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# The Main Properties of the Catalytic Reforming Catalyst

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***Abstract---****The article presents the results of adhesion, flowability, hygroscopicity, and wettability of RG-482, 582-1.2 catalyst dust under laboratory conditions. It is determined that the smaller the particle size, the easier they stick to the surface of the apparatus. The stickiness of dust was determined by the size of the solid particles of catalyst dust. In the course of the experiments, it was also proved that this catalyst dust is not sticky, this is because the catalyst dust mainly contains fine solid particles, a two-stage efficient process line for cleaning atmospheric air from fine solid particles was proposed.*
***Keywords---****aerodynamics, catalyst, dust, flowability, humidity, hygroscopicity, stickiness, wettability.*

## Introduction

The problem of protecting the environment from harmful emissions from industrial enterprises can be effectively solved only with a clear understanding of the nature of the origin, formation, and development of aerosol systems. An aero-dispersed or aerosol flow is often a rather complex multi-component system containing up to several hundred ingredients, most of which adversely affect the environment and humans (Gorbatenko, 2014). Catalysts, substances, change the rate of a chemical reaction and are not part of the final products (Shchenko, 2015).

Catalysts provide energetically less hampered reaction paths, which allows efficient use of raw materials. A wide range of industries as oil refining, obtaining various products, and creating new materials. Approximately 90% of modern chemical production is based on catalytic processes (Moulijn et al., 2001; Sprengers et al., 2003). The physicochemical properties of catalysts are of great importance for optimal use in the production process. Set the task of determining the physicochemical properties of this catalyst in laboratory conditions. Using several literature data, we carried out the following laboratory analyses to determine hygroscopicity, determine wettability, and determine flowability (Prokofieva & КРУГЛОВ, 1997; Lapinski et al., 2015).

The moisture content of dust is expressed in terms of moisture content or humidity. Humidity ratio (m/kg) is the ratio of the amount of moisture in the dust to the amount of absolute dry dust. Humidity is the ratio of the amount of moisture in the dust to the total amount of wet dust (Zeng et al., 2019; Ghoneim et al., 2016).

## Materials and Methods

There are several methods for determining hygroscopic moisture. The most common way is to dry the sample to a constant weight. Humidity is known as the ability of a liquid drop to spread over the surface of a solid body (dust particles). According to the wetting ability, solids are divided into well-wetted - hydrophilic and poorly wetted -

hydrophobic. In our experimental work, we used the film flotation method. The following analysis was carried out to determine the flowability of technical dust (catalyst dust) (Shchenko, 2015).

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**Results and Discussion**

The flowability of dust is the ability of dust particles to mix relative to each other under the influence of the external environment. Flowability will increase on the size of particles, their shape, and humidity, as well as the compaction of the dust layer (Tai et al., 2020; Mekhilef et al., 2012). Flowability is characterized by different indicators, most often by the dynamic angle of repose, which is enclosed between the horizontal surface and the generatrix of the cone, the shape of which is taken by dust freely poured from a narrow hole onto a flat surface. Experimentally, for this, a disk with a measured diameter is used, when raised above the bottom of a vessel, in which excess dust will fall. From the hole located above the disk along its axis, dust is provided until a cone is formed, filling the disk with its base. Using a ruler with a bar moved vertically, the height of the cone was measured and the angle is determined by the equation (Shchenko, 2015; Prokofieva & КРУГЛОВ, 1997):

$$\alpha = arctg\left(\frac{2H}{d}\right), \tag{1}$$

Adhesion is the ability of dust particles to form low-moving conglomerates, leading to the accumulation of deposits on the internal surfaces of gas ducts, bins, and dust outlets. The stability of the operation of dust-collecting equipment largely depends on the adhesion of dust, since increased adhesion of particles can lead to partial or complete clogging of the apparatus (Prokofieva & КРУГЛОВ, 1997).

It has been established that the smaller the particle size, the easier they adhere to the surface of the apparatus. Dust, in which 67% of the particles have a diameter of less than 10 microns, behaves as sticky. The stickiness of dust in a big size depends on its adhesive and adhesive ability, especially in the absence of binding liquids. Microscopic particles in a gaseous medium stick together (autohesion) and adhere to the surface of larger particles or the walls of the apparatus (adhesion) under the action of intermolecular capillary forces, the Coulomb interaction of oppositely charged particles (Sotelo-Boyás & Froment, 2009; Li et al., 2016).

The ability to stick together in the dust is evaluated by the value of tensile strength. Quantitatively, it is equal to the force related to the contact area required to break the layer. According to the tensile strength of the layer, dust-like materials are divided into 4 groups (Li et al., 2016; Georgieva et al., 2017; Almokhsen, 2019) (Table 1). The results of the adhesion study are used to select the type of guide element in cyclones and to assess the need to equip the bins with vibrators to set the maximum dust concentration.

