THREE-SHOCK EFFECT OF THE APPEARANCE OF CONFIGURATIONS WITH A NEGATIVE ANGLE OF REFLECTION ON THE STRUCTURE OF A SUPERSONIC JET

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The expiration of the supersonic jet from a nozzle at off-design operation occurs when the pressure in the gas stream at the nozzle exit is different from the ambient pressure medium. There may be cases of over-expanded $P_1 < P_a$ and under expanded jet, i.e. $P_1 > P_a$ ($P_1$ – the gas pressure in the output section of the nozzle, $P_a$ – pressure in the external environment). As a result, systems of alternating expansion and contraction waves and shocks appear inside the jet which may have a different configuration. There may be a three-shock configuration with a negative angle of reflection [1]. If the reflected wave in this configuration, crosses the line of symmetry, it is clear that such a configuration can not be stable, on the line the gas begins to accumulate, stationary process flow will be disrupted.

One can expect new wave structures of supersonic jet to appear or even the occurrence of vibration modes. In any case, the occurrence of a triple shock configuration with negative angle would lead to the change in the mode of operation of rocket engine. This effect is real to the expiration of jets from the nozzles, since the products of combustion of conventional fuels have a fairly low ratio of specific heats.

In the report the analytical studies with the aim of three shock theory are presented of different forms of three-shock configurations that may occur at the nozzle exit. They have been obtained over a wide range of governing parameters: pressure drop across the oblique waves emanating from the nozzle exit, the ratio of specific heats and the Mach numbers.