PNEUMATIC VIBROACOUSTICAL CLASSIFICATION

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ÖZET

Titreşimli ve sesli eylemlerin bilgimi, hava akışı olmadan 40 mikron ile 1,5 mm arasında sınıflandırma işlemini gerçekleştirebilir. Tabakalı ve lifli ürünler için üst sınıf daha büyüktür. Frekansı 25-150 Hz, genliği 0,25-1,5 mm olan bir titreşimle, %85'lik verim, ekolojik sorun yaratmadan sağlanabilir.

ABSTRACT

It was found that a combination of vibrational and acoustical actions enables classification to be realized without air flow. Boundary grain can vary from 40 micrometers to 1.5 millimetres. The coarsest grain in the feed could be about 3.0 mm. In case of flaky and fibrous products the acceptable upper size is several times larger. At easy achievable in industry vibration frequency 25 to 150 Hz and amplitude 0.25 to 1.5 mm, efficiency more then 85% could be achieved without ecological problems.

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In recent times wide applications of methods of dry classification have been used, in the presence of air flows, which involves not only classification devices but also solid-air separating and collecting devices thus complicating the flowsheets and often creating unsanitary working conditions. A combination of vibrational and acoustic effects enables classification to be realized without an air flow. To achieve this aim, the fine-grain dry materials are fed, for example, near the middle of a sloping surface and the surface is subjected to a vertical vibration. Due to both vibration frequency and amplitude and due to the angle of slope of the surface, particles under a certain size will move up the surface. The remainder of the particles will move downwards. So, that sloping surface works as a pneumatic classifier, which could be named VIBROACOUSTICAL, as when it is under vacuum, i.e. there is no acoustical radiation, in spite of the observed agitation of grains and particles caused by the vertical vibration, separation is not carried out. When the surface is not vibrating but there is acoustical action from another source again there is no separation. These tests *ar&* a direct proof that the process is typically a vibro-acoustical one. When the theory of the process was revealed it had been accepted that the upward particle movement was caused by the longitudinal component, to the surface, vibration force of the vertical upward vibration <Fv«z) and by the acoustic force <Fa) generated by the radiation pressure (Fig.l). The vibration force component that is perpendicular to the surface <Fv«i) is also important to lift the particle up from the surface and eliminates friction. The line of vibrational trajectory could be not only vertical but inclined to the sloping surface, too. When the angle of this inclination *(fi>)* is smaller the vibrating force component F»u2 is bigger and as a consequence the bigger are the particles moved up (Stoev, 1979).

Due to vibration the friction coefficient is very low, what enables the coarse particles to move easily downwards under the gravity force component Gz and vibration force component F_{vd2}.

The separation of different classes by size is facilited by the fact, that some granulometric class could be moved up under the influence of different parameters. As it is seen in fig.2 the upward movement of the sphalerite particles included in the size range 0.20-0.ÔS mm could be realized with different combination of frequency and amplitude and the angle of inclination of the vibrating surface. Among other things if particles in one granulometric class originate from two minerals, that have different densities the process of mineral separation could be realized as different density grains are moving up at different vibroparameters.

The behaviour of the particles depends also on their friction coefficient with the vibrating surface. Conditions can be chosen at which particles with higher dynamic friction coefficient move upwards and particles with lower dynamic coefficient move downwards. Particles with different forms can be devided in this way. This process is activated by the higher adhesive cohesion of plane and needle—fibrelike materials with the surface. For finegrained materials this cohesion is proved for particles less than *50jUm* (Azimatov, 1974). For them the values of adhesive cohesion and the gravity force are similar. With homogeneous in size isometric materials for the separation the elasticity coefficients are important, too. They determine the character of the Jump of the different particles, on vibrating surface.

The device for pneumatic vibroacoustical classification could have not only plane, but cone surface, too, with its top turned downwards <fig.3) or, contrary, with its top upwards.

