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Selecting The Most Suitable Stage For Filter Integration In A Multi-Stage Dust Purification System

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Abstract

This study investigated the efficiency of separating technological dust generated in cotton ginning plants using two-stage cyclones - SS-6 and SP-1.5. According to practical measurements, it was found that the dust separation efficiency of the SS-6 cyclone was 70.8%, and that of the SP-1.5 cyclone was around 51.3%. The overall efficiency of this two-stage system was 92.5%. At the same time, taking into account high environmental requirements, it is recommended to introduce an additional filtration stage. The three-stage cleaning system allows for more than 99% dust retention, which is important for increasing production efficiency and reducing environmental impact.

Keywords: Environment, cotton, dust, organic, fibrous materials, cyclone, filter, atmosphere.

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1. Introduction

In Chapter V, titled "Ways to Solve Environmental Problems", of the Presidential Decree No. PF-5863 of the Republic of Uzbekistan dated October 30, 2019, “On the Approval of the Environmental Protection Concept of the Republic of Uzbekistan for the Period up to 2030”, the following requirements are stated:

- It is necessary to ensure the use of dust and gas collection devices with an efficiency of not less than 99.5% at stationary sources of air pollution at newly commissioned production facilities;
- It is necessary to ensure the use of dust and gas collection devices with an efficiency of not less than 95% at stationary sources of air pollution at existing production facilities [50, 51].

To bring the dust collection efficiency of purification

equipment used in cotton-cleaning enterprises to the required standard level, methods of sequential placement of cyclones have been applied. In some enterprises, efforts have been made to improve this by installing 3 m³ VZP-type cyclones after SS-6 cyclones, or by distributing the air flow from SS-6 cyclones into two SP-1.5 type 1.5 m³ cyclones (Figure 3.15).

However, the excess presence of mineral, organic, and fibrous materials in cotton dust increases the volume of dust entering these purification systems beyond their designed intake capacity. As a result, the efficiency of the equipment drops below its technical specifications. These conditions have been studied and evaluated by many researchers, who have presented their conclusions in [19, 20].

a)

b)

Figure 3.15. Installation of VZP or two SP-1.5 cyclones for secondary purification after the SS-6 cyclone (a), and fibrous dust materials separated from the cyclones (b)

From the above photos, it can be observed that even when the purification system and cyclones are installed in two stages, fibrous materials are still present in the dust-laden air being discharged. Therefore, the change in purification efficiency at each stage is analyzed.

This system was installed at the Jarkurgan Cotton Cleaning Enterprise in the Surkhandarya region, where the fibrous materials in the dust-laden air discharged at each stage were measured. For this purpose, the initial mass of the collection bags was recorded at the cyclone inlet, outlet, and at the atmospheric discharge point over a 30-minute interval. After the dust collection process, the bags were weighed again, and the difference in mass was used to determine the amount of collected dust (see Figure 3.16).

Figure 3.16. Methods for determining dust-laden products separated from the cyclones

The measurements were carried out after the SS-6 cyclone and after the SP-1.5 cyclone, and the results are presented in Table 3.3 below.

Table 3.3.
Determination of purification efficiency at different stages

Parameters	Dust collected from the SS-6 cyclone	Dust collected from the SP-1.5 cyclone	
		1	2
Mass of dust entering the cyclone, g	995	148	146
Mass of product collected in the cyclone, g	688	75	70
Amount of fibrous material released into the atmosphere, g	290	72	75
Purification efficiency of each cyclone, %	70,8	51,3	48,6
Overall purification efficiency, %		92,7	92,4

As seen from the table above, 995 grams of dust-laden product entered the SS-6 cyclone from the linting section, and 290 grams of product were released into the atmosphere, resulting in a purification efficiency of 70.8% for the SS-6 cyclone. When two SP-1.5 m³ cyclones were installed as the second stage after the SS-6 cyclone's atmospheric discharge pipe, the purification efficiency of the first cyclone was 51.3%, and that of the second cyclone was 48.6%. Calculating the overall purification efficiency for the two-stage cyclone system, the first SP-1.5 cyclone achieved 92.7%, and the second cyclone achieved 92.4%.

From the experimental results, it can be concluded that if the purification efficiency of cyclones used in dust collection is between 85-90%, filters are recommended to be used in the second cleaning stage; conversely, if the efficiency is below 85%, filters should be employed in the third cleaning stage (see Figure 3.17). Using a three-stage cleaning system can increase the overall purification efficiency of the system to above 99.0%.

2. Conclusion

Based on the conducted practical experiments, the efficiency of the two-stage dust separation system was analyzed. According to the experimental results, the SS-6 type cyclone installed in the first stage achieved an average dust separation efficiency of 70.8%. The SP-1.5 type cyclones used in the second stage each had an efficiency of 51.3%. When operating together as a two-stage system, the overall dust separation efficiency was approximately 92.5%, which does not fully meet current environmental standards and production requirements.

Therefore, it is recommended to integrate high-efficiency filter elements as an additional third stage in the system. The addition of the filtering device is expected to increase the dust retention rate to 99% or higher. This approach not only ensures environmental cleanliness around the enterprise but also contributes to the reliable and stable operation of technological equipment, extends their service life, and improves production efficiency.

This enhanced system aligns with the principles of sustainable development and environmental safety in the cotton cleaning industry and serves as a solid foundation for future technological modernization efforts.

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