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Issue Article

Denis Chemezov
Vladimir Industrial College
M.Sc.Eng., Honorary Worker of the Education Field of the Russian Federation, Academician of International Academy of Theoretical and Applied Sciences, Lecturer, Russian Federation
https://orcid.org/0000-0002-2747-552X
vic-science@yandex.ru

Nikita Afanasyev
Vladimir Industrial College
Student, Russian Federation

Veronika Khlebnikova
Vladimir Industrial College
Student, Russian Federation

Dmitriy Bychkov
Vladimir Industrial College
Student, Russian Federation

Viktoriya Churkina
Vladimir Industrial College
Student, Russian Federation

Denis Korkunov
Vladimir Industrial College
Student, Russian Federation

Andrey Volvyankin
Vladimir Industrial College
Student, Russian Federation

CHARACTERISTICS OF A SUPERSONIC EJECTOR

***Abstract**: Some characteristics of the supersonic ejector were presented in the article. The dependences of the input and output values of temperature, velocity, pressure and total internal energy of the supersonic ejector jet flow were analyzed.*

***Key words**: supersonic ejector, flow, temperature, velocity, pressure, internal energy.*
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Introduction

Ejectors are simple mechanical components used for a wide range of applications, including industrial refrigeration, vacuum generation, gas recirculation, and thrust augmentation in aircraft propulsion systems.

Ejectors induce a secondary flow by momentum and energy transfer from a high-velocity primary jet.

The high-energy fluid (primary flow) passes through a convergent-divergent nozzle and reaches supersonic conditions. After exiting the nozzle, it interacts with the secondary flow and is accelerated through an entrainment-induced effect. The mixing between both flows takes place along a constant-area duct called the mixing chamber where complex interactions between the mixing layer and shocks can be observed. A diffuser is usually placed before the outlet to recover pressure and bring the flow back to stagnation.

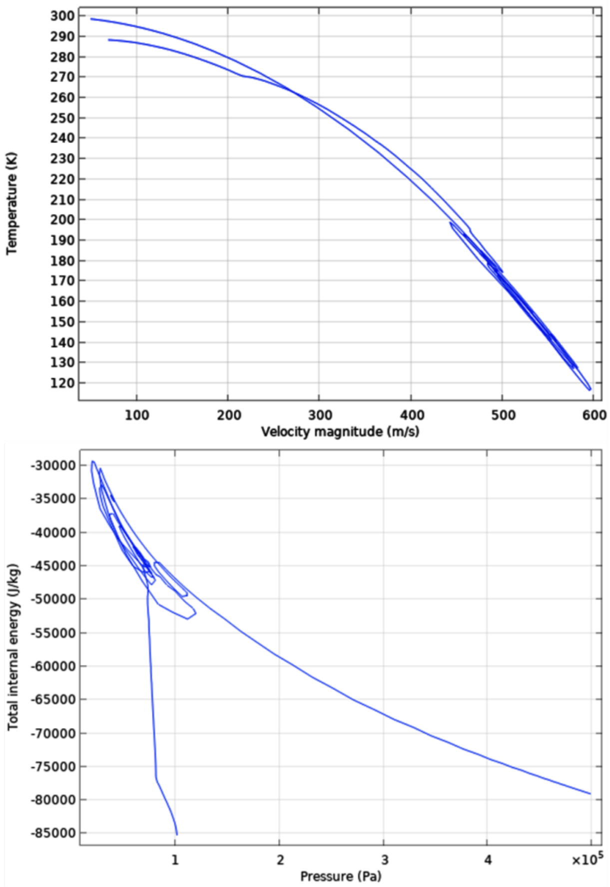
Experimental studies of supersonic ejectors are presented in a number of scientific papers [1-10]. Continuing the topic of operation of supersonic ejectors, it is proposed to consider some characteristics of these gas-dynamic devices through computer modeling.

Materials and methods

A compressible turbulent flow passing through the nozzle of the supersonic ejector was subject to simulation. For this purpose, the three-dimensional model of the supersonic ejector with the following geometry was built: diameter of the throat – 8 mm; diameter of the secondary inlet – 160 mm; diameter of the primary inlet – 16 mm; diameter of the divergent section of the nozzle – 12 mm; diameter of the diffuser – 51 mm; diameter of the mixing chamber – 24 mm; length of the mixing chamber – 240 mm; length of the diffuser – 70 mm; distance between the outlet of the nozzle and the inlet of the mixing chamber – 15 mm; length of the convergent section of the nozzle – 7 mm; length of the secondary nozzle – 90 mm; length of the divergent section of the nozzle – 23 mm; length at the inlet – 15 mm; length at the outlet – 15 mm. The output pressure is assumed to be 1 atm. The jet flow was carried out in accordance with the k-ε turbulence model. Thermal conductivity and dynamic viscosity were calculated in accordance with Sutherland's law. The Mach number and the turbulence intensity of the flow are assumed to be 0.14 and 0.05, respectively.

Results and discussion

The dependences of temperature on velocity and total internal energy on pressure of the supersonic ejector jet flow are plotted in the Fig. 1.



A

B

Figure 1 – The dependences of temperature on velocity (A) and total internal energy on pressure (B) of the jet flow.

The jet flow passes through the nozzle under pressure at an initial temperature of 120 K. At the same time, the flow velocity of the jet is maximum. The concentration of low temperatures is determined at the maximum flow velocities of the jet. When the jet passes up to half the length of the mixing chamber, the flow temperature increases by 0.7 times, and the flow velocity decreases by 0.25 times. At the outlet of the mixing chamber, the temperature and flow velocity of the jet reach values of 290-300 K and 25-50 m/s, respectively.

The jet flow passing through the nozzle has a minimum internal energy characteristic of the cooling process at subzero temperatures. As the pressure decreases, the flow heats up, and the internal energy gradually increases. For the selected operating conditions of the supersonic ejector, the internal energy increases approximately three times at a pressure of less than 0.5 MPa. It is noted that at low pressures, the internal energy of the jet flow is dissipated. The maximum value of the internal energy is calculated at a jet flow pressure of 1 MPa.

Conclusion

The characteristics of the action of the supersonic ejector to create a jet flow with negative temperatures were considered. Low internal energy of the jet flow can be observed both at high overpressure and at atmospheric pressure. The temperature of the jet flow varies by 2.5 times, and the flow velocity is more than 10 times relative to the initial values in the mixing chamber.

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