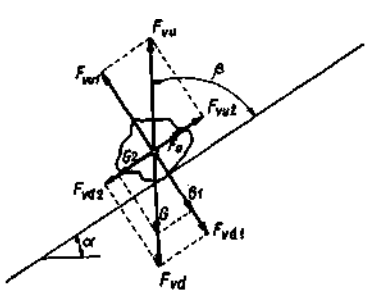


fig.1. The Basic Forces Acting for Particles Movement

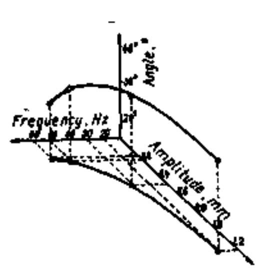


fig.2. Vibration Parameters and Angle for Upward Movement of Sphalerite Particles in Size Range 0.20 - 0.08 mm.

Selection of the cone variant depends on the product to be treated. When -Fine grains predominate the process shown in this -Figure is advisable, as during upwards movement, because the diameter enlarges, mechanically entrapped coarse grains are liberated. Contrary to this, when coarse grains predominate" the opportunities -For entrapment of -Fine particles are increased, and thinning o-F coarse particles in layers is necessary -For liberation of fine particles. This can be achieved by feeding the cone on its outer surface i.e. the cone top is upwards. The

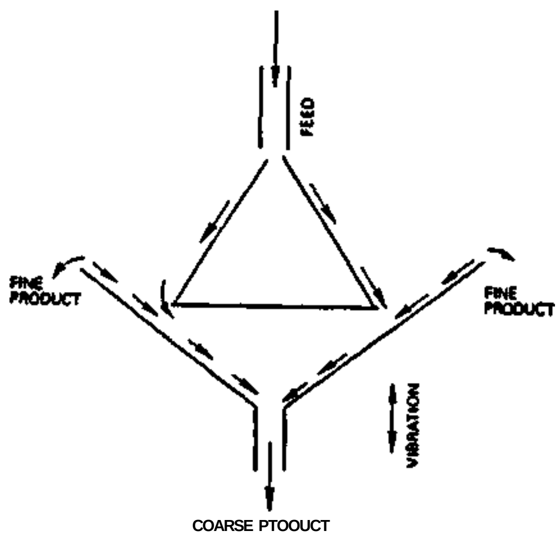


fig.3. Principle for Vibro-acoustical Classification on Cone Surface.

cone top is cut off and particles fall down trough the opening formed into a vertical tube that leads them out of the classifer.

It should be noted that besides the described scheme of classification (small grains move up, large grains move down) there exist a contrary variant too, at which small grains move down while large grains move up. At first sight this comes to a contradiction with the theoretical considerations but in fact it could be explained with the small value of vibrational accelerations which are similar to that of gravity. Under these conditions certain looseness and segregation of the material is achieved - larger grains coming over smaller grains.

Smaller grains -form something like a bed hindering the movement of the larger particles down which under the action of the vibrating force component F^ compactly move up. The compact movement of the large particles is enforced by the fact that when they leave the layer of the small particles permanent dynamic pushing is necessary. Small particles similar to a big granular aggregate slowly sliae down combined in one layer. This variant of separation has no practical value because of the small speed movement of the separate products. The latter determining the low productivity.

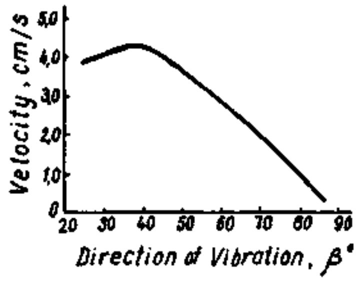
At the University of Mining and Geology, Sofia the pneumatic vibroacoustical classification has been studied in detail for different materials: coal, fluorite, pBrlite, barite, mica, asbestos, iron ore and polymetallic ores. Cones of different slopes of the cone-shaping surface and plane chutes of gentle changing slope have been used. Vibration was carried out by an electro-dynamical vibrator for easy alteration of the frequency and amplitude. Laboratory investigations carried out, reveal:

Vibroacoustical classification is achieved at industrially acceptable vibration parameters, i.e. frequency range from 25 to 100/150 Hz and amplitude range from 0.1 to 1.0/1.5 mm, at angles from 20° to 60°/70°. For the smaller particle sizes it is necessary to have a higher frequency, a smaller amplitude and a greater slope.

