

# Methods of increasing the efficiency of dust-laden air cleaning from the aspiration system of the uhk cleaning unit

*Abdulkhakim Usanov\**, and *Ergash Shomirzaev*

Termez Engineering-Technological Institute, Termez, Uzbekistan

**Abstract.** The article covers the results of an analytical review of technology and technical means for cleaning dust-laden air released during the cleaning of raw cotton by the UHK cleaning unit; the air is taken into cyclones using an aspiration system including pneumatic lines, a fan and a conical cyclone. As a result, the drawbacks of the existing aspiration system for UHK cleaning units were identified; it was determined that the efficiency of the aspiration system for cotton cleaning units largely depends on the correctly chosen design of the diffuser, in which part of the dynamic pressure is converted into static pressure. A working hypothesis that allows reducing pressure losses in aspiration pipelines arising due to the irrational design of their elements has been developed. The chosen direction for further research consisted of determining the optimal diameter of the air duct, considering the speed mode of operation of the cyclone connected to it, which serves to clean polluted air emitted by the fan into the atmosphere, choosing the length of the diffuser, ensuring minimal losses of dynamic pressure, air speed in the narrow and wide sections of the diffuser in depending on the performance of the fan of the aspiration system of the UHK cleaning unit for cleaning raw cotton from small and large impurities.

## 1 Introduction

Measures of environmental protection are aimed at the rational use of natural resources, preventing the harmful effects of the results of the economic activities on nature and human health. The technological process of primary processing of cotton is accompanied by a significant release of dust from technological and transporting machines into production premises and the atmosphere. As dust settles, it pollutes production premises and the territory of the plant, creating unfavorable working conditions for people and equipment. The norm of air dust content in the production premises of a cotton ginneries is no more than  $10 \text{ mg/m}^3$ , and the exhaust air emitted into the atmosphere is  $150 \text{ mg/m}^3$ . In order to create normal sanitary and hygienic conditions, production premises and individual dust-emitting installations are dedusted. Before exhaust dust-laden air is released into the atmosphere, it is also cleaned of dust [1,2].

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\* Corresponding author: [usanovabduhxakim@gmail.com](mailto:usanovabduhxakim@gmail.com)

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The dust content of the air exhausted from technological equipment in production workshops depends on the type, humidity and contamination of raw cotton; dust emission is most intense when processing low grade raw cotton.

In order to clean dust-laden air before releasing it into the atmosphere, centrifugal dust collectors, i.e. cyclones are widely used. It should be emphasized that cyclones used to collect dust carried away from a fluidized bed are capable of operating in a fairly wide range of dust content. Therefore, the approximate determination of dust content does not lead to significant errors in calculations and design so far. Nevertheless, the task of creating the most efficient and economical equipment dictates the need to continue research in the field of loss studies in order to obtain calculated dependencies that most correctly reflect reality [3-5].

Experimental and theoretical research of the efficiency of dust collection of direct-flow cyclones was carried out by Rusanov A.A, Kirpichev E.F, Idelchik I.E., Aleksandrov V.P., Kogan E.I, Shilyaev M.I, Shilyaev A.M, Straus V., Vasilevsky M.V. [6]

Due to the large increase in air pollution by dust emissions released during the primary processing of raw cotton, especially during the cleaning of cotton with UHK cleaning units is an urgent task.

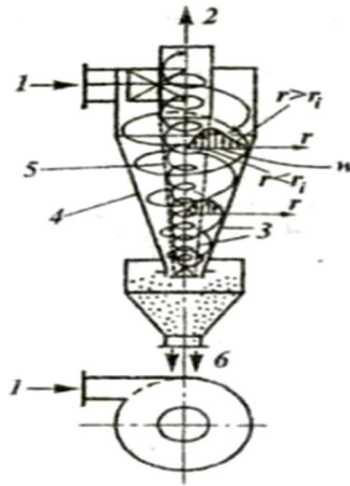
## 2 Materials and methods

The article uses fundamental methods of analytical review of technological machines, technologies for the primary processing of raw cotton, technologies for cleaning sawn waste, and the design of centrifugal cyclone installations.

