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RESEARCH ON THE PROCEDURE OF DUST PARTICLES INCREASE IN THE AIRTUBE OF INDUSTRIAL ASPIRATION SYSTEM

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Annotation

Combating the settled dust from the airtube aspiration system is one of the topical issues today. This is due to the fact that cleaning of the settled dust from the airtube requires long time to complete the cleaning of the aspiration system and cleaning airborne dust extraction areas by means of removing it, and mixing of the tubes with the production facilities are dangerous. However, if we take into consideration the fact that until these works complete, all technological processes need to be stopped and as it is well known this process will completely affect industrial productivity in the negative way.

In the industrial practice, often a tube or channel walls are not rough, but roughened. The roughness of the tube surface may result in increased speed of turbulent particles, so this should be considered in advance. If the hydraulic roughness of the surface of the wall is medium, it is possible to determine the velocity of turbulent particles.

Keywords: dust particles, ventilation, aspiration, airflow, airtubes, gas, safety, dispersion.

Introduction

The pulsating motion of the particles is the uncertainty of the amplitude and direction of the pulsed velocity vector of the gas flowing from one or more pulsed frequencies, randomly obtained due to the turbulent static regularities. The motion of particles with turbulent flow is much more complicated than the laminar flow. Because of the uneven flow of small particles in the turbulent pulsation, the carrier gas mole in addition to longitudinal motion produce chaotic or vibrational movements, which is called turbulent particle diffusion [1].

Like gaseous motion, particles are also randomly exposed in pulsation and diffusion movements, therefore static-looking particles are naturally exposed to the effects of gravity. At the same time, it is often observed that the pulsation moles that are transported are left unobserved by a sudden rise in particles and that the particles are not transported through the tube [2].

Defining the process of small particles falling under gravity force

The process of falling of small particles under the gravity force in the turbulent flow consists of two components: relentless low falling of the particles at the moment of pulsation mole transportation, and downward or elevation of particles along the pulsation site according to the direction of transportation, and it`s chaotic change of amplitude in their frequency.

As it was written in the section above, due to the determination of the aerosol turbulence velocity of the tube or channel, even if the nominal carrying capacity of the experimental work is very high, the results obtained will have scattered and large deviations[3].

Existence of such results shows that there are many situations that can have a detrimental effect on the process, though it does not involve harsh methodological errors. The followings are a kind of such situations: swinging flight of the solid particle by bumping into the tube wall, flowing of turbulent gas by launching upon the tube wall, becoming electrified of particles and tube walls, roughed surface of tube walls, defects in tube interconnection, air flow velocity and direction change, and the presence of temperature gradients [3,4].

When whirling particles rolled up or moved settling on the lower surface of the tube wall, bumping with each other or the tube wall, some of them settle and some of them are objects that are driven by a turbulent flow as a result of a collision (fig. 1-2) [2].

The following describes the swing leap schemes of a non-solid spherical shape in a horizontal channel: $\theta_{соуд}$ and F_{ms}^{ω} - the force of the particle with the collision angle corresponding to the tube wall; $u_{p\omega}^{н}$ and V_{ms}^{ω}- Corresponding length and horizontal combinations of particle velocity in the initial collision time; $F_{TP} = fF_{ms}^{\omega}$ - the friction force of the particle with the tube wall; $\theta_{отск}$ and F_e - the breakthrough force of jump on the wall angle of the particle; F_{ad} - the adhesive force of the particle on the wall surface [2]; $u_{p\omega}^{к}$ and $V_e = kV_{ms}^{\omega}$- longitudinal and transverse combination of particle velocity in jumping (fig. 1).

