ANNOTATION//ABSTRACT

Energy consumption in various forms the basis of industrial and agricultural production. According to forecasts and statistics, the average annual growth in electricity consumption in the world until 2030 will increase by 2.4% [1].

At the same time, it is customary to divide the types of primary energy into renewable and fuel. In global consumption, renewable energy use is less than 5 percent. The share of the use of wood and agricultural waste in the fuel energy sector is constantly decreasing and currently in the world fuel consumption is less than 1 percent [2].

Fuel energy, in turn, is divided into the use of coal, natural gas oil, from which heat is extracted through the combustion process. The use of atomic energy can also be incorporated into fuel energy since the difference of this thermal energy source is reduced to the form of thermal energy release without combustion. The share of conversion of atomic energy into thermal and electric energy confidently comes to the third place after coal and natural gas [3].

World coal reserves are very significant and in terms of volume (production) consumption are second only to oil. It is estimated that economically acceptable recoverable coal reserves are close to 1 trillion tons, which at the current production rate is availability of about 200 years. It should be considered that coal, oil and natural gas (in recent years and biological mass) are also used as technological raw materials with different processing depths [4].

The use of coal as a fuel for energy and partially technological raw materials will continue, at least in the coming decades. Currently, about 35% of electricity in the world is generated at coal-fired thermal power plants [5]. The attractiveness of coal as a source of primary energy is due to several circumstances:

- first, the relatively low cost of a unit of thermal energy,
- the second factor can be considered the mastery of its combustion at TPP.
- an additional advantage of coal can be considered the relative simplicity of its storage in significant volumes.
- the possibility of increasing the volume of consumption almost instantly, which, for example, when burning natural gas is several hours (in certain countries it can reach 10 hours)

However, coal burning is also accompanied by several negative factors. The greatest disadvantage of coal as a fuel is manifested:

- in the form of environmental impact (in which ash and slag waste storage can be included). The furnace slag process is largely caused by the organization of the furnace process and occurs, as a rule, when the operating parameters deviate from the recommended values.
- necessity of its preparation for incineration
- wear of boiler equipment in contact with coal (before entering the furnace) and ash after combustion.
- presence of Sulphur in fuel since Sulphur combustion products (SO2 and SO3) in the presence of moisture can form sulphureous and sulphuric acids (corrosion

of metals of steam generators, internal combustion engines, building structures, etc.) [6]. However, emissions of sulfur oxides at Kazakhstan TPPs are noticeably less than at coal TPPs of many countries, due to the relatively low sulfur content in the initial coal - less than 1 percent (see Table).

Names of coal	S, %	Names of coal	S, %
the Kazakhstan		**USA**	
Shubarkol	0,5	Springfield	4,0
Saryadyr	0,3	Danville	3,0
Maikuben	0,4	**the Russian**	
Ekibastuz	0,8	Apsat coal	0,3
Karazhyra	0,4	Chitkandinsky coal	0,2
the Spanish		**REPUBLIC OF SOUTH AFRICA**	
Siliville	5,0	Witbank	2,0

Figure 6 - Sulfur content in coal composition.

Reducing the emission of fly ash into the atmosphere and storing waste is technologically and technically sufficiently spent. The process of wear of equipment with fly ash has also been studied enough and devices and mechanisms for its reduction have been developed.

Coal as an energy fuel is of particular importance for Kazakhstan, in particular, about 70 percent of all installed energy capacity is used as coal fuel. Most of Kazakhstan's deposits produce coal in a relatively cheap, open-pit manner [7].

One of the negative indicators of the use of coals is the abrasive wear of volatile ash surfaces, usually located in the convective shaft of the boiler. Known studies of abrasive wear patterns are mainly related to the study of the effects of fly ash.

When discussing the performed studies of abrasive wear with fly ash, it seems that it is necessary to distinguish between

- study of wear process mechanism [8]
- influence on this process of many parameters [9].