## 3 Results and discussion

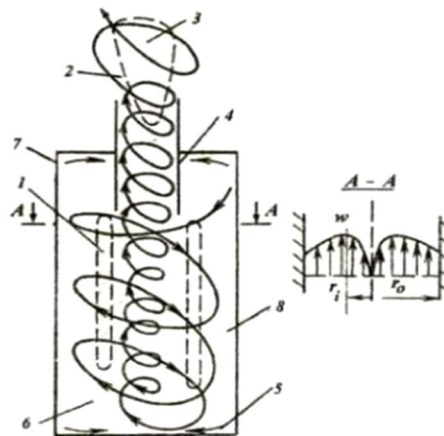
In centrifugal dust collectors-cyclones, dust-laden air is purified from large dust (more than  $50\mu$  in size). When the air flow rotates inside the cyclone, a centrifugal force develops, under the influence of which dust particles are separated from the air and thrown towards the outer wall. Conical cyclones are widely used in the cotton industry.

As a result of analyzing the movement of dusty gas in a cyclone, it is possible to establish the following characteristic zones (Figure 2). Recirculation zone 1, which is an oblong oval, negatively affects dust separation. At the exit from the cyclone in zone 2, the gas speeds in the three main directions are of the same order of magnitude. Zone 3 serves as the central toroidal outlet recirculation area. The exhaust pipe 4, which is partially immersed in the center of the installation, reduces the "diffusion" of particles through the adjacent layer along the length of the upper cover of the dust collector.



**Fig. 1.** Scheme of the cyclone device: 1- dusty gas; 2- pure gas; 3- zones of high dust concentration; 4- cone; 5- zone of the vortex core; 6- dust unloading.

The operation of the device is significantly influenced by the presence of an adjacent layer at the lower end wall 5. In this connection it is made conical. The reversal of the vortex motion of the gas occurs in zone 6. When the direction of motion of the vortex changes, the peripheral speed becomes significantly greater than the other two. The inlet pipe for supplying gas for cleaning to the cyclone is located in zone 7. Thanks to the area of the strong field of centrifugal forces near wall 8, separation of particles is ensured and their residence time in the apparatus increases [7-9].



**Fig. 2.** Scheme of gas flow in a cyclone: 1- annular zone; 2 and 3- zones at the exit from the device; 4- exhaust pipe; 5- boundary layer zone; 6- traffic circulation zone; 7- entrance zone; 8 - separation zone.

Drive for using energy-saving technologies at cotton factories when cleaning raw cotton determined the directions for improving the aspiration system of cleaning machines. One of them is the reduction of pressure losses in aspiration pipelines that arise due to the irrational design of their elements.

The efficiency of the aspiration system for cotton cleaning units largely depends on the correctly selected diffuser design, in which part of the dynamic pressure  $H_d$  is converted into static  $H_{st}$ .

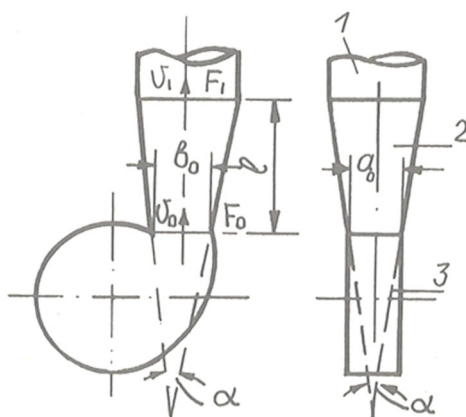
At cotton factories, when creating an aspiration system for cleaning machines, they use a pneumatic line with branches for each section of the purifier and a UVS 22 fan to suck in the air mixture and transfer it to the cyclone.

Correct determination of the diffuser parameters allows increasing the amount of sucked air mixture by reducing dynamic pressure losses.

For a specific case, in other words, for the aspiration system of the UHK cleaning unit, there are no recommendations on the selection of the diameters of the suction pipelines from each of its sections, the optimal location of the main (large) pipeline relative to the length of the UHK unit and, finally, the speed of air entry into the cyclone. The main large pipeline is usually installed symmetrically relative to the length of the UHK unit, while it is known that in the first sections along the cotton path a relatively large amount of contaminants come out. Or, for example, in well-known recommendations, the cyclone entry speed is within a wide range, from 14 to 20 m/s [10].