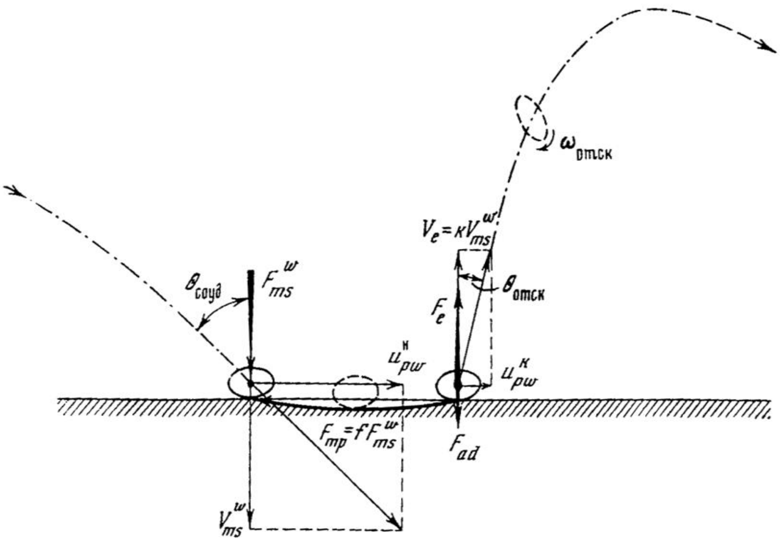


Figure 1 - The breakthrough scheme of the non-solid spherical component of the horizontal channel wall

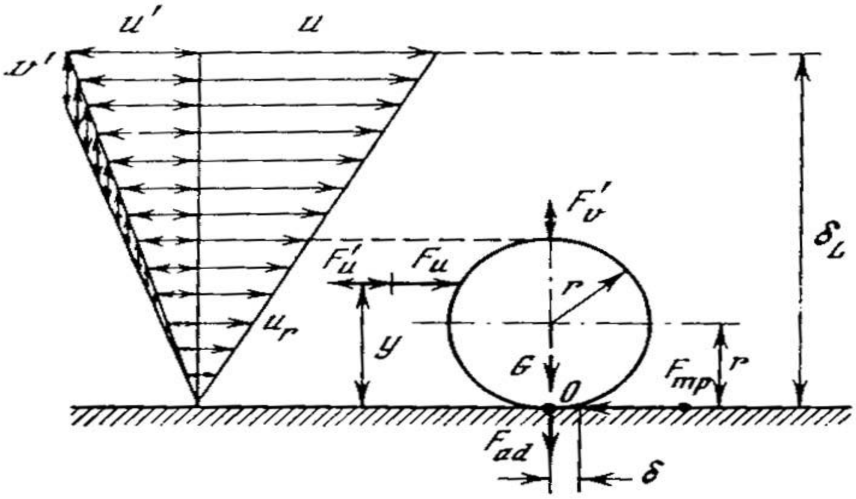


Figure 2 - The scheme of forces acting on the spherical particle that is held in the horizontal channel wall

Comparative indicators of the friction coefficient f with the velocity regeneration coefficient k are given in the table 1.

Table 1 – Comparative indicators of f and k coefficients depending on the particles and the types of wall materials

Particle material	Wall material	Friction coefficient f	Velocity regeneration coefficient k
Glass	Steel	0,55	0,94
Steel	-	0,15	0,55
Wood	-	0,6	-
Quartz	Glass	-	0,82
Lime	-	-	0,39

The breakthrough of the particle on the wall is shown in the longitudinal direction in the scheme. In the theory of dynamic interactions of bodies, the longitudinal movement is considered to be zero. However, at the end of the collision, lowering the value of $u_{p\omega}$, along with the angle θ that brings to the lowering from $\theta_{соуд}$ to $\theta_{отск} \prec \theta_{соуд}$ the friction of the particle with the wall is not reminiscent.

Scientific results of schemes

We came to the following conclusion based the scheme. Firstly, Begnold defined, that to explain the slope of the particle incline the Magnus force is not needed and secondly, when the indicators f and k are low, it can be in contrast like this way $\theta_{отск} \succ \theta_{соуд}$. The scheme of forces acting on the spherical particle on the horizontal wall is shown in the figure 2 [2].

