CONVERSION OF HYDROCARBON FUEL IN A THERMAL PROTECTION REACTORS OF HYPERSONIC AIRCRAFT

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Endothermic reactions as a method of cooling are considered by many researchers due to the necessity of removal and recovery of large heat fluxes The use as reagents of different types of hydrocarbons allows, except removal of heat by the endothermic effect of the reaction to obtain a hydrogen-containing fuel having better energy characteristics. The use of hydrocarbon fuel conversion for cooling heat-stressed areas of high-speed vehicles and organization of their burning in supersonic air flow have been considered by the experts from the sixties of the last century.

Thermal protection of heat-stressed surfaces of a high-speed vehicle flying in dense layers of atmosphere is one of the topical issues. Not of a less importance is also the problem of hydrocarbon fuel combustion in a supersonic air flow. In our concept under development it is supposed that in the most high-stressed parts of airframe and engine catalytic thermochemical reactors (TCR) will be installed, wherein highly endorthermic processes of steam conversion of hydrocarbonic fuel take place. Simultaneously with heat absorption hydrogen generation will occur in the reactors. It is well known, that the major drawback of hydrocarbon fuels resides in considerable (t_d ~ 10 ms), as compared to hydrogen (τ_d ~ 0.*1* mc), times of ignition delay which leads to the necessity of long combustion chamber. However, mixing hydrogen produced in TCR with basic mass of kerosene results in decrease of ignition time for flammable mixture. Thus, the considered concept solves both designated tasks.

This paper presents the results of a study of conversion of hydrocarbon fuel in a slit reactor. Were investigated different modes: high conversion, high-performance hydrogen, the maximum heat removal. Schematic diagram of the setup is shown in Fig.1. The object of the pilot study is the structure consisting of two concentric tubes with a clearance between them h = 4mm. The inner tube is heated by plasmotron jet, and the clearance between the tubes is a thermochemical reactor . It is the cooling jacket to the inner channel. The walls of TCR are made out of stainless steel used for the manufacture of flame tubes of the combustion chambers.

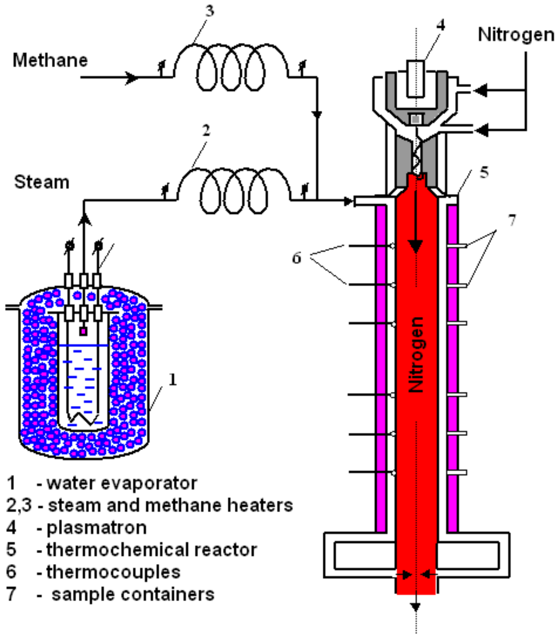

Fig.1 Experimental set-up

First, experiments were performed in the reactor with smooth walls, which have a natural catalytic activity. At flow rate of steam-methane mixture G = 0,8 g/s and a wall temperature Tw = 1100 º C methane conversion degree did not exceed 6 % vol. Reduction of flow rate to 0,2 g/s resulted in the increase of conversion degree up to 37 % vol. due to the increase in the residence time of the mixture in the reactor. However, a qualitative change in the situation occurred when a volumetric nickel catalyst with a developed surface was placed into the reactor. The degree of conversion at that increased to ≥ 92 %, as shown in Fig.2. Hydrogen yield at G = 0.8 g/s and Tw = 1100 º C made up 45% vol. and at Tw =1300 ^{o}C increased up to 65 % by volume.

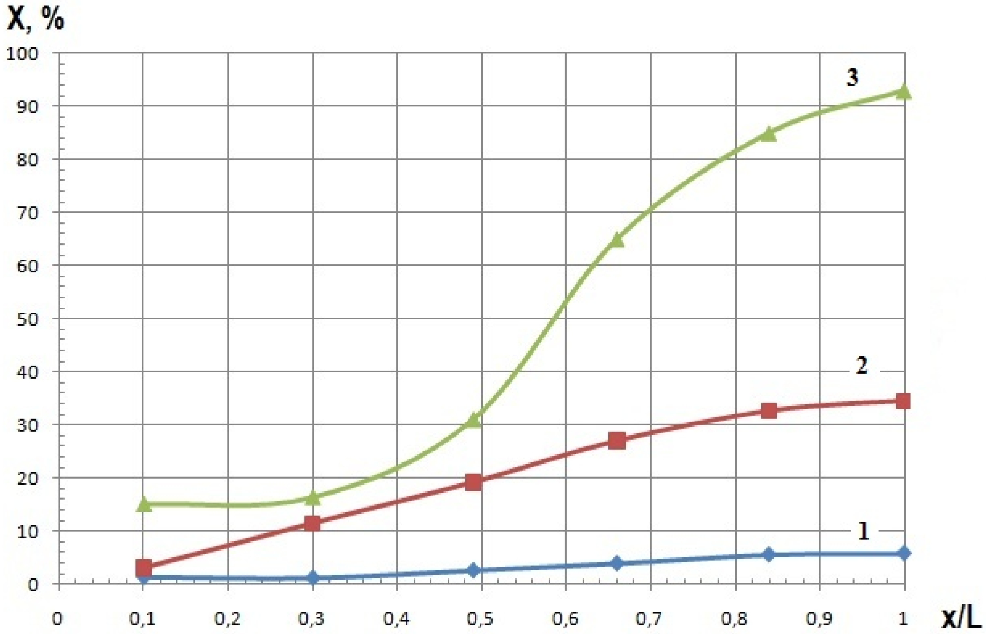

Fig.2 Steam conversion change along the reactor's length.
1 - G = 0,8 g/s, smooth wall 2 - G = 0,2 g/s, smooth wall 3 - G = 0,8 g/s, volumetric catalyst

Our experiments qualitatively confirmed the results of calculations of TCR modeling in slender channel approximation. Flow rate of chemically reacting mixture and the temperature of the wall on which the reaction takes place have the greatest effect on the characteristics of the process under study.