The study of abrasive wear of equipment was carried out, as a rule, on existing units, at which the wear intensity of various surfaces, as a rule, of a tube mold, was determined. with different arrangement of pipes in a convective shaft with different transverse and longitudinal steps between pipe rows [10] The distribution of wear along the perimeter of the pipes was also determined.

- development of devices and technical solutions to reduce abrasive wear of boiler equipment surfaces.

The actuality of the research subject. In most of Kazakhstan's deposits, coal is extracted in a relatively cheap, open-pit method. Coal as an energy fuel is of particular importance for Kazakhstan, in particular, about 70 percent of all installed energy capacity uses coal as fuel.

One of the negative indicators of coal use is considered abrasive wear of fly ash surfaces, usually located in the convective shaft of the boiler and other elements in contact with the moving flow of coal (coal dumpers from the conveyor belt, raw coal hoppers, coal feeders and others).

The well-known studies of abrasive wear patterns are associated mainly with the study of the impact of fly ash. The most complete studies were carried out at the Kazakh Research Institute of Power Engineering named after Academician Sh. Chokin, Doctor of Technical Sciences, Professor M.I. Vdovenko and Candidate of Technical Sciences A.Y. Bayakhunov, concluded with the approval of the all-union standard for the express method of determining the abrasiveness of fly ash.

However, in these and other studies the concentration of abrasive particles was controlled at an insufficient level and was determined by calculation. In addition, the experiments were conducted practically within a very narrow range of ash particle size variation. The abrasive ash velocity was determined by the velocity of the carrier flow. The carrier flow created, to a certain extent, conditions allowing the specimen to be streamlined by the finest particles. Basically, a flat plate, set at different angles, was used as a wearing sample, while most of the surfaces, located in the convective shaft of the boiler, are tubular in shape. All experiments were carried out with ashes at room temperature and at humidity, which folded up in researches; the possibility of change of particle size during interaction with a solid surface was practically not considered. It can be especially emphasized that the main part of the research was carried out with fly ash and there are practically no studies on abrasive wear by coal particles.

In particular, the processes of crushing and grinding of coal are inevitably accompanied by abrasive wear of grinding bodies. On the other hand, it is known that coal particles, unlike fly ash, can change their abrasive properties at different temperatures and at different humidity. Up to the fact that at high humidity of coal there is a "smearing" of grinding elements. In addition, when heated, volatile substances are inevitably released from coal particles, which may affect the intensity of abrasive wear. However, such studies are practically absent.

In this regard, it was decided to conduct research on the abrasive wear of surfaces by coal particles with dimensions close to crushed coal.

The purpose of the study is to determine the intensity of abrasive wear by carbon particles at different temperatures, at different humidity, at a change in size, at a different volume of emission of volatile substances, angle of attack and shape of the sample. It is also necessary to study the intensity of abrasive wear, while it was advisable to conduct experiments with coal from three main deposits of Kazakhstan.

Conducting such a study requires solving a whole group of problems: in particular, even before the start of creating an experimental installation, it was necessary to determine the wearing object. The first and obvious option is to reproduce the version of wear by particles moving in the air flow using the analysis of the wear of fly ash.

However, a detailed analysis of the results of the study of the wear of fly ash, which in almost all studies moved in the flow of air or flue gases, showed that such studies can be carried out in a very narrow range of particle size changes and, as a rule, distorting flow of the sample with small particles is superimposed. On the other hand, this variant reproduced wear, mainly in a convective mine, in which wear only by fly ash occurred. In addition, in such an organization of experiments, a stream with

ash particles is used only "once" and leaves the plant. When the spent ash particles are returned for re-testing, there will be two factors distorting their size.

- firstly, particles with sizes less than a certain size will not be captured in separation plants,

- secondly, when colliding with the surface of the sample at a certain speed (it can be called critical), an inevitable partial grinding of ash particles occurs,

- thirdly, the study of the wear of volatile surfaces in contact with the ash separated from the carrier stream (scrubber, removed ash and others) was excluded.

