Problems of industrial waste disposal in the Fergana region

Shahlo Domuladjanova

Abstract. In the article, the problems of waste disposal of production plants such as "Fergonazot" JSC, "Koqon spirt" JSC, "SWC" JSC, Fergana oil refinery and textile industry enterprises in Fergana region were studied and provided information on the results of the conducted research. Also, socially and environmentally effective methods of waste processing and disposal were researched. Work was carried out to calculate the efficiency of processing. Information on technological processes, tools, equipment and research methods for obtaining chalk, lime, gypsum, cement and other building materials through waste processing was presented.

1 Introduction

Due to the gradual depletion of natural resources, and the deterioration of the environmental situation, in recent years, close attention has been paid to the disposal of industrial waste products. The use of waste products from various industries as raw materials for obtaining many valuable products is one of the most important problems of modern industry [1,2].

In 2020 alone, in the region, the total volume of waste generated from industrial enterprises amounted to 3893039 tons, of which 1136956 tons were reused and recycled, 2596330 tons of waste is currently taken out of storage facilities located on the territory of enterprises.

In the context of the transition of the economy of the Republic to market relations and based on world experience, it is necessary to develop a strategy to reduce waste, on the one hand, through the reconstruction of old industries, the introduction of low-waste technologies, their collection and storage, and on the other hand, reuse and recycling of waste [3,4,5].

One such valuable waste is clay sludge, which is formed at the Fergana oil refinery during the production of paraffin. Clay sludge is formed as a result of the clarification of paraffin with the help of special clay. Unclarified paraffin is passed through the layers of clay and at the same time, impurities of oil products are retained in the clay. After use, the clay is transported by road to the city dump. At present, a more decent amount of clay sludge has been accumulated in landfills. Due to their physical properties, these wastes are flammable and therefore it is unacceptable to store them both on the territory of the enterprise in special storage tanks and in city dumps [6,7,8].

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2 Methods

The following methods were used: calculation, measurement, laboratory, weight, counting, chemical, physical-chemical, physical, mechanical and differential-thermal methods of analysis.

3 Calculation methods

Example of calculation of combustion products $[6, 7]$.

*Calculation of emissions of particulate matter from fly ash and non-combusted fuel. ($1$)

$W$ - fuel consumption $t/year, g/s$ (solid and liquid), gas.

$hA$ - ash content of fuel per operating weight, % ($Table 1$).

$z_n$ - The proportion of solid particles captured in the ash collector is determined by the technical characteristics of the ash collectors. If there is no ash catcher, then $z_n = 0$.

*Calculation of carbon oxide emissions.

$M_{CO} = 0.001 \cdot C_{CO} \cdot B \cdot \left(\frac{q}{100}\right) \, t/year, g/s$.

$C_{CO}$ - the calorific value of natural fuel, $Table 2$.

$q$ - the heat loss due to chemical incompleteness of fuel combustion, %.

$R$ - coefficient taking into account the proportion of heat loss due to chemical incompleteness of fuel combustion due to the presence of carbon oxides in the combustion products, kg/kWh is taken for solid fuel, gas - 0.5, fuel oil - 0.5.

$Q_{4}$ - lower calorific value of fuel, determined by $[10]$.

$K_{NOx}$ - coefficient taking into account the degree of reduction of nitrogen oxides as a result of the application of technical solutions.

*Calculation of nitrogen oxide emissions.

$M_{NOx} = 0.001 \cdot B \cdot Q_{1} \cdot K_{NOx} \cdot (1 - k) \, t/year/s$.
4 Research results

Studies conducted at the Department of Oil and Gas Processing Technology of the Fergana Polytechnic Institute showed the possibility of recycling these wastes: obtaining paraffin from clay sludge in proportions from a waste unit - 5 - 10% of paraffin.

The technology for obtaining paraffin from clay sludge in semi-industrial conditions is as follows:

- Warming up of clay sludge at a temperature of 100 - 120 °C, in special containers. Waste in the amount of 100 - 150 kg is placed in the container for heating and mixing for 30 - 60 minutes.
- Separation of paraffin mass in the form of black-brown color of clay. Bringing the resulting mixture to a boil with the possibility of separating the paraffin from the clay.
- Clarification of the paraffin mass by heating it to a temperature of 110 °C and then passing it through the same clay that was present in the waste;
- Draining paraffin into a special container using a tap.
- Obtaining commercial paraffin;
- Production of candles in special forms. Production of products from paraffin (candles) in special forms.