Additional identifications: F_u and F_u' - the influence of the gaseous impact on the particles on the horizontal force, respectively, it is the average and pulsating forces; F_v' - the influence of the horizontal pulsating force of gas; G - gravity force of the particle; δ - radius of the point of contact of the particle with the wall. The quantitative indicators calculated on both schemes are low, and therefore they are often disregarded [1,3].

However, according to schemes, there is a possibility to detect particles settlement coefficient $\eta_{уд}$ while the particle is interacting with the wall.

It is known that the coefficient of particles contained in the dry tubular walls is directly related to their diameter. Let us consider the calculated values for the detection of the content of uranium particles $\eta_{уд}$ when the airflow u_m = 7,57 *m/s* ($\mathrm{Re}_D = 36000$) is inside the dry vertical tube of the wall with diameter D = 71,4*mm* (figure 3).

As it is shown in the figure, when the dimension is $d \leq 0{,}25$, the particles are maintained at 100% in the tube wall, and when 50% is equal to d = 0,5 – 1,5*mym,* particles with the dimension $d \geq 10$*mym* are kept at 10-20% (particles which are put ahead, kept at the wall much more than others) [1,4].

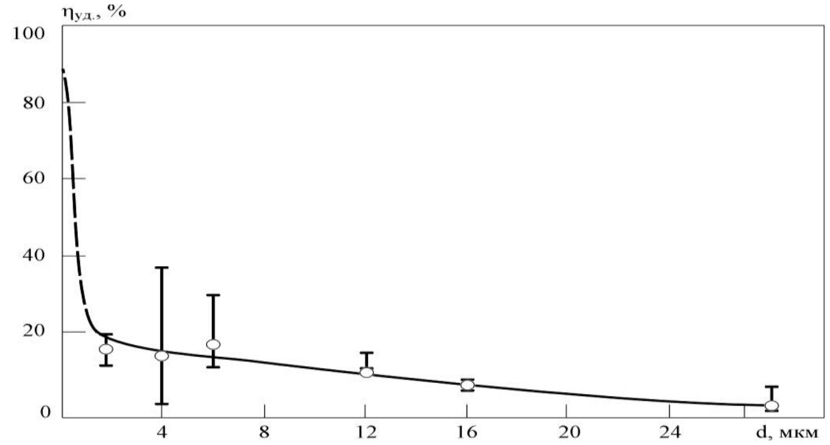
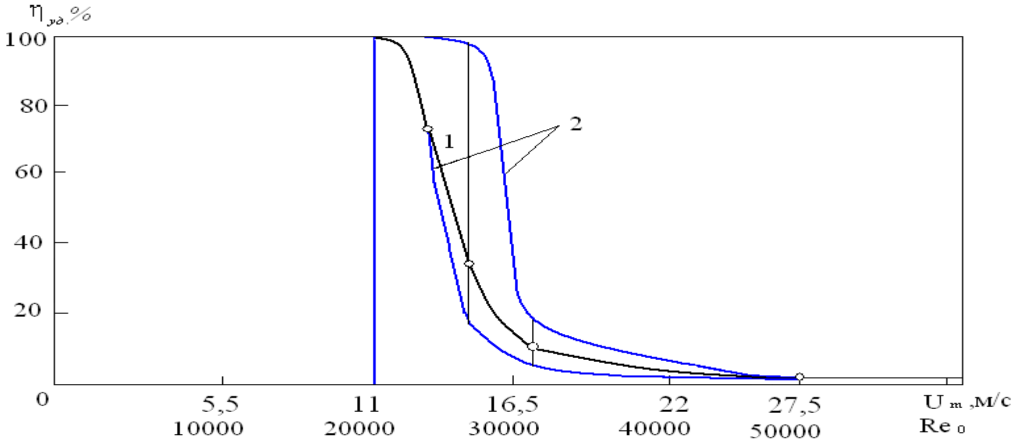


Figure 3 - Changes in particle settlement index at the time of enlargement of uranium particle diameter when the airflow with the dry wall and diameter D = 71,4 mm in the vertical tube is u_m *= 7,57 m/s (vertical lengths are the boundaries of these index values, and points are high probability indicators are shown)*

Particles in the tubes with the dry wall depending on the size of each other, are maintained only to a certain limit velocity. Calculated by experimental results, the value of the velocity of the uranium particles $\eta_{уд}$ with the diameter D = 29,3*mm* and dimension d = 8-9*mym* of the tube in the form of the airflow rate is given. It can be seen that the detachment coefficient is rapidly falling in the interval of u_m = 11 – 16,5 *m/s* (figure 4) [2].

