# Modeling the gas and liquid flow in the channels of the microplasmatron that is a plasma unit for applying fine coatings

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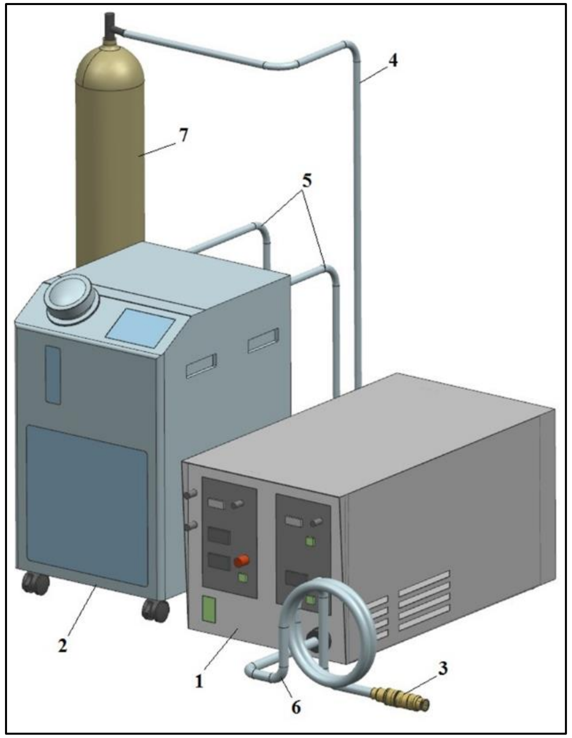
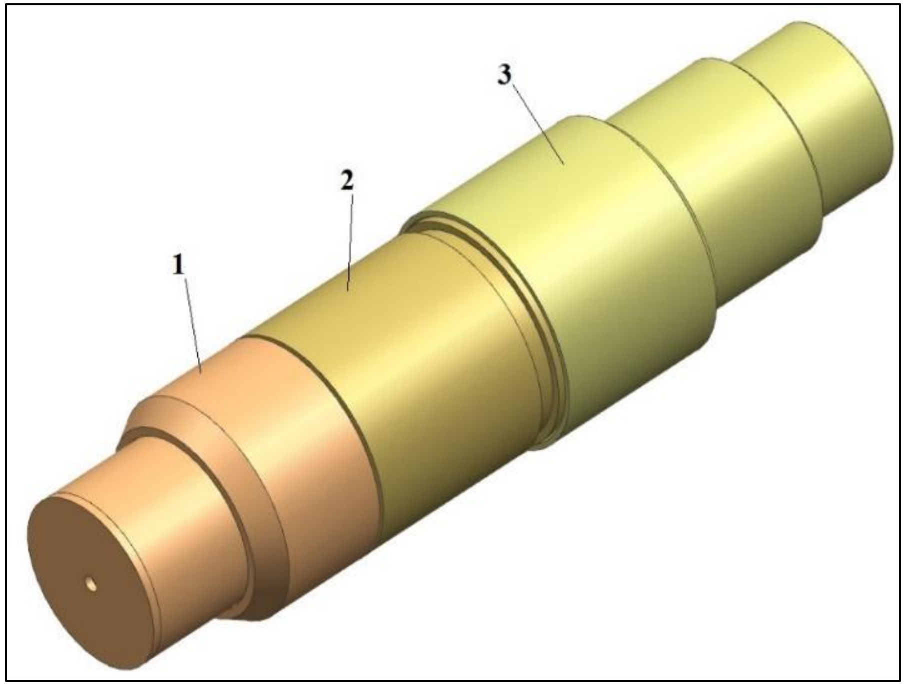
# Design of the developed device for plasma application of fine coatings




Design of the device: 1 – service unit, 2 – cooling unit, 3 – microplasmatron, 4 – gas hose, 5 – water hose, 6 – microplasmatron supply hose, 7 – gas cylinder




The microplasmatron structure: 1 – anode section, 2 – cathode section, 3 – bottom section