While wear by carbon particles also occurs during the movement of "purely" carbon particles (crusher, coal discharger from conveyor belt, grinding organs of mills, separator elements and others). In this regard, the option of studying wear "only" by carbon particles at a special installation was chosen. This in turn required:

- **creation of an installation** for the study of abrasive wear when changing the main parameters of the process

- elaboration of methodology - keeping the size of carbon particles in the wear volume in the permissible limits (5% of the initial size) while studying the intensity of the abrasive wear process:

- determination of the permissible speed and time of the sample movement;

- determination of the permissible degree of filling the volume of the installation with the wear material;

- **determination of the influence** of the main parameters on the intensity of abrasive wear, including:

- coal particle size,
- level of heating of coal particles,
- the degree of extraction of volatiles,
- moisture of the coal volume,
- at different angles of interaction of the sample with the coal volume.

Experiments are conducted with three Kazakhstan coals.

The novelty of the research results:

- A method of studying the intensity of abrasive wear with preservation of the size of wearing coal particles within the permissible limits **was elaborated**;

- An installation for determining the intensity of abrasive wear **was created** (patents for a useful model were obtained);

- **Determination of the abrasive wear intensity**:

- By different coals,
- at different sizes of wearing coal particles,
- at various rates of interaction of the wear material and the sample;
- at different angles of interaction between the sample and the coal volume;
- at different shapes of the wearing sample;
- at different temperatures of the coal volume;
- at different levels of combustible volatiles extraction from the coal volume;
- at different moisture content of the coal volume.

Reliability of the results obtained. When conducting experiments, the required conditions for conducting experiments were observed and measuring equipment was used with the required accuracy:

- to determine the fraction of loose material, a set with different sieve sizes was used, followed by weighing the share of fuel on each sieve on analytical scales,
- sample weighing before and after experiments was carried out on analytical balance,
- thermal treatment of wear volumes of carbon particles was carried out in a muffle furnace with temperature control by a thermal imager and a thermometer,
- the strength of the sample was measured by a stationary solid meter.

All these parameters were measured by proxies. The reliability of the experiments is confirmed by a series of experiments using identical fractions of coal, in which their required coincidence was observed.

The following are submitted for the defense:

1. Methodology of research and creation of a facility to study the intensity of abrasive wear by different coals when changing the main parameters of the process.
2. The study results of the intensity of abrasive wear:
   - by different coals;
   - at different sizes of wearing coal particles;
   - at different speeds of interaction of the wear material and the sample;
   - at different angles of interaction of the sample with the coal volume;
   - at different shapes of the wearing sample;
   - at different temperatures of the coal volume;
   - at different levels of combustible volatiles extraction from the coal volume;
   - at different moisture content of the coal volume;
   - at different hardness of the wear sample.

The approbation of the obtained results. In the process of completing the dissertation, seventeen scientific papers were published. Based on the research results, 2 patents of the Republic of Kazakhstan for inventions, 1 patent of the Republic of Kazakhstan for a useful model, six reports were published in the materials of international conferences, 2 articles in the editions of the KOKSON MHVO database. The following articles have been published in international editions of the Web of Science and Scopus databases:

1. Orumbayev R.K., Bakhtiyar B.T., Umyshev D.R., Kumargazina M.B., Otynchiyeva M.T., Akimbek G.A. Experimental study of ash chafe of boiler heat exchange surfaces. // Energy Volume 215, Part A, January 15, 2021, 119119. https://doi.org/10.1016/j.energy.2020.119119, Web of Science, Q1, percentile 96. The applicant's contribution is 60%, (Thomson Reuters).

2. Akimbek, G.A., Aliyarov, B.K., Akimbekova, S.A., Zhauytm, A. Determination of the intensity of abrasive chafe by different chafeing materials. //Metalurgija, Том 60, Выпуск 3-4, Стр. 351 – 354, July 2021. Web of Science, Q3, percentile 60. The applicant's contribution is 60%, (Thomson Reuters).