It has been determined that the airflow velocity is not so high in the horizontal channels. Depending on the velocity of airflow of dust particles, the alignment of the alumina shows the dependence of the 35x38mm to the lower part of the horizontal channel on the settlement index. (figure 5).



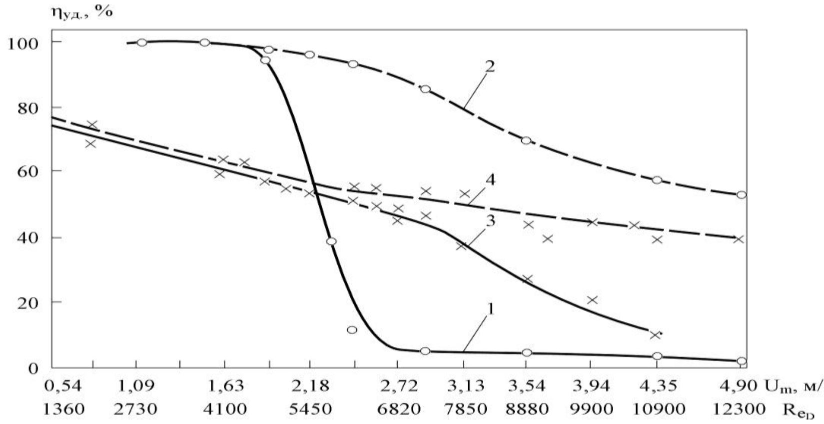
1 - centralized curve; 2 - range of scores

Figure 4 - Changes in the value of the settlement coefficient when the dry vertical tube is inserted with the velocity of the particles airflow in the diameter of d = 8 – 9mym of uranium

It is known that the roughness of the tube or channel walls can lead to an increase in the hydrodynamic barrier coefficient. Therefore, , we see that the frictional coefficient for rough-bend tubes rises according to B.L. Shifrinson formula [2].

$$\lambda = 0{,}11\left(\Delta_Э / D_Э\right)^{0{,}25}, \qquad (1)$$

here $\Delta_Э$ - "convex" height, for steel tube without joint is equal to 0,014, for ventilation tubes is 0,15mm, for aluminum tubes is 0,05mm, for glass tubes is 0,001mm, for polymer tubes is 0, and for interval tubes, roughness is equal to $\mathrm{Re}_D = 4 \cdot 10^3 - 10^5$, we can use Altschul formula that was considered from the combined Blasius and Shifrinson formulas



Fraction 1 *d* = 50-60*mym* in dry channels; fraction 2 is the same in moist channels; fraction 3 d = 20 – 30mym in dry channels; fraction 4 is the same in moist channels

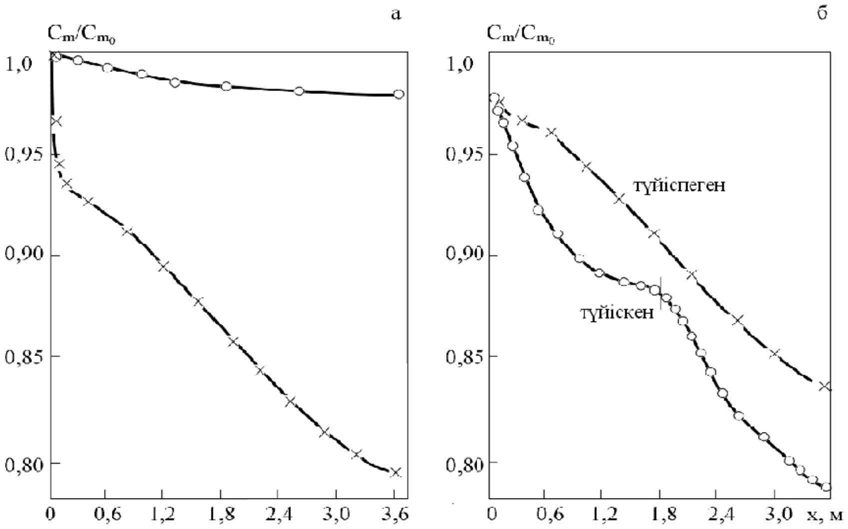
Figure 5 - Changes in the settlement factor due to the increase in the airflow velocity of the alumina hydrogen sieve settled on the lower part of the horizontal air tube

