding rolls sink to the grinding rolls pillow.

The lubrication system ensures an effective lubrication of bearings grinding rollers. Conditioned lubricant is fed to each roll individually from the total station lubricants [20].

Specific energy consumption of the proposed mill depends on the rank of grinding coal and the required degree of grinding coal meal. Grindability of coal is usually determined on a scale Hardgrove Grindability Index (HGI) [1]. Specific energy consumption of the mill is determined on a scale of HGI (kWh / tonne of product). Specific energy consumption is based on production capacity taking into account the residual moisture coal meal. This point is very important for some ranks of coal which have residual moisture.

The power supply system of the mill. Lump coal is put into the mill by means of a screw feeder, which also serves as an air lock.

Rotating air separator is mounted on the top of the mill case. The rotor shaft is driven by AC motor with adjustable speed through the reduction gear assembly. The rotor rotates within the ring with the guide vanes. The material from the mill entrained air enters the rotor through the guide vanes. Rotor sorts out large particles which are removed by the guide vanes, and then through a funnel sorting they fall onto the grinding table for the further grinding. At this time, the air and the final product leave separator through the outlet duct. Reduction range of the final product is controlled by changing the rotor speed.

This unit can be equipped with dynamic separator LSKS [7]. The separator can separate particles up to 1 micron (and achieve sieve residue 1% R 10 microns). With the installation of mechanical and technological parameters, separator may provide grain size distribution of the finished product.

LSKS separator can operate selectively and produce a finished product with a steeper or flatter distribution curve particle size distribution.

By the rotation of the rotor it accelerates tangentially supplied to it a powder-gas mixture. The resulting centrifugal force separates the coarse particles. By setting the rotation speed of the rotor in conjunction with the gas flow and its direction of feed is possible to get a finished product with a different distribution curve of particle size distribution.

A special feature of this design of the separator is a continuous additional separation separated particle streams by rotor. As a result of the centrifugal force they

are separated by the separator rotor, they are again picked up by the gas flow and returned for re-separation. At the same time the accumulated particles are loosened and better follow the product stream in the form of individual particles and do not fall, as apparent oversize back onto the grinding table.

The standard gearbox is used for the proposed mill has greater endurance helical gear or a more compact gearbox with bevel gear planetary type. Gears are designed for use in high dynamic loads and have a large reserve of fail-safety. Axial thrust bearing takes the weight of the grinding table and the grinding action of force. When all the segmented design all bolsters are immersed in an oil bath.

An important element of the operating mills is its maintenance. Worn grinding elements (bandages rolls and slab grinding table) can be replaced simply and quickly. Grinding rolls are removed from the grinding chamber in a vertical position with the help of the cylinder for rotating the rolls. It provides access to hoist the grinding rolls, bandage rolls and plates grinding table.

When grinding raw coal grinding elements throughout the life of the wear substantially uniformly and productivity of the mill starts to decrease only when completely worn grinding elements. Partial wear of grinding elements can be aligned targeted carbide Weld inside the grinding chamber.

Grease for bearing pads and inner bearing and gear-units passes a pre-preparation and filtration in a single pump station.

Replacement of worn rollers segments in small mills is conducted outside the mill. The entire roller assembly is removed using a special trolley and served on the platform in front of the mill. Larger mills allow replacing the segments of rollers and the grinding table inside the mill, which mill is equipped with a small winch [10].

For the design of vertical roller coal mill the following points are next standard settings:

- Specific pressure when grinding. It is in a range between a minimum value in the grinding of coal fuel and a maximum value during the grinding of the slag.
- Humidity source of parent fuel. These mills can be operated with the fuel to 25-26% moisture.
- The fineness of the product. The final fineness of the product, depending on the composition of the raw mixture is between 6% and 30% of the residue on 90 micron sieve.
- Drive power. Defines values for engine power and gear is power in the grinding test.

The size of the mill is set on the basis of the external diameter of the grinding table working in decimetres [dm].

The most important characteristic of the roll mill is the amount of work rolls. The number and size of the rolls are determined according to the required performance based coefficient of performance of the mill, determined on the basis of the coefficients of the grindability, humidity and fineness. The required gas stream is decisive for the design of the mill case and separator.

Coal roller mills have a modular design. Modules are considered as blocks consisting of rolls, rolling levers and components suspension system roll with their pedestals. In the grinding table are places as required from 2 to 6 modules.

The drive is powered by a motor. It drives through flexible coupling planetary gearbox with bevel gear. The drive gear shaft disposes horizontally; the output shaft extends perpendicularly upwards. The output element is a horizontal flange reducer. Gear unit is equipped with the pad thrust bearing which in the upper part of the body assumes grinding force. Gearboxes for roller mills are continuously improved in cooperation with leading manufacturing companies. Application conditions are agreed jointly, which have to work reducers, bench tests are conducted. The experience of many years of operation the mills determines the design of the gears and components for all weather conditions.

Today modern gearboxes as mills have a modular design. The power distribution allows to reduce weight while simultaneously rotating multiple application of structural elements in gears of different sizes and capacities.

The modular design according to today's level of technology allows gear to increase power without developing a new concept of design.

For the layout of the proposed coal grinding system does not require a motor is elevated starting torque. Since the rolls are raised hydraulically, the breakaway torque when the mill is filled with only 40% of the time at full load. Such starting torque can easily provide a standard motor.