Boiling crude paraffin continues for 30 minutes, the resulting paraffin is taken.

Paraffin, in turn, is used to obtain candles, for lubrication and other purposes.

The company "Ecolog" has implemented this technology in semi-industrial conditions and a technology has been developed for obtaining paraffin from clay sludge.

The Fergana Regional Department of the Ministry of Natural Resources provided direct assistance to carry out this work, which helped in providing the necessary amount of waste.

Based on the developed technology, a technological line for the production of paraffin and candles from them was mounted. About 500 kg of paraffin was released.

The technology for obtaining paraffin under these conditions is presented below. 100 - 150 kg of clay sludge is loaded into a container and heated gradually over 30 - 60 minutes at a temperature in the range of 100 - 150 °C, depending on the quality of separation of the paraffin mass from clay.

After completing melting, the paraffin mass is drained with a tap into a second container intended for further processing of the paraffin mass. The remaining clay from the first tank is unloaded for further use. The container with the paraffin mass is heated and after reaching the temperature up to 100 - 110 °C, clay is loaded with an amount of up to 30% of the volume of the paraffin mass.

After loading the clay, heating continues for another 30 minutes. After that, the heating is turned off and the mass settles for 15 - 20 minutes.

After that, paraffin in the form of a light yellow color merges into plastic molds for cooling and giving it a marketable appearance.

The resulting paraffin, in addition to using it for the production of candles, can be used as a base in the production of shoe polish and the textile industry as a lubricant in the production of threads.

Along with this, the resulting paraffin can be used as a mass in paraffin physiotherapy.
Thus, 0.5 tons of paraffin were obtained in semi-production conditions of the Firm "Ecolog". The economic effect of the implementation in production conditions will be 1 million sums, with the processing of 100 tons of waste per year.

Farg'onaazot JSC generates sludge waste in the amount of up to 16-18 tons per day, which is an excellent raw material for obtaining building materials (for example, chalk and quicklime).

Where do these wastes come from, they are obtained by cleaning the polluted air through lime milk, which, after adsorption and absorption, remains in lime milk, turning into sludge waste, that is, clean purified air is released into the atmosphere.

Figure 1 shows the sludge collector of Farg'onaazot JSC in the village of Beshalysh, Tashlak district, Fergana region.

The main component of sludge waste is the content of 60-70% chalk. The technology for obtaining chalk from sludge was consists in firing it at a temperature of 120-200 ℃ for 6-12 hours, depending on the feedstock. The developed technology for obtaining building chalk was introduced in the semi-industrial conditions of the firm "Ecolog". For many years now, good building chalk manufactured by the firm "Ecolog" has been sold throughout the Fergana Valley and beyond.

Technological regulations and specifications for product quality have been developed for the production of chalk. The resulting chalk is used as an additive in paint, rubber products, putty and other building materials.

From various industrial wastes of the region, such as sludge wastes (Farg'onaazot JSC), phosphogypsum wastes (the former Novokokand chemical plant), ash (Fergana CHPP), sulfomineral cement grade 400 were obtained.

An approximate classification of raw materials for the production of lime binders is given in Table 1.

<table>
<thead>
<tr>
<th>Raw material</th>
<th>Composition of raw materials %</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>CaCO₂</td>
</tr>
<tr>
<td>Limestone:</td>
<td></td>
</tr>
<tr>
<td>Clean</td>
<td>95-100</td>
</tr>
<tr>
<td>Low magnesia</td>
<td></td>
</tr>
<tr>
<td>Ordinary</td>
<td>87-95</td>
</tr>
<tr>
<td>Low magnesium</td>
<td></td>
</tr>
<tr>
<td>Marl</td>
<td>75-90</td>
</tr>
<tr>
<td>Hydraulic</td>
<td></td>
</tr>
<tr>
<td>Dolomitized</td>
<td>75-90</td>
</tr>
<tr>
<td>Dolomite</td>
<td>55-75</td>
</tr>
<tr>
<td>Hydraulic</td>
<td></td>
</tr>
<tr>
<td>Dolomitized</td>
<td>50-70</td>
</tr>
<tr>
<td>Magnesia</td>
<td></td>
</tr>
<tr>
<td>Dolomit</td>
<td>55-75</td>
</tr>
<tr>
<td>Dolomitized</td>
<td>50-70</td>
</tr>
</tbody>
</table>

Technological regulations and specifications for product quality have been developed for the production of chalk.
According to GOST 5331-63, depending on the chemical composition, carbonate rocks are divided into five classes - A, B, C, D, and E (Table 2).