Increase of the value λ rises the dynamic velocity of the gas. It means that it leads to the increase in the velocity of settled turbulent particles. This view can be traced from a curve that reflects a decrease in concentration when uranium aerosol particles with a dimension of *d* = 16*mym* flows with the airflow velocity of u_m = 5,3 *m/s* by the tube with a diameter of *D* = 29,3 *mm* (figure 6a).

$$\lambda = 0{,}11\left(\frac{\Delta_Э}{D_Э} + \frac{68{,}5}{\mathrm{Re}_D}\right)^{0{,}25}. \qquad (2)$$

It is possible to notice that the intensity of particle settlement in the tubes with roughness is very high, as the particles concentration at the end of the tube with the length of *L* = 3,6*m* is about 25 times smaller than the flat lower surface of the tube end [3].

If the roughness of the surface is very high, the adhesive layer will disappear and instead of the aerosol particles velocity settlement and the turbulent transportation speed, particle streem occurs.



a – flat surface of the tube (1), and rough surface (2);
b - presence of the tube joint

Figure 6 - Concentration curve for uranium aerosol particles flowing along the tube

It is possible to observe that the intensity of settlement at the entrance to the particles of the air tube (3) in comparison being higher than other parts of the tube can be seen from the influence of flaring at the entrance to the tube. In addition, the flare effect is due to the incorrect connection of the tubes. (figure 6 b).

The contraction of horizontal cross sections in the conveyors leads to compression of the boundary layer, which in turn lags behind the laminar flow to the turbulent flow. Therefore, Reynolds number threshold values are always higher than tube lines. Increasing the gas speed leads to compression of the current line. Therefore, if the particles are not very small, they will abstain from the gas flow and move from the current to the wall [3].

The expansion of the horizontal cross section in the diffuser leads to the thickening of the boundary layer, and when the angle of expansion is the larger it causes it to fall away from the tube wall. Therefore, Reynolds number of threshold value is much less in the diffuser compared to the tubelines. Due to the fall in gas speed and the breakdown of the current line, an increase in the speed of the gas flowing out of the particles leads to a fluctuation of the particles from the current line to the flow.

And in curved tubes and bumps these two situations are immediately observed. When the boundary layer in the inner convex wall of the pipe is slippery, the boundary layer falls off the wall without falling or the thickness of the border. Overall, the Reynolds number of threshold values proves to be higher than the vertical tubes. When bend radius is $R_{из}$, Reynolds number corresponding to the beginning of turbulent flow in curved tubes is determined by the following formula:

$$\mathrm{Re}_D = 1{,}85 \cdot 10^4 \left(d/2R_{из}\right)^{0,3}. \qquad (3)$$

Reducing the bending radius enhances the formation of the flare process by removing the boundary layer from the wall, and when radius is in this way $R_{из} \prec 1{,}5D$, the friction on the boundary layer, and, in contrast to the other conditions, are significantly more weighted. First of all, the transition from the laminar flow of gas to turbulence changes gradually, as if some of the impediments arose. Flaky particles in the gas fluctuate depending on the outer wall of the tube because of the centering forces [1,2]. Situations which were given above illustrate that the settlement of the aerosol particles from the turbulent flow to the tube can be greatly influenced only on the tube elements, especially in areas where the radius of the curvature is not large or bent. This situation is given in the case of the Reynolds number $\mathrm{Re}_D = 1620$, 2830 and 5050, the tube with the diameter of D = 16,8*mm* and with the length that is equal to L = 2*m*, in horizontal and vertical tubes for intermediate modeling systems for testing with the radius of the interconnection $R_{из}$ = 80*mm* that is coupled with the bumps, settlement set of dioctyl phthalate droplets $\rho_p \cong 1г/см^3$ with the dimension of d = 8*mym* is given by percentage (%) (figure 7).