The installed engine capacity depends on the energy consumption of the mill. It is determined during the grinding test. It is recommended to choose the closest motor power of a standard type.

For managing and optimizing the operation of the mill, one can use the expert system MCE database that will be improved during the further studies. Operation system ensures full utilization of productive resources while maintaining maximum performance settings possible in the current operating conditions. MCE adapts automatically the control parameters setting to working conditions and type of crushed coal, ensuring optimum performance at full or partial load of the mill. MCE system also ensures compliance with quality parameters and stable operation of the plant.

The principal design feature of mills of this type, compared with other available on the market vertical mills is their modularity. The modular design of vertical roller mills makes it possible to use the same, proven in practice, the structural elements in the mills of different purpose and different performance. Technological module consists of grinding mill rolls, arm roll pedestal and suspension system. This design allows to adjust individually the grinding rolls and to automate the process of grinding.

Implementation of the modular concept allows to expand the standard series of mills, and contributes to a more flexible design of the mills in strict accordance with the requirements and conditions of the customer.

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- Design and installation of ready-to-operate grinding plants for raw coal.
- The use of individual concepts, from design to commissioning.
- Individual solutions due to the optimized production techniques.
- Individual solutions, while the design for coal grinding plant raw materials with the possibility of replacing the mill components and assemblies.
- Service, in order to achieve reliable work unit; consultation on further technical development.
- Providing spare parts.
- Certification according to EN ISO 9001: 2000.

CONCLUSIONS

1. The search for new solutions in the direction of producing fuels from coal that are more efficient and more usable of energyresources with a relatively low cost, objectively led to the creation of coal-water fuel (CWF).
2. The current state of the fuel and power potential of many European countries dictates the conditions of the selection of the most promising fuels according to all indicators. Nowadays the energy supply of developed countries is mainly based on these energy-carriers: Combustible Fuels (oil, gas, coal); Nuclear fuel; Renewable energy sources (biomass, solar and wind energy, etc.); Industrial hydrocarbonaceous products / waste (petroleum coke, blast furnace gas, synthetic gas, etc.).
3. The significantly greater economic efficiency of coal compared to gas and oil allows to reduce running costs and to provide enterprises with the maximum profit in the energy sector.
4. Technology of production CWF requires finding alternative plants for crushing coal, which are more effective in many performances.
5. Based on these requirements, the construction of a vertical roller mill equipped with a high-dynamic separator is the proposed in the paper. This mill provides grinding of any rank of coal to the required fraction and it is a very cost-effective solution when it comes to specific energy consumption.
6. There was also a scheme of arrangement grinding of coal working in non-inert and considered the principle mode of operation of the mill.
7. Implementation of the modular concept allows to expand the standard series of mills, and contributes to a more flexible design of the mills in strict accordance with the requirements and conditions of the customer. Design and installation of ready-to-operate grinding plants for raw coal. The use of individual concepts, from design to commissioning. Individual solutions due to the optimized production techniques. Individual solutions, while the design for coal grinding plant raw materials with the possibility of replacing the mill components and assemblies. Service, in order to achieve reliable work unit; consultation on further technical development. Providing spare parts. Certification according to EN ISO 9001: 2000.
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ТЕХНОЛОГИИ ИЗМЕЛЬЧЕНИЯ УГЛЯ ДЛЯ ПРОИЗВОДСТВА ВОДОУГОЛЬНОГО ТОПЛИВА

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Аннотация. Поиски новых решений в направлении получения из угольных топлив более эффективных и удобных для использования энергоносителей, обладающих относительно невысокой стоимостью, объективно привели к созданию водоугольного топлива (ВУТ). Значительно большая экономическая эффективность угля в сравнении с газом и нефтью позволяет существенно снизить текущие эксплуатационные расходы и обеспечить предприятиям энергетической отрасли максимальную прибыль. Технология производства ВУТ требует поиска альтернативных установок для измельчения угля, которые являются более эффективными по многим показателям.

Исходя из этих требований, в работе предложена конструкция вертикальной валковой мельницы оснащённой высокопроизводительным динамическим сепаратором. Данная мельница осуществляет помол любого вида угля до необходимой фракции и является очень экономичным решением, если речь идет об удельном расходе энергии. Также была разработана схема компоновки системы измельчения угля работающей в неинертном режиме и рассмотрен принцип работы мельницы.

Известен ряд технологий преобразования углей в так называемые экологически-чистые, эксплуатационно-удобные виды топлива – газообразное и жидкое. Однако в их подавляющем большинстве используются сложные процессы термической или химической переработки с большими капитальными вложениями и повышенными требованиями к эксплуатации. Значительный объем запасов угольных топлив в Украине и высокая цена на нефть и газ однозначно диктует необходимость массового использования водоугольного топлива в ближайшее время, однако сегодня осуществляется лишь поиск оптимальных решений по использованию ВУТ в качестве основного топлива. В настоящее время существует множество технологий и компонентов приготовления ВУТ. В качестве сырья для приготовления ВУТ используются различные марки каменных и бурых углей, угольный шлам состоящий из смеси различных компонентов: угольной пульпы, продуктов илонакопителей, отвалов терриконов, тонкодисперсного угля, низкосортного угля.

Ключевые слова. Технологии, уголь, измельчение угля, мельницы, экономическая эффективность, энергетика.