# Mathematical model

- Model of the flow of liquids and gases

Continuity equation: $\frac{\partial \rho}{\partial t}+div(\rho \upsilon)=0$

Equation of motion: $\rho \frac{d\upsilon}{dt}-\rho F-divT_{\sigma}=0$

Energy equation: $\rho \frac{du}{dt}-T_{\sigma}D+divh-\rho q=0$

Entropy equation: $\rho \frac{d\eta}{dt}+div\frac{h}{T}-\frac{\rho q}{T}-\omega^{*}=0, \omega^{*}\geq 0$

Equation of motion: $\frac{d\rho\upsilon}{dt}-\rho F+div(\rho\upsilon\upsilon-T_{\sigma})=0$

Energy equation: $\frac{d\rho e}{dt}+div\left[\left(\rho eE-T_{\sigma}\right)\upsilon+h\right]-\rho\left(F\upsilon+q\right)=0$

Entropy equation: $\frac{d\rho\eta}{dt}+div\left(\rho\eta\upsilon+\frac{h}{T}\right)-\frac{pq}{T}-\omega^{*}=0$

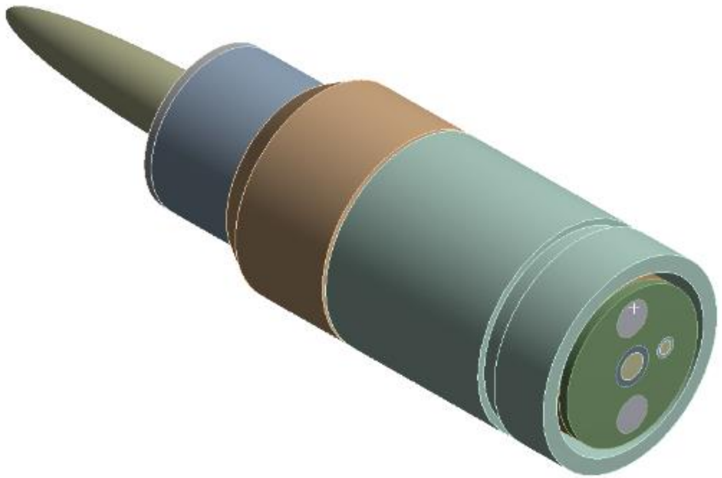
- *Convective heat transfer model*

Heat flow in a moving: $q=q_t+q_k$

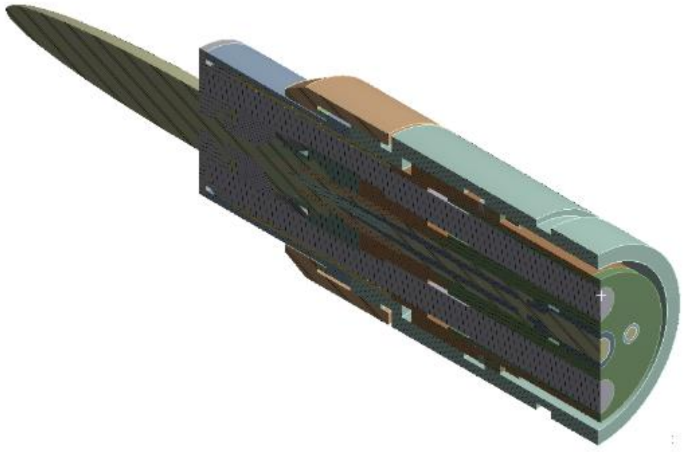
## Turbulence models

| Turbulence model | Short description |
|---|---|
| **Spalart-Allmaras** | The model uses only one additional transport equation for the turbulent viscosity coefficient. Best suited for aerospace applications. (flow around aircraft wings, turbine blades). Recommended for use for plane problems. |
| **Standard k-ε** | This model takes into account the influence of turbulent kinetic energy and its reduction due to viscosity. The model introduces 2 additional equations describing the transport of kinetic energy of turbulence and dissipation of turbulence. Allows you to solve problems with strong turbulence, contains coefficients determined experimentally. |
| **RNG k-ε** | It is a continuation of the Standard k-ε model. Allows you to determine the coefficients involved in equations analytically. Has worse convergence compared to Standard k-ε, not recommended for use with areas with vortex. |
| **Standard k-ω** | Unlike the Standard k-ε model, instead of the dissipation equation, the equation for the dissipation rate of turbulent energy is solved. The model places high demands on the quality of the mesh, as well as on the correct initial approximation. |
| **RSM** | The model adds 7 Reynolds equations. Used in volumetric tasks with a high degree of turbulence, as well as with rotation. Has a high consumption of computer time. |