Although the length of the folds is smaller, the particle settlement is much higher than the vertical and horizontal parts. This can be seen in the various elements of the test sorting system, as well as the results of the aerosol particle settlement (table 2).

Also, due to the specific scheme of the tube line system, the presence of turbulent flow of bent sections and aerosol particles in tube lines leads to inertial transition. Calculations of the inertial shrinking scheme of aerosol particles in folded tubes are reviewed in the scientific papers [2].

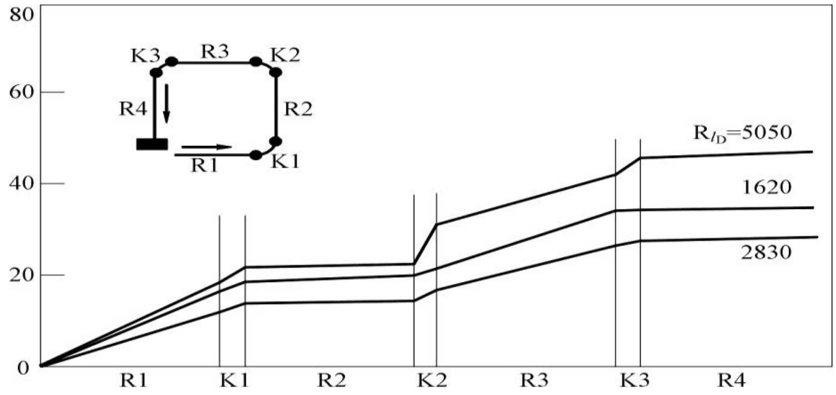


Figure 7 - A set of dioctyl phthalate shrinking droplets, marked on the test sample modeling system (%)

It is of great interest in the data that in the case of the Reynolds number`s little value, the effect of the gas flow rate on particle discharge along the mixed airtube lines being low. In some cases, the aerosol particles experience an additional inertial effect even in the vertical areas of the pipe. This process is called turbulence flow. This type of motion is in the direction of the tube and the tube joins or divides into each other, and after the parts with other local barriers occur in the unstable parts of the tube's airflow, it leads to increasing the concentration of particles in contact with the tube wall, as well as intensive settlement of small particles in the wall of the tube. The experimental studies show that such swirls do not exist in the vertical parts of the pube in the airflow.

Table 2 – Experimental results obtained from the model sorting system

Part of the system	The fraction of settled particles (%)		
	Reynolds Number Re_D		
	1620	2830	5050
$L = 2m$ $(R1)$ (lower) horizontal tube	17,0	12,0	18,0
$\alpha = 90^0$ and $R_{из} = 80\,мм$ $(K1)$ first bending	2,4	1,6	3,8
$L = 2m\,(R2)$ (uplifted) vertical tube	0,41	0.20	0,57
$\alpha = 90^0$ and $R_{из} = 80\,мм$ $(K2)$ second bending	1,7	2,6	11,0
$L = 2m$ $(R3)$ (upper) horizontal tube	16,0	12,0	15,0
$\alpha = 90^0$ and $R_{из} = 80\,мм$ $(K3)$ third bending	0,47	1,3	6,4
$L = 2m\,(R4)$ (not lifted) vertical tube	1,4	0,64	2,1
Filter valve	<0,002	<0,002	<0,002
Overall	39,38	30,34	56,87