Based on the above, a working hypothesis that allows reducing pressure losses in aspiration pipelines that arise due to the irrational design of their elements has been developed.

E.g., in the case under consideration, the exhaust hole of the fan of the aspiration system is made of a rectangular shape with an area  $F_0$ , and the air duct to which the diffuser is connected with a length of  $l$  has a circular cross-section with an area  $F_1$ . The difference in their areas causes an expansion of the angle  $\alpha$  (Figure 3), which affects the resistance of the aspiration system. These parameters determine the conditions for creating a transition pipe (diffuser), whose cross-section along the length will change with minimal deviations from the linear dependence.



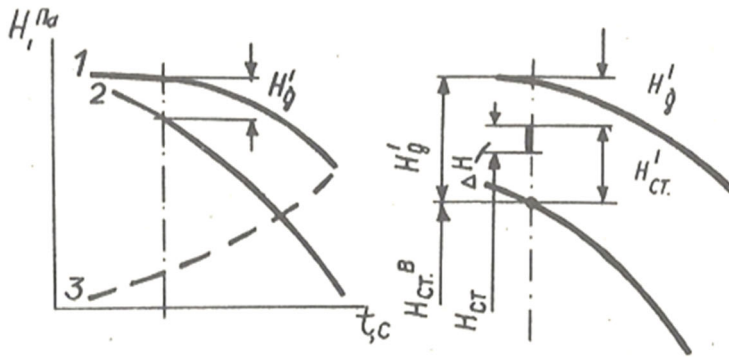
**Fig. 3.** Scheme of a diffuser with a fan. 1-air duct; 2-diffuser; 3-fan.

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As the diffuser expands by angle  $\alpha$ , the air flow speed changes from  $V_0$  to  $V_1$  before entering the air duct.

The pyramidal shape of the diffuser is considered to be close to the actual one (Figure 1), for which there is no data in the literature on its resistance coefficient  $\gamma$ . In this regard, during the experiments, we studied the change in the coefficient of resistance of the diffuser for the aspiration system of the UHK cleaning unit with a fan, depending on the indicator  $\frac{F_1}{F_0}$  that is additionally created static pressure and expansion angle [11].

In the diffuser, dynamic pressure is converted into static pressure due to its expansion, accompanied by a decrease in the air flow speed in it from  $V_0$  to  $V_1$  (see Figure 3) [6]. The additional static pressure  $H^{1st}$  created in this case is determined by the difference in dynamic pressures in the narrow  $H^1_d$   $H1g$  and wide  $H^{1d}$  sections of the diffuser, taking into account the pressure loss  $\Delta H$  in it (Figure 4).



**Fig. 4.** Aerodynamic characteristics of the UVS-22 fan and pressure conversion. Pressure: 1-full; 2-static, 3-dynamic.

The task of the research is to determine the optimal diameter of the air duct, considering the speed mode of operation of the cyclone connected to it, which serves to clean the polluted air emitted by the fan into the atmosphere. We will also choose the length of the diffuser that ensures minimal losses of dynamic pressure and air speed in the narrow and wide sections of the diffuser, depending on the performance of the fan of the aspiration system of the UHK cleaning unit for cleaning raw cotton from small and large impurities.

## 4 Conclusion

Based on the results of an analytical study of the technology for cleaning dusty air in existing aspiration systems of UHK cleaning units, significant drawbacks of the used installations were identified and a working hypothesis was developed that allows reducing pressure losses in aspiration pipelines arising from the irrational design of their elements. The tasks of further research are outlined, which include determining the optimal diameter of the air duct, taking into account the speed mode of operation of the cyclone connected to it, which serves to clean the polluted air emitted by the fan into the atmosphere. The length of the diffuser will also be justified, ensuring minimal losses of dynamic pressure, air speed in the narrow and wide sections of the diffuser, depending on the performance of the fan of the aspiration system of the UHK cleaning unit for cleaning raw cotton from small and large impurities.

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