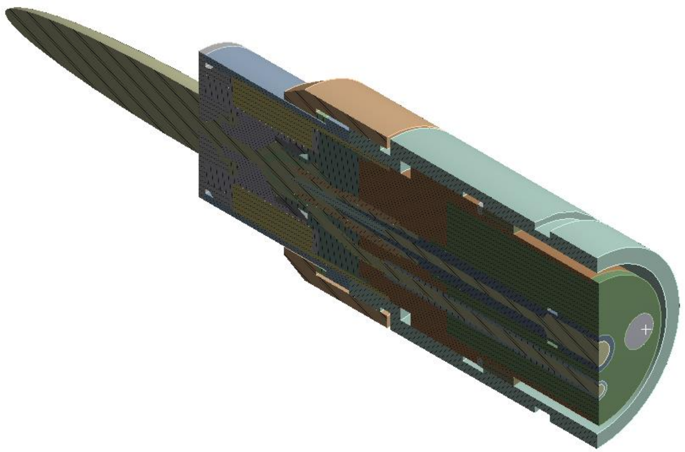
# Calculation scheme



Full calculation model

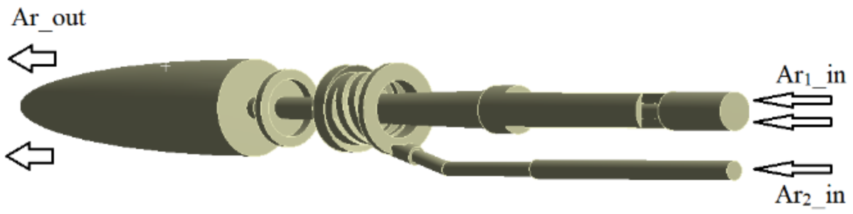


Full calculation model in section A

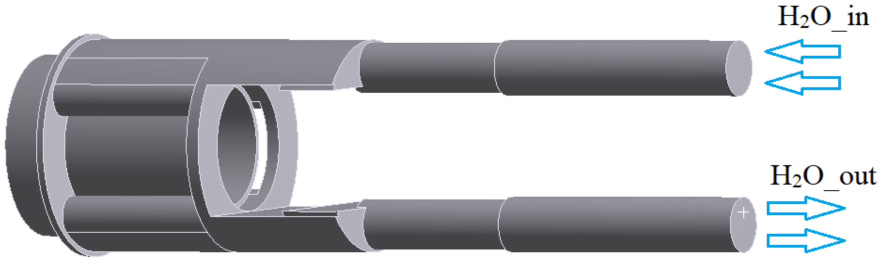


Full calculation model in section B

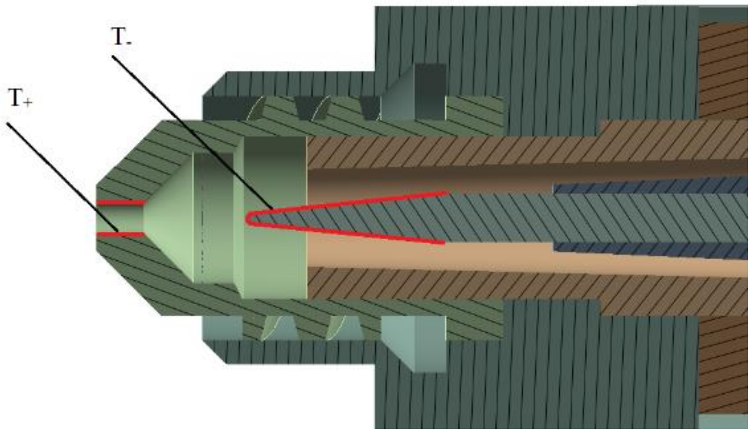