3. Akimbek, G.A., Aliyarov, B.K., Badaker, V.C., Akimbekova, S.A. Methodology and experimental setup for the study of relative abrasiveness of bulk

solids. // News of the National Academy of Sciences of the Republic of Kazakhstan, Series of Geology and Technical Sciences, 2022, 2022(1), pp. 14–20. Scopus, Q4, percentile 47. The applicant's contribution is 60%, (Scopus)

4. Akimbek, G., Aliyarov, B., Akimbekova, S. The Development of the Method and Determination of the Relative Abrasiveness of Bulk Substances. // E3S Web of Conferences, 2020, 207, 05003. Scopus, Q4, percentile 25. The applicant's contribution is 60%, (Scopus).

The Practical value of the research.

1. The installation for determining the abrasive wear by loose bodies and on its basis the method of determining the abrasive wear by coal particles, which can be useful in the design of heat-power equipment is created.

2. The created unit is used in carrying out laboratory works:

- LW #1 Research of abrasiveness of particles of bulk materials of medium fraction,
- LW# 2 A method for determining the degree of yield of volatiles at working temperatures of 20 to 4000C.
- Methodical instructions for laboratory works on discipline "TEU" for the 4th year students;
- the act of implementation in the educational process of the laboratory work on the discipline "Thermal power installations".

The Personal contribution of the author:

The stand is designed and created and the methodology of the required research with acceptable reliability is elaborated, the study of the influence of the interaction rate, size, temperature and humidity of coal particles, the degree of coal volatiles output, the shape of wear samples on the intensity of abrasive wear by coal particles is carried out, the analysis and generalization of the results, the calculation scheme is developed, the reliability of which is confirmed by coincidence with the experimental data.

Dissertation summary.

The first section of the dissertation provides a review of the literature on the study of the process of abrasive wear of fly ash, on the study of the main ways to reduce abrasive wear of boiler heating surfaces with fly ash, and others. Based on this review, the insufficiency of studies of abrasive wear by carbon particles along the entire path of movement from the unloading of cars to the channels of the air mix of burners was established.

The second section is devoted to the description of the experimental bench for the study of the abrasiveness of loose materials and the selection of wear material and samples.

The third section is devoted to the choice of a research method for studying the effect of changing the main process parameters on the intensity of abrasive wear, in particular, it was necessary to ensure:

- control of the size of carbon particles at different speeds and duration of contact of the sample with the volume of carbon particles,

- determine the level of permissible filling of the plant volume with carbon particles,

- determine the acceptable size and material of the wear specimen,

- provide for the possibility of changing the angle of installation of the wear specimen,

- it was necessary to determine the conditions for obtaining the required volume of coal

- with different temperatures,

- with different level of volatile output,

- with different humidity of coal

- with different sizes of wear carbon particles.

The fourth section presents the results of determining the intensity of abrasive wear by carbon particles when changing:

- size of coal particles,

- moisture content of wear volume of coal,

- degree of volatile yield,

- speed of interaction of wear particles with wear of samples of different shapes,

- results of analysis and generalization of the obtained data,

- preparation of formula for calculation of abrasive wear process by carbon particles.

The appendices summarize the recommendations for the use of the proposed unit, patents, certificates of implementation, extracts from the protocol, certificates, the protocol for the best work in the SRWS, RK 2022.

In the conclusion of the dissertation, the results of the study are summarized and the main conclusions on the dissertation work are formulated. The objectives of further research were formulated, in particular, the need for research on the developed method of abrasive wear during crushing and grinding of coal was noted.

At this installation, with great certainty, the intensity of abrasive wear of hydroelectric power station elements when interacting with solid particles of different sizes falling on the contacted surfaces, at different concentrations, at different angles of attack, at different speeds of the incoming water flow can be studied.

This installation also allows to study the patterns of release of volatile different coals and their mixtures with other combustible substances (to a certain extent, the gasification process).

I express my deep gratitude to my scientific director, academician of the National Academy of Sciences of the Republic of Kazakhstan, doctor of technical sciences, professor B.K. Aliyarov.