

**HETEROGENEOUS CONDENSATION OF WATER VAPOUR AND CARBON
DIOXIDE IN ROCKET ENGINE PLUMES, OPERATED IN THE UPPER
ATMOSPHERE**

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Models of temperature and pressure changes of combustion products in rocket plumes of last stages of the launcher "Proton", "Molnija" and "Start" engines, operated in the upper atmosphere at altitudes above 120 km are calculated. It is shown that the condensation of water vapor can occur at distances 100 - 150 m from the engine nozzle, and the condensation of carbon dioxide at distances at distances 450 - 650 m.

The process of water vapor and carbon dioxide condensation in the plumes of these launchers are modeling. Effect of a heating of condensed particles by the latent heat of condensation and energy losses due to radiation and heat by an exchange with the combustion products are taken into account. The dependences of temperature and the thickness of the condensate layer on time by means of a solution of the equations of heat balance and mass balance of the condensed particles are obtained. Water vapor and carbon dioxide condensation in the exhaust stream of rocket "Start" practically does not occur. In plumes of launchers "Proton" and "Molnija" thickness of "water" layer on the particles can reaches $\sim 100 \text{ \AA}$ and the thickness of carbon dioxide may be $\sim 60 \text{ \AA}$.