# Calculation scheme




Calculation scheme describing the behavior of the working gas

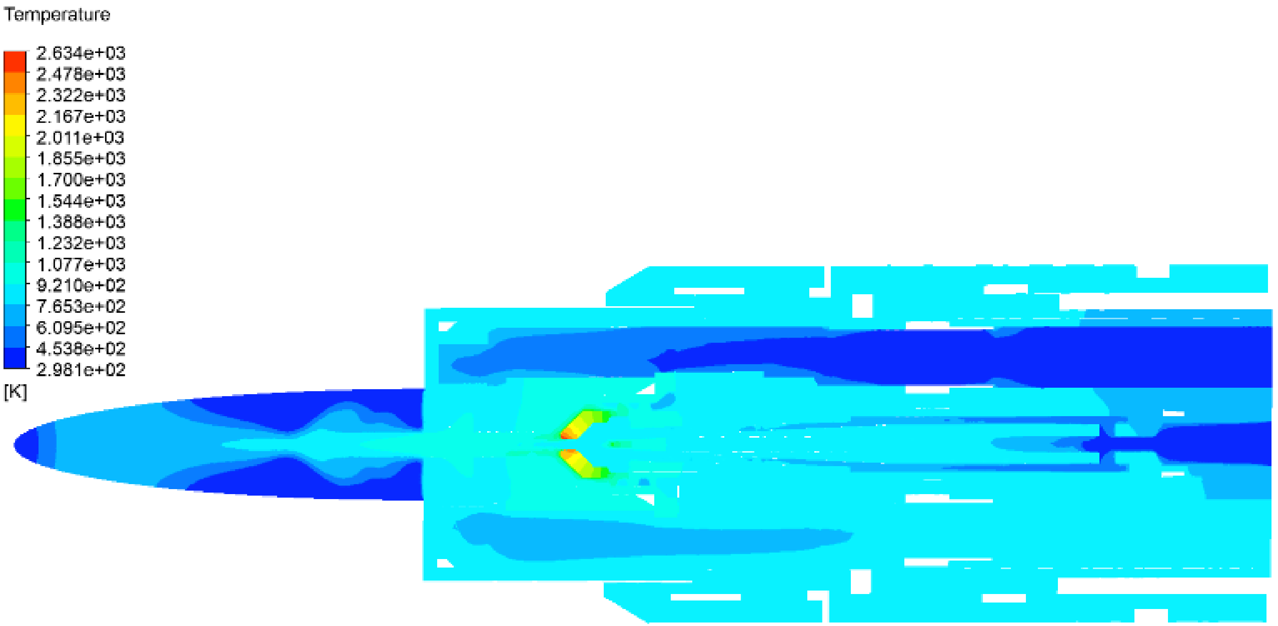



Calculation diagram describing the behavior of the coolant

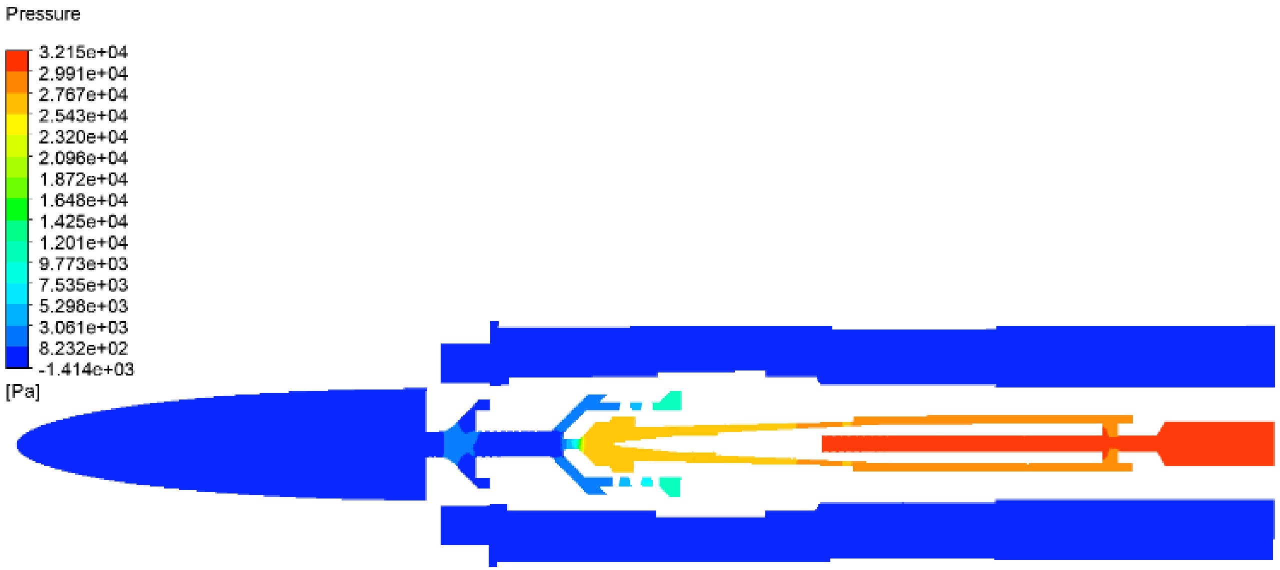



