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SIMULATION OF AIR FLOW IN VENT CHANNELS OF MEDICAL EQUIPMENT

Abstract. The article considers the problem of measuring the air flow under high pressure in medical equipment, as well as proposed ways to reduce the pressure with the help of designed solutions. The air flow is modeled in Solidwoks Flow Simulation 2017 and the efficiency of the proposed methods of solving the problem is checked.

Keywords: flow turbulence, high air pressure, low air pressure.

INTRODUTION

One of the main problems in measuring the air flow in the vent channels of medical equipment is its turbulence. As air currents begin to swirl and move at a variable speed, the accuracy of measurements of its parameters invariably decreases. This problem especially arises when it is necessary to reduce air pressure by any means. The paper will consider the method of reducing the pressure with a designed solutions in the form of special plugs inside the vent channel, as well as simulate the behavior of air flow during passage through them [1].

INITIAL DATA OF AIR FLOW SIMULATION AND ITS DESCRIPTION

Quite a promising area in the design of medical equipment, which today is very relevant (because of the pandemic COVID19) - is ventilators (artificial lung ventilation). These devices are usually connected to oxygen cylinders, where it oxygen is stored under very high pressure (15-20 MPa), and the device itself is supplied with a pressure of 2-6 Bar (approximately 0.2-0.6 MPa). At the same time, this level of pressure is unacceptable for supply to most sensors of the device, because they are simply not designed for air flows of such power. Moreover, such pressure should not be applied to the patient's airway due to the risk of oxygen oversaturation, as well as mechanical damage to the lungs and airways.

Therefore, the issue of reducing the inlet pressure is relevant, and there are many solutions to this issue. A special design solution was proposed in the work, the essence of which is to install a special fluoroplastic muffler with a certain number of holes in the vent channel. The simulation was performed to test the efficiency and performance of the designed silencers, as well as to compare several options [2].

The first option (model 1) of the muffler design has 5 holes with a diameter of 2 millimeters. The air flow simulation procedure was performed in CAD Solidworks Flow Simulation 2017, and the results are shown in Fig. 1. The input data of the input stream are given in table. 1.

Table. 1 Inlet air flow data

Physical state	Gaseous
Species	Air
Inlet pressure	4,2 Bar = 0,42 MPa
Flow type	Laminar and turbulent
Intensity of turbulence	2%
Air temperature	293 K

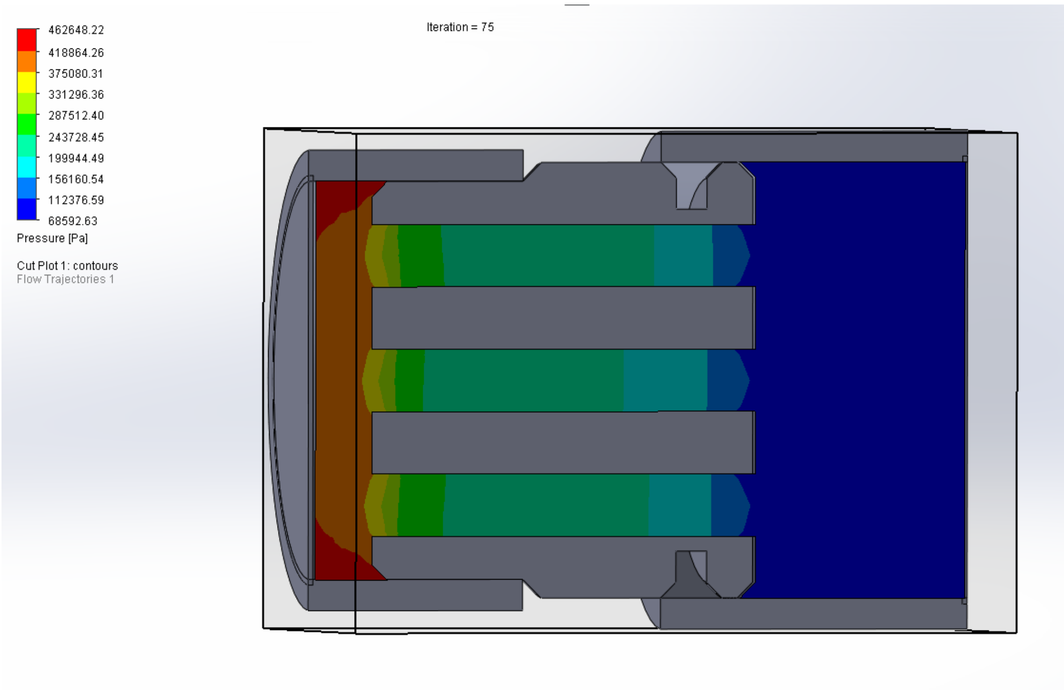
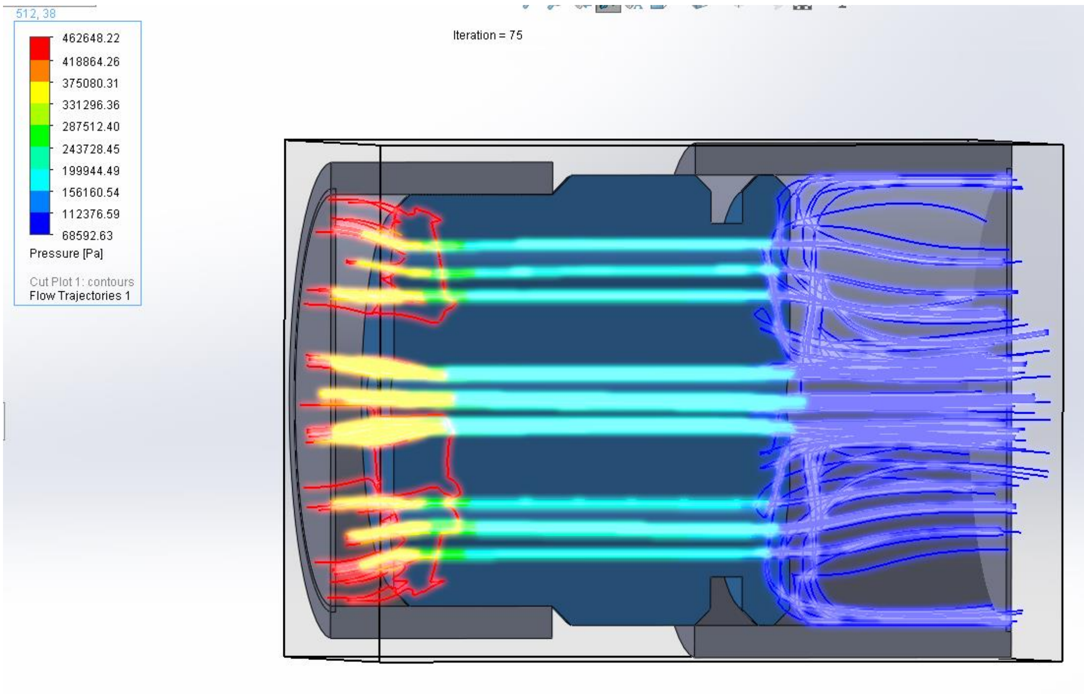