Results of the research

1. Depending on the value of the dust particles in the dry air tubes, only a certain limited velocity determinants are maintained;
2. If the roughness of the surface is very high, the adhesive layer disappears, and spontaneous particle expansion stream occurs instead of settled velocity of aerosol particles and turbulent transmitted velocity;
3. Increased airflow speeds can lead to compression of the current line. Therefore, if the particles are not very small, they will abstain from the air flow and increase the chance of falling out of the current line to the wall of the tube;
4. Even in vertical areas of the tube, aerosol particles experience an additional inertial effect. This view is called turbulence flow. This type of motion, in the turned place of the tube, and when the tube joins or divides into each other, and after the parts with other local barriers, the air flow of the tube occurs on unstable areas, and leeds to the concentration of particles leaning on the back of the tube wall increases, as well as small

particles intensively settle onto the tube wall.

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Түйін

Аспирацилық жүйе ауақұбыры ішіне отырып қалған шаңмен күресу, бүгінгі күні өзекті мәселелердің бірі. Себебі, ауақұбыры ішінде отырып қалған шаңды тазарту үшінаспирациялық жүйені толықтай тоқтатып, шаңбөлшектері отырып қалған аймақтарын бөлшектеп алу арқылытазалау жұмыстарын жүргізу үшін, көп уақыт қажет және құбырлардың өндірістік құрылғылармен аралас орналасуына байланысты, мұндай жұмыстарды іске асыру қауіпті. Сондай-ақ, осы жұмыстар толығымен аяқталғанша барлық технологиялық процестер тоқтатылуы қажет екендігін ескерсек, өнеркәсіп өнімділігіне қаншалықты кері әсерін тигізетіндігі белгілі.

Өндірістік тәжірибеде көбіне құбыр немесе канал қабырғаларының теп-тегіс болмай, кедір-бұдырлы болуы жиі кездеседі. Құбыр бетінің кедір бұдырлы болуы, бөлшектердің турбуленттік отыру жылдамдығының жоғарылауына әкеледі, сондықтан бұл жағдайды алдын ала ескерту қажет. Егерде қабырға бетінің гидравликалық кедір бұдыры орташа болатын болса, онда бөлшектердің турбуленттік отыру жылдамдығын анықтауға болады.

Резюме

Борьба с осевшей пылью внутри трубопроводов аспирационной системы на сегодняшний день является одним из ключевых вопросов в области промышленной безопасности. Для очистки трубопроводов от осевшего слоя пыли необходимо останавливать работу аспирационной системы. Для того чтобы очистить детали трубопроводов от слоя пыли необходимо эту работу про водить по частям, на которое уходит определенное время и так как трубы

в своем сочетании распологаются вместе с производственными устройствами, то осуществление такой работы сопровождается определенными опасностями. Общеизвестно, что работы по остановке технологического процесса отрицательно влияют на производительность отрасли.

Техническое перевооружение промышленности и применение мощной техники будут способствовать увеличению запыленности воздуха в рабочих зонах, достигающей в настоящее время 2000 мг/м^3 и более.

Поэтому борьба с пылью на производстве вошла в число наиболее важных народнохозяйственных проблем, предусматривающих необходимость разработки комплекса эффективных мероприятий, направленных на обеспечение нормальных санитарно-гигиенических условий труда и защиту окружающей среды от вредного воздействия промышленной и породной пыли в условиях положительных и отрицательных температур и создание, в конечном счете, "Экологически чистого производства".

Summary

Fighting with the rest dust in aspiration system’s pipeline is one of the key questions today. It’s because for the cleaning of the pipeline from the dust the whole work of aspiration system must be stopped; for the cleaning of details from the dust the cleaning work must be done partly, and it takes much time. Besides if we stop the work process before finishing it, it will influence in productivity industry.

The technical re-equipment of the industry and the use of powerful machinery will contribute to an increase in the dust content of air in working areas, currently reaching 2000 mg / m^3 and more.

Therefore, the fight against dust in the production sector was one of the most important national economic problems, requiring the development of a set of effective measures aimed at ensuring normal sanitary and hygienic working conditions and protecting the environment from the harmful effects of industrial and breed dust in conditions of positive and negative temperatures, Ultimately, "Environmentally friendly production."