. Boundary separation grain size can vary from 40/*m to 1.5 mm but the process is carried out with the higher efficiency when the boundary separation grain size is 70 to lOOy/m, which is most often necessary in dry classification. In the case of plane (mica) and fibrous (asbestos) products, if the plane side diameter or fibrous length *are* the criteria, then the maximum sizes are increased by 3 times for plane particles and by 5 times or more times for fibrous ones.

. Vibroacoustical classification efficiency depends on boundary grain density, the particular size fraction, vibration and design parameters. From the design parameters the most significant is the length of the upwards path for the fine material and the downwards path for the coarse material. The longer path provides more opportunities for moving products to be self-cleaned -from undesired mechanically entrapped grains and particles. At relative outputs comparable with those obtained by conventional methods, an efficiency of more than 85 % is achieved at separations up to 1 m lengths. Another important design parameter is the separation surface stiffness as efficiency might significantly be reduced if particular points of the surface do not vibrate synchronously and synphasally. In that case fine material moves backwards or alternates from linear upward movement into peripheral movement and circulation might occur. The evenness of the working surface is of some importance, too. For some materials, for instance abrasive, rough surfaces give better results, but for fine classification of talk, byrite, bentonite it is better to use varnish surfaces.

. The relative throughput is comparative with existing air flow classifiers. The productivity could be increased by optimizing the angle of vibration force trajectory (fig.4) (Djendova, 1972).



-Fig. 4. Velocity of Upward Movement of Particles vrs. Inclination of Linear Vibration Trajectory (Constant Parameters are f=50 Hz, A=0.1 mm, α =30°, d=0.05 mm pyrite particle).

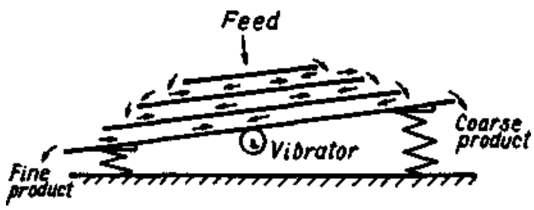


fig. 5. **Malty-stage Vibroacoustlcal Plane Classifier with Scavenger and Cleaning Operations.**

The throughput is easy to be multiplied by the use of multy-stage constructions i.e. several surfaces situated one upon another when every separating surface works individually or some of the surfaces *are* used for scavenger or cleaning operations i.e. to clean the fine or coarse product from admixtures (fig.5). If surfaces of particular stages *are* of different slope and the material consequtively passes through every one of them then several different fractions might be recovered by a single machine. Different fractions might also be obtained by a single plate surface if as well as the longitudinal slope there is a transverse one. Then the feed moves in a fan-shape and moves both up and down and from the inclined side. Thus particle size in particular fan zones decreases from the bottom to the top. Large scale separators with such kinds of surface are used in industry in the Russian Federation for classification of abrasive materials, e.g. copper, bronze, zinc and graphite dusts and for processing of asbestos ores <fig.6>. It has been noticed that the results are better if surfaces are slightly banded in an oval and in the case of the coarser material where the friction force is higher, the surfaces should be rough or covered with rubber.

. Vibro-acoustical classification is effective for dry material treatment. Inner-porous moisture is of no importance but surface moisture provokes adhesion which might significantly reduce efficiency. This also is valid for all other dry classifications. When products **have a large** content of fine sticky particles that tend to adhere, the process also deteriorates. In that case cleaning of the surfaces or the creation by polyfrequency impact vibrations are advisable. The simplest way to realise this is to install loose rods that just touch the surface or to put in rollers in small cassettes, when the surface vibrates, the random vibrations generated clean the surface from the adhered particles.

. In spite of expectations there is an insignificant amount of dust. That can be explained by sonic coagulations as during fine classification, movement of particles form a diaper and do not dust.