Calculation diagram describing temperature distribution

# Calculation of flow parameters of working gas and liquid and thermal state of plasmatron elements

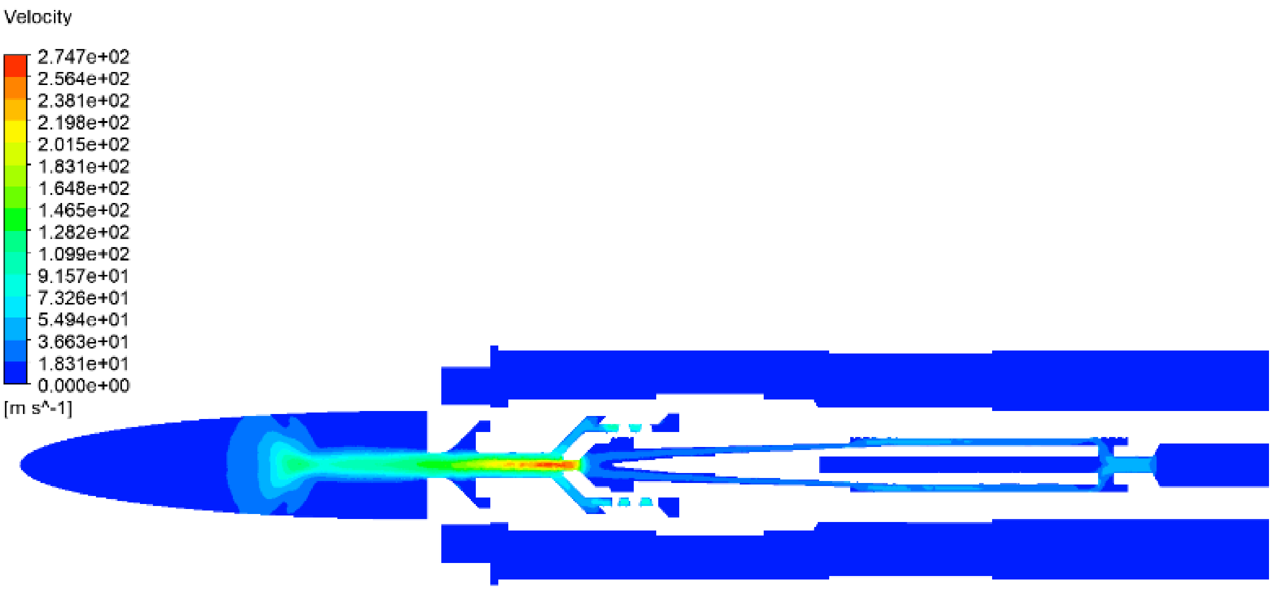



Section A, temperature distribution

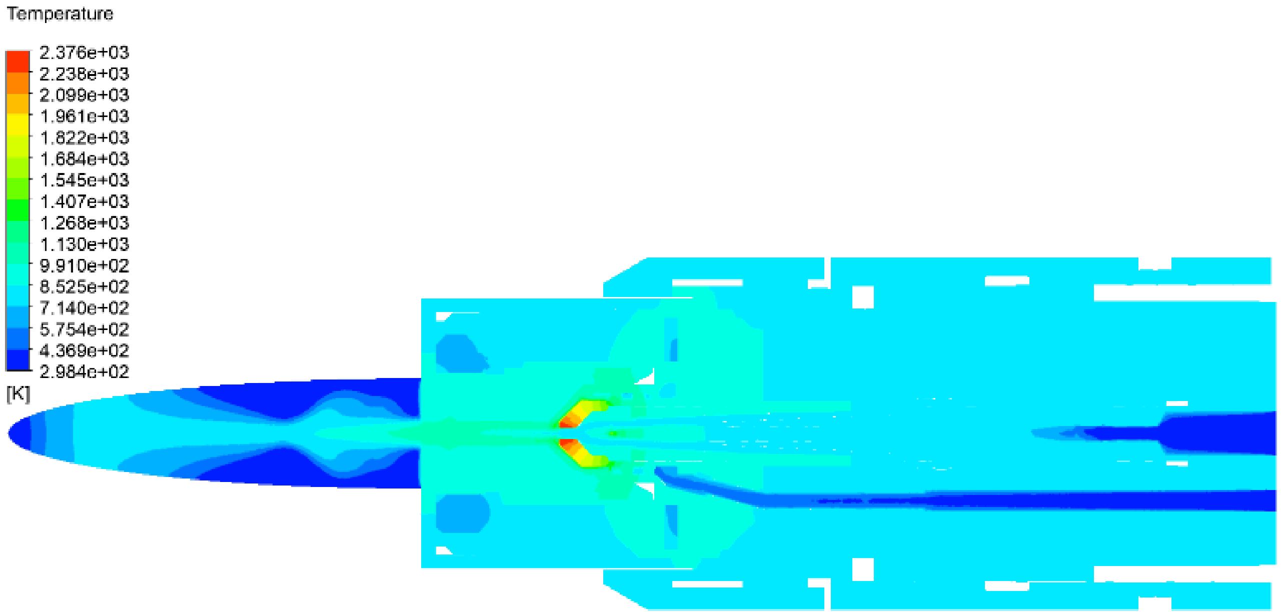