Table 1
The value of the breaking strength of the layer of pulverized materials

| *Adhesiveness group* | *Tensile strength of the dust layer (P, Pa)* | Types (materials) of industrial dust |
|---|---|---|
| 1-group | <60 | Slag, dolomite, alumina, dry clay, quartz sand |
| non-adhesive | 60-300 | Shale, coke, magnesite apatite, blast furnace dust |
| 2-group | 300-600 | Dry cement, iron pyrite, soot, etc. Dust with a maximum particle diameter of 25 µm |
| Slightly adhesive | >600 | Gypsum, alabaster, wet cement, cotton, wool, and all dust with particles less than 10 microns |

Slightly adhesive >600 Gypsum, alabaster, wet cement, cotton, wool, and all dust with particles less than 10 microns
From Table 1 it can be seen that the cohesion of the catalyst dust corresponds to the 1-group "non-coalescing". Based on the foregoing, we conducted a series of experiments to determine the physicochemical properties of catalytic reforming dust grade RG-482, 582-1.2. The tendency of technical dust to wetting is estimated by the film flotation

method. The method is based on determining the proportion of the mass of industrial dust particles sunk over a certain time (in our case, catalyst dust) poured into a thin layer on the surface of the water (Farfán et al., 2020). To determine the wettability of dust, 1 g of dust was taken, from a vessel with water with a diameter of 10-12 cm (water layer thickness - 7 cm). The pouring time should be at least 2 minutes, while the vessel or funnel is moved so that a fresh portion of dust does not fall on the dust already held on the surface of the water. After pouring out the entire sample, the water remaining on its surface as dust is poured into a glass. The dust settled on the bottom of the vessel is quantitatively transferred to a filter pre-weighed on an analytical balance and filtered. The dust filter is placed in an oven and dried at 105 ℃ to constant weight. The dried filter is cooled in a desiccator and weighed to the nearest 0.0001 g. Wettability is calculated by the formula:

$$\eta = \frac{M_3 - M_2}{M_1}, \quad (2)$$

Where:
$M_1$ is the mass of dust, g;
$M_2$ - a mass of filters, g;
$M_3$ is the mass of the filter with settled dust, dried at 105 ℃, g.

Conducted several parallel analyses to determine the wettability of the catalyst dust and calculated the arithmetic mean of the results. The analyses carried out to determine the wettability of the catalyst dust are given in Table.2.

Table 2
Results of wettability analysis catalyst dust

| Type of tested dust | Mass of dust taken for research ($M_1$), g | Mass of filter ($M_2$), g | Mass of filter with dust after drying ($M_3$), g | Mass of settled dust, g | Dust wettability, % | Av., % |
|---|---|---|---|---|---|---|
| technical dust | 1 rp | 0,4447 | 1,3003 | 0,8562 | 85,62 | |
| technical dust | 1 rp | 0,4279 | 1,2461 | 0,8182 | 81,82 | 83,09 |
| technical dust | 1 rp | 0,4834 | 1,3019 | 0,8183 | 81,83 | |

Type of dust under investigation Mass of dust taken for investigation ($M_1$), g Mass of filter ($M_2$), g Mass of the filter with dust after drying ($M_3$), g Mass of settled dust, g. The wettability of the studied dust is determined by the proportion of sunken particles: poor - < 30%; medium - 30÷80%; good - > 80%. Based on the results of the analysis, the percentage of catalyst dust wettability is 83%, this is because the dust we are examining has good wettability (Al-Amshawee et al., 2021; Lazghab et al., 2005).

In the course of the experiments, the flowability of dust was determined. To determine the flowability, a disk with a measured diameter was fixed at a certain height above the vessel, in which excess dust would fall (Adachi & Tainosho, 2004). From a hole located above the disk along its axis, dust is poured until a cone is formed, filling the disk with its bases. Using a ruler, measure the height from the formed cone (Fig. 1). Based on the data obtained, the dynamic slope angle is calculated (formula 1).

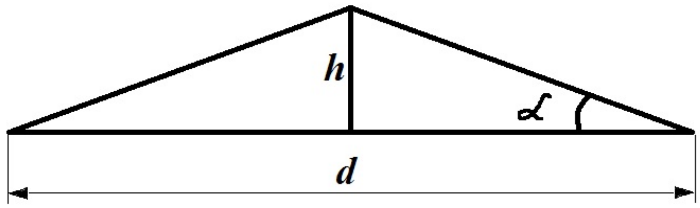


Figure1. By definition, the dynamic angle of repose

To determine the hygroscopicity of technical dust in laboratory conditions, the method of drying and absorbing the moisture of technical dust in a desiccator with water was used.

Table 3
The results of determining the flowability of dust

| Type of tested dust | Cone diameter, cm | Cone height, cm | The dynamic angle of repose, ∠° | $\alpha_{cp.}$ |
|---|---|---|---|---|
| 1 | 3,8 | 1,1 | 30 | |
| 2 | 3,8 | 1,8 | 43,5 | 39,96 |
| 3 | 3,8 | 2,0 | 46,4 | |

To do this, we take 10 g of a sample, dry it in an oven to constant weight, weigh the sample with pre-weighed filter paper, then put it in a desiccator with water to absorb moisture and measure the weight of the sample every hour. We leave for a day until the weight does not change, i.e. until the dust absorbs maximum moisture (Juarez-Enriquez et al., 2017; Chen et al., 2018). After several parallel experiments, the average result was obtained. From Table 3 it can be seen that the flowability of the investigated dust was on average $\alpha_{cp.}$ – 39.96.

Hygroscopicity is the ability of dust to absorb moisture from the environment to equilibrium with the moisture content of this environment. Moisture absorbed by dust affects such properties of dust as electrical conductivity, stickiness, flowability, etc. (Lapinski et al., 2015). Also determined is the hygroscopicity of the investigated dust, the results are given in table 4.

Table 4
Determination of the hygroscopicity of catalyst dust

| Sample weight, g | Weight after drying, g | Sample weight with moisture, g | Content, % |
|---|---|---|---|
| 10,0 | 9,4542 | 11,1301 | 11,77 |

Table 4 shows that our experiments to determine the hygroscopicity of the studied dust averaged 11.77%.

## Conclusions

Thus, the conducted studies indicate that this catalyst dust is non-sticky, this is because catalyst dust mainly contains fine solid particles; it is advisable to use two-stage efficient installations to purify atmospheric air from catalyst dust.

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