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Payam Hamze, post-graduate (Iran)

National Aviation University

A METHOD FOR COOLING THE ROCKET ENGINE NOZZLE USING GAS OF THE GAS GENERATOR

Vernher von Braun, a German scholar, was the first who used rocket engine nozzle cooling with gas of the gas generator in his developments. He designed F-1 engine as the first stage of Saturn 5, which to this day remains the most powerful hoisting missile in the world ever lifting a payload into orbit. This rocket was used actively in the United States in the lunar program, and all of its launches were declared successful.

The main feature of F-1 engine was its cooling system that used the gas-generator gas for cooling the nozzle. The cooled gas made it possible to increase the total mass of gas in the nozzle, which increased engine boost. Von Braun was the first, who proposed the use of a heat exchanger and of an exhaust manifold assembly of gas turbines for this purpose.

The heat exchanger was used for cooling the hot gas, coming from the turbine, which was fed into exhaust gas manifold assembly of the turbine and then circumferentially injected into the nozzle, parallel to its walls.

Wernher von Braun used liquid oxygen as a cooling element in the heat exchanger. However, this method provided cooling only of the removable part of the nozzle. The rest of the engine was cooled with liquid kerosene, i.e. von Braun used two types of cooling in his design: liquid was used for cooling the upper part of the engine and cooled gas for cooling its lower part.

Along with the advantages, this method had a major drawback. It consisted in the obligatory presence of cold liquids, the temperature of which had a strictly restricted range. In case of violation of this range, the engine cooling did not give the desired effect.

In order to solve this problem, we propose a method for cooling the nozzle by changing the energy of the gas passing through the turbine of the turbopump unit. Since the gas energy is determined by the sum of many physical quantities, then by changing the indicators of some of them the necessary generator gas temperature reduction can be achieved without the use of cold liquids.

To achieve this aim, application of an additional gas generator in the rocket engine is proposed. This gas generator is required to regulate those gas energy components, which could provide the necessary cooling conditions.

Since the gas, which passed through the primary turbine of the engine, has a low pressure, it can be injected directly into the nozzle due to the difference between the pressures at the gas exit point of the gas turbine and the gas entry point in the nozzle. On the other hand, this gas still has a high temperature and cannot be used for cooling the nozzle. In order to solve the injection problem and, at the same time, the nozzle cooling problem, it is necessary to reduce the gas temperature and increase its pressure. Once these conditions are fulfilled, the cooled gas can be fed directly into the engine nozzle.

The use of an additional gas generator can provide such changes of the gas energy components, which will make it possible to adjust the pressure difference required for its supply to the engine nozzle as well as to control its temperature. Thus, ensuring the possibility of the cooled gas supply from the gas generator directly to the nozzle, we will be able to solve the gas cooling problem.