Fig. 1 The results of air flow simulation a) by inlet pressure



b) by direction and intensity of air flow

After analyzing the simulation results (Fig. 1 a) - the outlet pressure is much lower than the inlet. The calculation of the coefficient of pressure reduction is performed by formula (1):

$$\frac{P_{in}}{P_{out}} = \frac{462648}{68592} = 6{,}745 \quad (1)$$

(1) - P_{in} – inlet pressure, P_{out} – outlet pressure.

Also, with the same input data as in table. 1, was simulated the air flow through the muffler of another design (model 2), with the presence of 8 holes with a diameter of 1 mm each one. Also, for possible equalization of the air flow, a groove was made in the shape of a cone at the outlet of the muffler. The three-dimensional model and simulation results can be seen in Fig. 2.

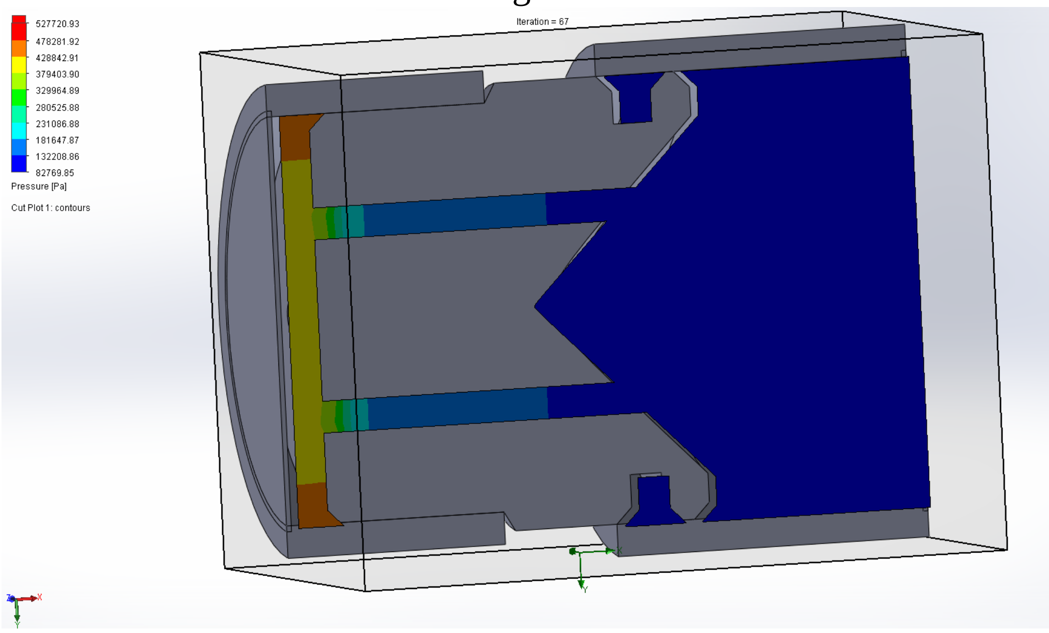
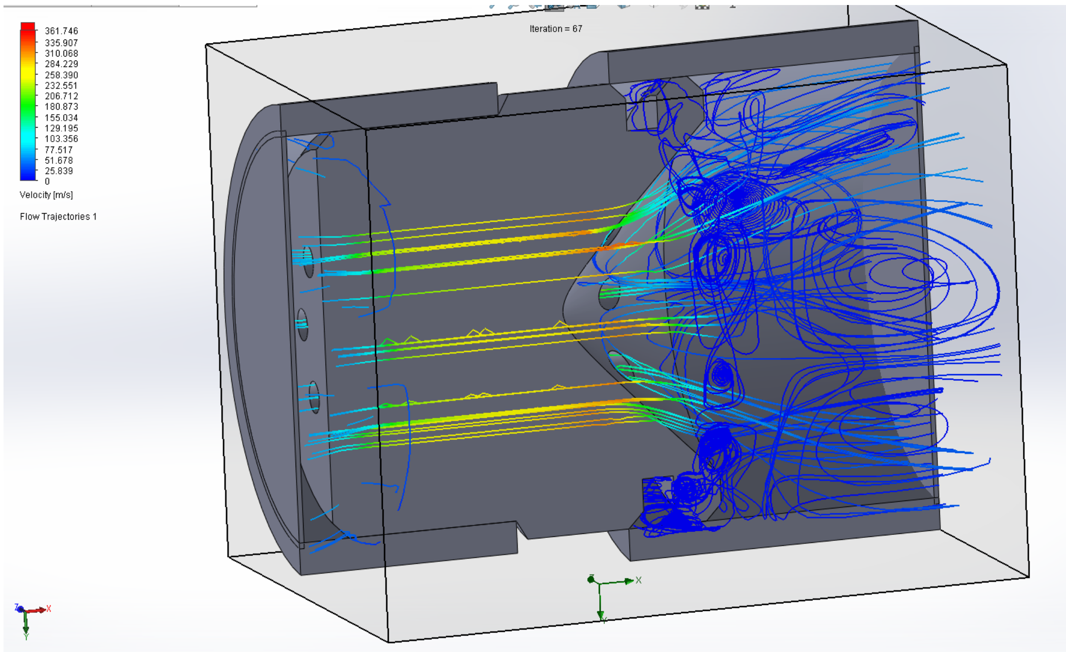


Fig. 2 The results of air flow simulation a) by inlet pressure



b) by direction and intensity of air flow

After analyzing the simulation results (Fig. 2 a)) - the outlet pressure is much lower than the inlet. The calculation of the coefficient of pressure reduction is performed by formula (2):

$$\frac{P_{in}}{P_{out}} = \frac{527720}{82769} = 6{,}37 \quad (2)$$

In (2) - P_{in} – inlet pressure, P_{out} – outlet pressure.

Obviously, the design of the muffler (model 2) is more difficult to manufacture, as it is necessary to drill more holes of smaller diameter, as well as the surface in the form of a cone. At the same time, the coefficients of pressure reduction in it are almost the same as in the design of the muffler model 1.

But its main difference is obvious in fig. 2 p. As already mentioned in the work, the turbulence of the air flow does not allow accurate measurements of its parameters, so it is necessary to bring it as close as possible to the state of laminar, ie, "align" the direction of flow. The fig. 2 b shows the "twist" of the air flow, which indicates its ultra-high turbulence [3]. A possible cause of this effect is a conical surface at the outlet of the muffler, which was designed to further equalize the flow of air. The simulation results proved that this assumption is incorrect, so comparing the two simulated studies, we can conclude that the design of the muffler (model 1) is more appropriate for use because it showed the best result in regulating the turbulence of the exhaust air flow.

CONCLUSIONS

After developing three-dimensional models of mufflers and modeling the air flow using them in Solidworks Flow Simulation 2017, the results of modeling the air flow for two developed models of mufflers with the same parameters of the inlet flow were compared. Therefore, the results obtained indicate that the first variant of the muffler (model 1) is more suitable because it showed a better result in reducing the pressure, while the output air flow was less turbulent than the second option (model 2), in which the air flow is less controlled and unpredictable, and thus the process of measuring its parameters will be complicated.

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