Section A, pressure distribution

# Calculation of flow parameters of working gas and liquid and thermal state of plasmatron elements

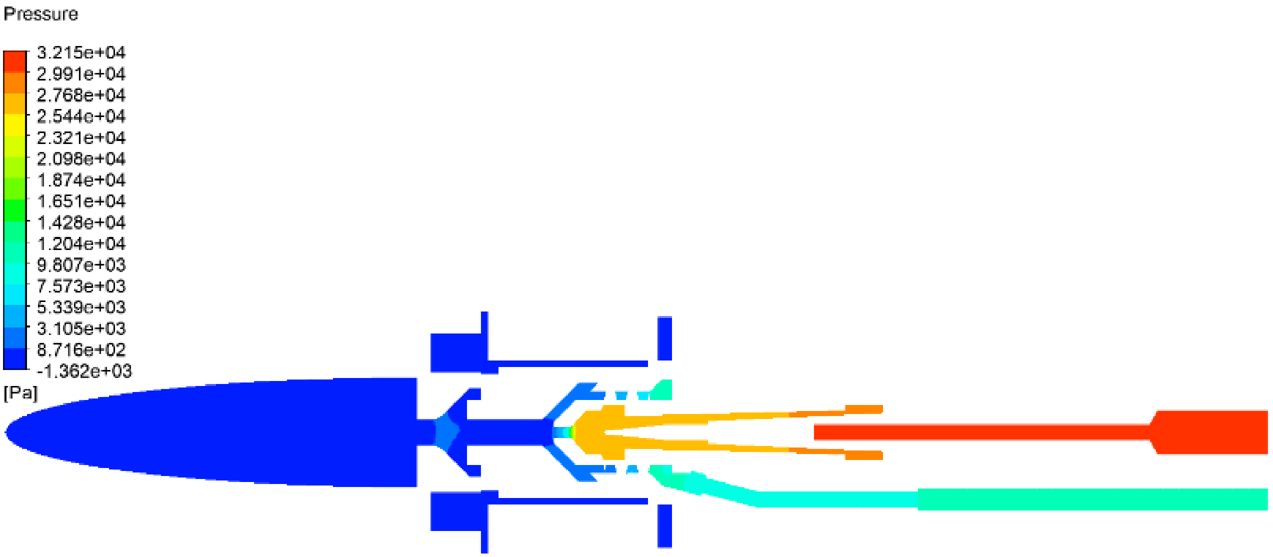


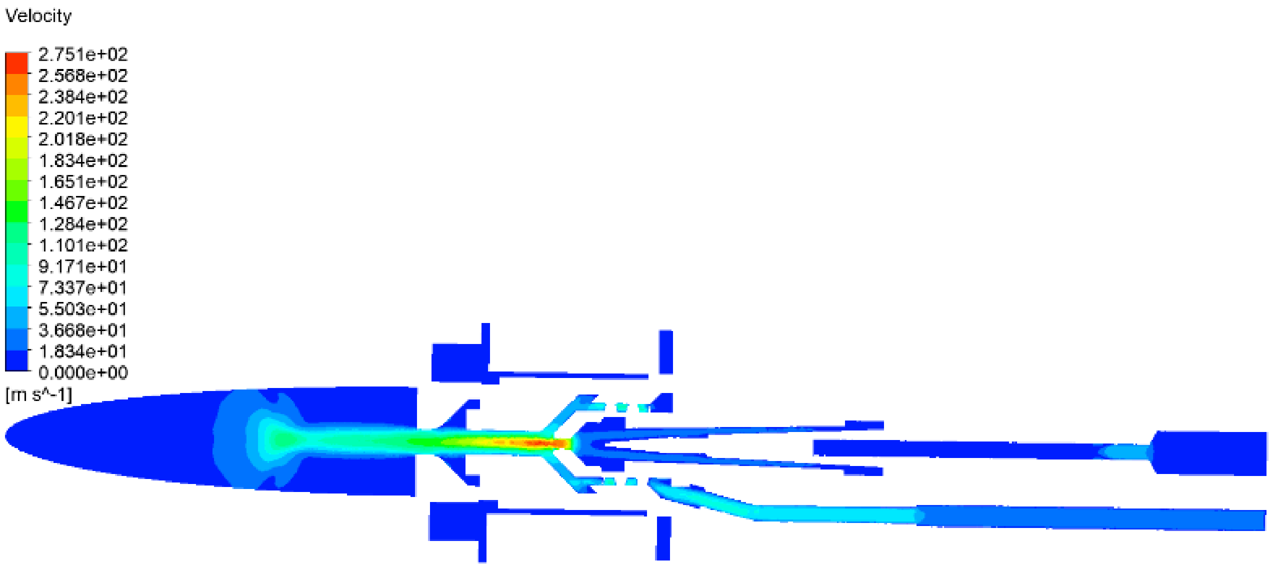

Section A, velocity distribution




Section B, temperature distribution

# Calculation of flow parameters of working gas and liquid and thermal state of plasmatron elements




Section B pressure distribution

Section B, velocity distribution

# Thanks for Your attention!

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