Optimisation of Characteristics of a CW Chemical HF Laser with a New Method for Oxidizing Gas Production

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The energy parameters of an supersonic cw chemical HF laser operating by using a new method for oxidizing gas production, which is based on the principle of two–zone mixing, are optimised. The total amount of the inert diluent (helium) supplied to the laser was varied during experiments by varing its relative fraction only in the second mixing zone (in subsonic parts of the nozzles). In the first mixing zone (in gas generator) its relative fraction was constant.

An original design of a self–contained supersonic cw HF laser with a modified radial expansion nozzle array using nozzle–injector–injector scheme for reagent mixing (referred to as the *A* type laser in the following) was proposed in our paper [1]. The modified nozzle array was equipped with special injector for spraing the cold inert diluent at the nozzle inlet. This made it possible to supply atomic fluorine and the inert diluent separately to the nozzles, and also ensured a two–zone mixing of reagents and the subsequent low–temperature flow of the oxidising gas in the supersonic parts of the nozzles. The engineering approach proposed in [1] was patented as a new method for oxidising gas production.

Experimental studies of an *A* type laser [1] confirmed its operational capability and gave its output parameters during redistribution of various amounts of helium from the first mixing zone (of the combustion chamber of the gas generator with a primary dilution degree ψ_1) to the second mixing zone (adjoining the nozzles) with a secondary dilution degree ψ_2. The total dilution degree ψ_Σ of the fuel mixture remaind constant during the experiment: $\psi_\Sigma=\psi_1+\psi_2$=const. It was shown that for an almost complete transfer of helium (95%) from the first mixing zone to the second one (which corresponds to ψ_1~0.7 and ψ_2~13.5), the laser radiation power increased by 70% for pressure in combustion chamber p_c=const while the specific energy output increased by 40%.

The aim of this study, which is a continuation of our earlier work [1], is to optimise the energy parameters of an *A* type HF laser by varying the relative fraction of the secondary inert diluent supplied to the second mixing zone, the position of the optical axis of the resonator relative to the nozzle array, and the total mass flow rate of the reagents.

Experimental studies revealed the following facts. Variations in the secondary dilution degree ψ_2 in the investigated range ($10\leq \psi_2\leq 21$) lead to considerable variations in the spatial and power characteristics of laser radiation. As the coefficient ψ_2 is decreased, both the laser power and specific energy output increase, while the lasing region length Δx_L decreases. As ψ_2 is increased, the energy parameters decrease but the lasing region length increases considerably (up to Δx_L=52 mm). For a value of ψ_2 close to the optimal value (ψ_2^{opt} ~10) and for a corresponding optimal position of the optical axis of the resonator x_c^{opt} =21 mm under the conditions p_c=const ~1.2 kg cm^{-2}, the output power of the *A* type laser was increased by 50% and specific energy output was increased by 60% compared to their values in the nominal operating regime of the laser (ψ_2^{nom} ~15 and x_c^{nom} =17.5 mm) realised in our earlier investigations [1]. In this case, the total concentration of the inert diluent decreased by 35% while the lasing length increased by 20%.

A comparison of the energy parameters of the basic (initial) model of the laser (*B* type laser) [2], whose nozzle array was subjected to modification, and modified model (*A* type laser) shows that the integral effect resulting from a transfer of 95% helium from the first to second mixing zone and optimisation of its total amount is manifested in increase in output power of the *A* type laser by factor of 2.6, and of specific energy output by a factor of 1.6. The lasing region length increases in this case by factor of 1.6. The physical reasons behind such an integral effect are revealed.

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