HYDROPHOBIZED LIMESTONE POWDER AS AN ANTIEXPLOSIVE AGENT

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Introductions

As a precaution against coal dust explosions, stone powder is spread within mine barriers. During an explosion the stone powder disperses, mixes with the coal dust and prevents flame propagation, acting as an inhibitor. Stone powder reduces the flame temperature to a point where devolatilization of the coal dust can no longer occur; starved of fuel, the explosion is inhibited. The amount of stone powder required to inert an explosion depends on: particle size of the stone material, particle size and type of the coal dust, as well as atmosphere composition (humidity, content of air and methane) present in underground coal mines.

Two types of stone powder are produced (regular and water-proof) which are used for sprinkling and for constructing dust barriers. A regular limestone powder is most commonly used for these purposes. Its major defect is its tendency to lose volatility, because of agglomeration under humid conditions, often reaching 100 % water saturation in mine atmospheres. Using the waterproof powder may eliminate it. Such powder has been produced by coating regular powder with stearic acid during grinding in stone mills [1, 2]. In modernized quarries and plants, modern mills of a complex construction are employed, in which contamination with hydrophobizing agents is practically avoided. For this reason, new methods of modifying the character of limestone surfaces are searched for.

Experimental

Material and manufacturing method

In this work Lime dust from the Czatkowice Quarry of Lime [3] was used as a raw material during research. Two methods of manufacturing of hydrophobic material are proposed: hydrophobization from stearic acid vapour and from silicone solutions. The first one consists in stearic acid vapour and dust counter current flow [3].

Materials obtained in this way, may be used as an anti-explosive agent in mining industry. This waterproof product protects human life so its properties are very important and should be well known. One of the most important issues is the determination of the index of hydrophobization of samples. It is easy to determine it when stearic acid is used as a modifier, because there is a standard, which defines this measurement. The manufactured, in this way, sample (S_18) contains 0.18 % of stearic acid, being an acceptable level according to the Polish Standard [1].

The second method of powder hydrophobization consists in mixing raw dust with commercial silicone solution - SARSIL® H-15. In the case of this modifier the authors had to work out the method for determination of hydrophobization C coefficient. The film flotation method [4] was used for this purpose when the commercial material (PH) was used as a comparative sample. The C coefficient defined to what extent the hydrophobic properties of the obtained S_SH15 sample are different from the hydrophobic properties of the commercial PH sample on contact with a suitable (10, 20, and 60 % (w/w)) methanol solution. The average value of the C = 84 % coefficient shows that the S_SH15 sample obtained sufficient hydrophobic properties.

Methods measurement of powder properties

Obtained samples were analyzed with the use of the research methods originally applied in the powder technique due to the powder state of the material. Moreover the adhesive force and shear test was measured.

Results and Discussion

Powder Characteristics Tester – type PT-E, Ser. No. 901331

Carr [5] has tried to evaluate powder's flow ability and flood ability in a numerical manner with the combination of listed in Table 1 various physical characteristics. The tables for the conversion of the measured figures into a common index were published.

Table 1 The characteristic of raw and hydrophobized lime dusts.

Characteristics	Raw	P_18	S_SH15
Bulk density [kg/m^3]	724	798	790
Packed bulk density [kg/m^3]	1475	1377	1414
Compressibility [%]	51	42	44
Repose angle [deg]	52	47	37
Fall angle [deg]	35	33	34
Difference angle [deg]	17	14	3
Dispersibility [%]	20	41	16
Carr's ratio [%]	50	42	44
Hausner's ratio	2.0	1.7	1.8

Shear test

Some shear tests were performed to determine the effect of hydrophobization on the powders behaviour characteristics. Data from shear tests is mainly an important basis for the design of reliable bulk solids handling equipment. We used the shear tester, which was made according to the European Standard [6]. The technique for measuring is described in many papers [7, 8]. Data from shear tests (Fig. 1) shows that the effect of surface modification on powders flow ability measured with Jenike shear cell method is reflected in obtained results.

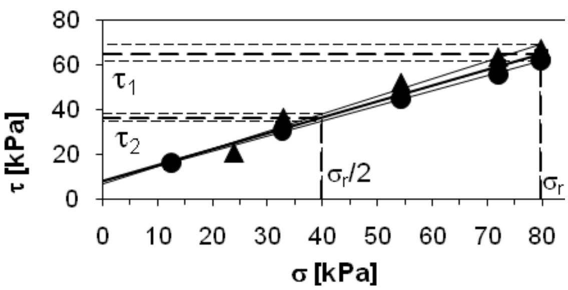

Fig. 1 Relations shear stress – normal stress of tested materials (■-raw, ●- S_18, ▲- S_SH15).

Measurement of the adhesive force

The adhesive force was measured [9] for the coarser limestone particle fraction (0.385-0.400 μm) modified in the same way as the fine ones. The array of particles placed on a tacky surface was contacted with the metallic flat surface (Fig. 2).

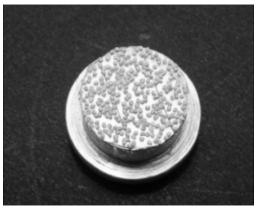

Fig. 2. The measurement of the adhesive force - array composed of particles placed on a tacky surface.

The obtained results for modified material were neglected. For raw material the adhesive force appeared at humidity of about 60 %, then grew to value of 0.008 N at humidity of 95 %. It is rather a small force but measurements show that the modified material lost its adhesive properties. We took this measurement only on contact with metallic flat surfaces. It would be better to conduct the same survey with the use of lime plate; these investigations are planned and then the sample method by other modified will be tested as well.

Conclusion

Both the S_18 sample and the S_SH15 sample acquired the hydrophobic character. Therefore we can state that the both proposed methods of hydrophobized lime dust manufacturing are useful.

It was interesting how the modification process influenced the change of typical lime dust properties. The obtained results enable us to make a characterization of lime dusts not only as a water resistant material bat also from the cohesion point of view.

Only two from the used research methods are useful in calculating the criterion for evaluating the degree of hydrophobization of modified dusts, i.e. the film flotation method and Powder Characteristics Tester.

On the basis of the result obtained during the shear test it is noticeable that the way of modification is reflected in it. The adhesive force measurements show that the modified material lost its adhesive properties. The parameters obtained with the use of Powder Characteristics Tester enable us to estimate the flow ability and volatility of dusts.

References

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