<table>
<thead>
<tr>
<th>Components</th>
<th>А</th>
<th>Б</th>
<th>В</th>
<th>Г</th>
<th>Д</th>
</tr>
</thead>
<tbody>
<tr>
<td>CaCO₃</td>
<td>≥93%</td>
<td>≥90%</td>
<td>≥85%</td>
<td>≥47%</td>
<td>≥72%</td>
</tr>
<tr>
<td>MgCO₃</td>
<td>≤4%</td>
<td>≤7%</td>
<td>≤7%</td>
<td>≤45%</td>
<td>≤8%</td>
</tr>
<tr>
<td>Clay impurities</td>
<td>≤3%</td>
<td>≤3%</td>
<td>≤8%</td>
<td>≤8%</td>
<td>≤20%</td>
</tr>
</tbody>
</table>

The chemical composition of some wastes is shown in Table 3.

<table>
<thead>
<tr>
<th>П.П.П.</th>
<th>SiO₂</th>
<th>Fe₂O₃</th>
<th>Al₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>SO₃</th>
<th>P₂O</th>
<th>Σ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>

Table 4. Chemical composition of sludge waste of Farg’onaazot JSC

<table>
<thead>
<tr>
<th>П.П.П.</th>
<th>SiO₂</th>
<th>Fe₂O₃</th>
<th>Al₂O₃</th>
<th>CaO</th>
<th>MgO</th>
<th>SO₃</th>
<th>HCl</th>
<th>Σ</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Technological regulations have been developed for the obtained sulfamineral cement, which, if necessary, can be implemented at any small enterprise, capital investments are required.

The main component in phosphogypsum is the content of 93-95% gypsum. Therefore, studies were carried out to obtain gypsum from phosphogypsum.

A technology for obtaining gypsum from phosphogypsum has been developed, and technological regulations and a business plan for the construction of small enterprises for the production of gypsum have been drawn up.

When obtaining building materials, such as, for example, gypsum imported from other republics, waste is an inexpensive raw material. Phosphogypsum is a finely dispersed material, which is already a ready-made raw material for the production of gypsum, while several operations are reduced, such as crushing and grinding lumpy material.

As is known from the literature, building gypsum is usually obtained from gypsum dehydrate CaSO₄·2H₂O. When it is fired at a temperature of 150-160°C, partial dehydration of dehydrate gypsum occurs in its transition to semi-aqueous gypsum CaSO₄·0.5H₂O. Phosphogypsum consists of the same elements as natural gypsum.

Experimental studies were carried out on a laboratory installation, where the temperature, and firing time varied, while taking into account the capabilities of existing firing installations in industrial enterprises, such as digests and dryers. Some strength characteristics of the obtained samples are given in Table 4.

The specific gravity (density) of sludge waste was determined by the Lechatale-Kandro volume meter and calculated by the formula:

\[ \gamma = G \left( V_a - g \cdot sm \right) \]
Where:

- $G$ – the weight of powder in a volume meter, g
- $V_a$ – the absolute volume of powder in a volume meter, $\text{sm}^3$

To determine the compressive strength, samples were prepared in eight variants with different content of sludge waste in the mortar (Fig. 2).

Fig. 2. Samples for testing

To determine the volumetric weight, a standard funnel with a shutter at the bottom was used. The funnel (capacity 2.5 l) was filled with waste sludge powders. A vessel is installed under the funnel, with a pre-weighed capacity of 1 litre. Having opened the shutter of the funnel, the vessel was slowly filled with material previously dried to a constant weight from a height of 10 cm until a pyramid was formed above the vessel, then the pyramid was carefully cut off with a ruler and the vessel with the material was weighed.

Table 5. Research Results in Tumble Dryers

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Firing Time, min</th>
<th>Indicators of Samples at a Firing Temperature of 500°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compressive strength, kg s/cm</td>
<td>2</td>
<td>24,6</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>81,2</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>45,1</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td>0,00</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>0,00</td>
</tr>
</tbody>
</table>

Analysis of the data in Table 4 shows that this method is acceptable for obtaining gypsum from phosphogypsum, the best gypsum performance is obtained by firing phosphogypsum at a temperature of 500°C for 6 and 3 minutes.

