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Theoretical analysis of changing gas dynamic characteristics of the dust filter with a short diffuser while in operation

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Abstract

The results of the experimental and numerical studies of the dust filter with a short diffuser at various size of a filter element clogging are given in the paper. The connection between the value of the filter clogging and the growth of hydraulic losses in a flowing part of the filter is found, the emergence of this effect from the point of view of redistribution of velocities and vortex formation of a stream is proved. Satisfactory agreement between the calculated and the experimental results is obtained.

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Keywords: analysis; gas dynamic characteristics; short diffuser; filter; velocity profile; pressure losses

1. Introduction

One of the operation features of a short diffuser with a big expansion angle (from 60º and above) is an expressed core of local velocities, observed at the diffuser outlet in the area which is a direct projection of the diffuser inlet [1]. At the same time, the alignment of the velocity profile occurs at the considerable distance from the outlet section of the diffuser.

Short diffusers have been widely used in design of various devices including air filters in life support systems [2]. It is explained by the intention to keep compactness of a design upon transition from the smaller section of the air duct to the larger section of the filter and vice versa. However, the use of a short diffuser in a filter design, apparently, will lead to a non-uniform distribution of a stream along the operating surface of a filter element [3]. As a result, there is an assumption that such character of air stream in a short diffuser can result in the deterioration of operation characteristics of the filter, for example, increasing hydraulic losses because of the premature clogging of the central area of the filter element and the stream overflowing to the peripheral area which is gradually filled, too. It can become the reason of a filter element replacement before the expiry of its life as filter pressure losses will become higher than admissible values.

Nowadays, there is a number of works on studying the flowing of gaseous fluids in the flowing part of short diffusers [4-6]. However, there are no researches analyzing the “short diffuser – filter” system. There are only recommendations concerning the replacement of a filter element for a new one when filter admissible pressure losses are exceeded without considering the condition of the filter element itself [7]. Thus, the task of assessing the influence of a short diffuser design on gas dynamic parameters of the filter seems to be up-to-date. The solution of this task demands carrying out numerical and experimental studies with the purpose of receiving an overview of the air stream in the flowing part of the filter and taking down its gas dynamic characteristics.

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2. Study subject

Study subject is the air stream velocity field profile in the flowing part of the filter with a short diffuser as well as pressure losses on this filter. Let us describe the process as a whole and the parameters of the study subject. The stream moves along the air duct which length L is 300 mm and diameter d is 112 mm, from there it gets to the flowing part of the filter consisting of a body, an insert imitating a filter element, a short diffuser and a confusor (Fig. 1). The stream leaves the flowing part of the filter via the output pipeline which length m is 100 mm. The body has a rectangular form with section BxH being 320x320 mm; a diffuser and a confusor with length l being 68 mm are conic, with the largest diameter D being 280 mm. The insert is a cloth made from filtering material fixed on a frame and installed crossly in the body at the distance c = 50 mm from the output section of the diffuser and at the distance e = 430 mm from the inflow section of the confusor. Clogging of a filter element is imitated by the placement of a slip with blocked permeability (where foam rubber thickness d is 20 mm) on the cloth surface. The slip is placed coaxially to the diffuser inlet. When carrying out research three options are considered: without a slip and with a slip having diameter D_1, equal to 112 and 280 mm. When carrying out numerical researches the filter element is modelled by the equivalent punched partition, and clogging of a filter element is modelled by decreasing the size of openings in the area limited by the corresponding diameter. The profile of the velocity field is considered in the output section of a short diffuser (section a-a), as well as immediately behind the insert (the equivalent partition) (section b-b). Pressure losses are considered for the whole filter.

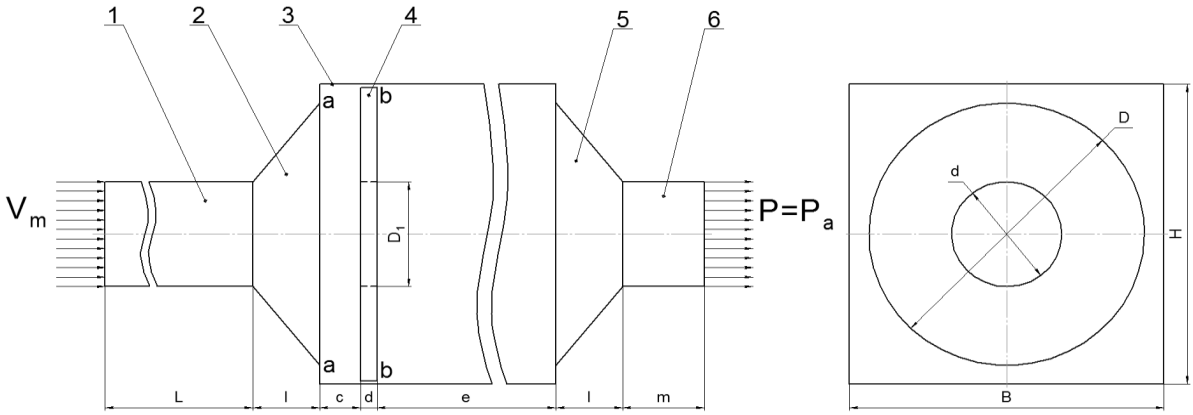

Fig. 1. Scheme of the study subject: 1 - air duct; 2 - short diffuser; 3 - body; 4 - equivalent partition; 5 - confusor; 6 – outlet pipeline.

3. Methods

3.1. Experimental method

For carrying out the experimental studies the stand (Fig. 2) having geometry and the structure similar to the numerical model, was developed and designed. The method of the experimental study includes the definition of the velocity field profile in the output section of a short diffuser and behind an insert, and pressure losses on the filter.