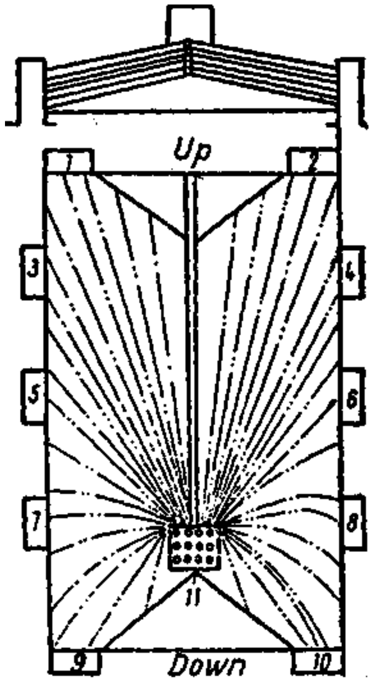


fig. 6. Vibroseparator M-40 Used in Russia -for Asbestous Fibre Separation on Different Grades.

The process has been industrially testes with a plane classifer of 1 m* surface and with a cone classifer of diameter 0.95 m (thus in fact being a large loudspeaker). Tests were carried out on an installation for perlite production (Kardjali, angaria), when throughput is 1 m=/m» per a hour a high efficiency of 93.3 % is achieved at energy consumption of 0.22 kWh/t.

Relative output based on the upper fine product could be calculated by the expression

$$Q = 7.2 \frac{\mu h \rho v}{l} , \quad tm^2/h$$

Relative output based on the oversize (course) product could be classified by the expression

$$Q_c = 0.36\ k \mu \rho \sqrt{2gH_r}, \quad t/m^2h$$

where U -^coefficient of loosening (charges in the range 0.15-0.5); h- height of the layer of the material at the discharging periphery, m ; ß - density of the material, kg/m^3; v - velocity of upward movement, m/s; H- height of coarse product discharging, m; 1 - length of cone forming line, m.

To decrease the energy consumption it is advisable to use as constructional material for separating surfaces hard aluminium alloys or right hard wood.

When very fine products are treated (average size about 5 *Urn)* adhering of particles on working surfaces could be eliminated by vibrating them with saw like current impulses with continuation in the range 2 - 20us. Efficiency could reach about 80 %.

Many companies who produce vibration machines also produce vibrating chute feeders with vibration frequency and amplitude which is suitable for effecting vibro-acoustical classification. By relative simple reconstruction these machines can be used for vibro-acoustical classification. The slope needs to be the reverse of that for existing constructions, the feeding unit should be nearer the middle of the machine and the discharge openings for the coarse product should be made in the lower part. If increased throughput is required the several additional working surfaces can be installed above the bottom.

Combining sieving and vibroaooustic pneumatic classification gives ideal results. A stiff grate with slot holes placed longitudinal to the direction of the motion of the material is subjected to vibrations in a direction vertical or inclined to the feeding zone (i.e. in a reverse direction to that normally applied). Thus fine grains that usually form the lower product now pass to the feed end and fall through the holes.

Five machines of this type assembled at the "Cristal" factory in Pernik, Bulgaria are used for sieving glass sand. These give a separation efficiency of almost 100 V, which cannot be achieved by any other sieving machine si. acceptable throughputs.

At Jinzhou and Xinkang asbestos processing plants in China, similar devices are used to separate asbestos fibres from fines and gangue. Over inclined vibrating stepless screens, asbestos fibres move upwards and gangue downwards, and the fine particles pass through the holes in the screen. Replacing the existing pneumatic flow concentrators, these devices have helped to increase the production of Grade 1 asbestos by B8.7 "/. and that of Grade 2 by more than 200 '/. «Chuxiong, 1989).

The good economical and ecological results of vibroacoustical classification give us a hope that in the near future it will find wider useful applications for the benefication of different natural and synthetic products.

REFERENCES

AZIMATOV, F., 1974; Investigation of the process of vibroclassification, Ph.D. thesis, The Mining Institute of Magnitogorsk, CIS.

CHUXIONG, Y., 1989; A NBW Type of Asbestos Concentration Screen. Proceeding of 2nd World Congress of Non-metallic Minerals, Beijing, China.

DJENDDVA, S., 1972; Mean Velocity of a Particle in Vibroacoustical field, Godishnik VMGI, XVII.

STOEV, 8., 1979; Vibroacoustical Technique for Mineral Processing, Technika, Sofia.