Studies have shown that phosphogypsum produces excellent gypsum that meets all technical requirements.

Sulfur concrete was obtained from clay sludge and oil sludge waste of the Fergana oil refinery, where clay sludge is a mineral filter, and oil sludge is a binder of sulfur-containing materials, the filler is not needed here, since oil products completely replace it.

Technology has been developed for using sludge waste as additives to the asphalt concrete mixture instead of mineral powder. The developed technology has been introduced at the Fergana Asphalt Concrete Plant.

High-quality lime can only be obtained by firing carbonate rocks in the form of pieces that differ a little in size. When the material is fired in pieces of different sizes, unevenly burnt lime is obtained (the fines are partially or completely burnt, and the core of large pieces is unburned).
In addition, when loading shaft furnaces with pieces of different sizes, the degree of filling of the furnace increases significantly, and, consequently, the gas permeability of the material decreases, which makes firing difficult. Therefore, limestone is prepared appropriately before firing; it is sorted by the size of the pieces and, if necessary, larger oversized pieces are crushed. In shaft kilns, it is most expedient to burn limestone separately in fractions: 40-80, 80-120 mm in diameter, and in rotary kilns 5-20 and 20-40 mm.

Since the dimensions of the blocks of the extracted rock often reach 500-800 mm or more, it becomes necessary to crush them and sort the entire mass obtained after crushing into the desired fractions. This is carried out at crushing and screening plants operating in an open or closed cycle using jaw, cone and other types of crushers. Crushing and sorting of limestone should be carried out directly at the quarry and only working fractions should be delivered to the plant.

Roasting is the main technological operation in the production of air lime. At the same time, several complex physical and chemical processes take place, which determine the quality of the product. The purpose of roasting is:

1) Complete decomposition (dissociation) of CaCO$_3$ into CaO, MgO and CO$_2$ is possible;
2) Obtaining a high-quality product with an optimal microstructure of particles and their pores.

Fig. 3. Lime kiln

Roasting requires the following raw materials: limestone, coke and air. The chemical reaction of the thermal decomposition of limestone consists in firing it at a temperature of 1000 ℃.

There are other ways to obtain quicklime from various wastes, such as waste sludge from Farg’onaazot JSC. At the Department of Life Safety of the Fergana Polytechnic Institute, studies were carried out aimed at obtaining quicklime from the waste of Farg’onaazot JSC, several installations and technology for the disposal of sludge waste have been developed.

Waste disposal issues of Farg’onaazot JSC and the introduction of technology for producing quicklime, which is based on the roasting of sludge waste from Farg’onaazot JSC with a catalyst, were studied. Roasting is carried out in a rotary kiln 15-50 m long, 1-2 m in diameter (the longer the kiln, the lower the specific fuel consumption).
The introduction of this technology at the Firm "Ecolog" made it possible to obtain an economic effect of up to 50 million sums, with a sufficient amount of natural gas. The novelty of the work lies in the fact that sludge wastes are processed, which were not used in this capacity. Chalk has long been produced from them for construction purposes, but quicklime has not yet been obtained.

In addition, the environmental aspects of the processing of sludge waste are visible, this is the cleaning of burial grounds, which is a great contribution to improving the air environment and recultivating the soil in the locations of these burial sites, almost free raw materials – waste will find its application.

A technological line has been created on the territory of the "Ecolog" company for the production of quicklime, which consists of the following equipment: a screw feeder, a conveyor, a bunker, a drum mixer, a plate granulator, a drying belt, a place for packaging and packaging finished products in bags, a finished product warehouse, pipe with a gas burner.

The technological process for obtaining quicklime powder consists of the following operations:
- loading and transportation from the warehouse of raw materials (waste) to the furnace;
- purification from various impurities;
- roasting of raw materials;
- storage (cooling);
- packaging and warehousing.

Fig. 4. A prototype of a rotary kiln for burning sludge waste to produce quicklime.
5 Conclusions

The productivity of the rotary kiln is 375 kg/hour, with 3 tons of finished products per day.

Conclusions

The economic efficiency of the sale was due to a decrease in the cost of purchased lime, the socio-economic effect will be due to the disposal of waste and improving the environmental situation in the area where these wastes are located, i.e. burial grounds. Raw materials—wastes have a low value.

Industrial waste from the enterprises of the Fergana region is an excellent raw material for obtaining building materials.

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ITSE-2023 https://doi.org/10.1051/e3sconf/202343104013