Supersonic COIL Driven by Centrifugal Bubbling SOG with Efficient Depletion of Chemicals in Single Pass

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A centrifugal bubbling SOG generated gas at 100 torr of total pressure with efficient depletion of chemicals in one pass. A 1 kW class ejector COIL powered by this SOG demonstrated a specific power of 12.5 W per 1cm^3/s of BHP volumetric rate at chemical efficiency 22.7%.

The increase of the laser power of COIL per unit volume flow rate of the BHP passed through SOG is a quite important for decreasing of weight and size of the laser. A centrifugal bubbling SOG is the most proper for this goal. Generation of small chlorine bubbles moving with high velocity in the BHP being under high centrifugal acceleration ensures fast chlorine utilization and separation of the gas from liquid. The efficiency of chlorine utilization and $O_2(^1\Delta)$ yield are slowly depend on the ratio of chlorine molar flow rate to the BHP volumetric rate. A relative water vapor fraction can be supported at a low level by increasing of the output oxygen pressure. As a result a droplet free gas flow of a high pressure, high $O_2(^1\Delta)$ and low H_2O vapor fraction can be generated.

The centrifugal bubbling SOG consists of the rotating cylindrical bubbler of 60 mm in diameter, BHP and chlorine feeding systems. BHP flows on the rotating babbler surface as the axially moving layer of several mm in thickness. A chlorine-helium mixture is injected into the BHP layer through the array of cylindrical nozzles located inside of the circular strip of 1 cm width on the side wall of the rotating cylinder. So, the total working area of the bubbler was 18.8 cm^2. The axis of the nozzles is on the angle of 30° to the bubbler surface. Oblique injection of the gas into BHP layer induces substantial additional rotation of the BHP layer and diminishes normal gas momentum.. The tests of SOG have been performed at the chlorine loading up to 3.2 mmole/s per 1cm^2 of the bubbler area and bubbler rotation frequency up to 80 revolutions/s. For the measurements of $O_2(^1\Delta)$ and water vapor concentration a multi channel registration of singlet oxygen emission in 634 nm, 703 nm, 762 nm и 1268 nm bands was used. The dependences of singlet oxygen yield, chlorine utilization and water vapor fraction on the height of the BHP layer, centrifugal acceleration, ratio of chlorine molar flow rate to the BHP volumetric rate were measured. A droplet free gas flow of 100 torr total pressure and partial oxygen pressure of 36 torr has been generated. The efficiency of chlorine utilization was higher than 90%, singlet oxygen yield was near 50%. A water vapor fraction was near 15% at ratio 1 mole/s of the chlorine flow rate to the 1 litre/s of the BHP volumetric rate.

An ejector COIL of 5 cm gain length was powered by this centrifugal bubbling SOG operating at 4.2×10^5cm/s^2 centrifugal acceleration. A gas temperature of the active medium was monitored by rotational structure of oxygen $^1\Sigma\rightarrow{}^3\Sigma$ transition in 762nm band. At nominal conditions the gas temperature was estimated in the range 160÷180K that corresponds to Mach number of the gas flow of 2.2. A laser power versus BHP volumetric rate was detected for total mirror transmission of 2%. The chemical efficiency was higher than 21% for the ratio of chlorine molar flow rate to the BHP volumetric rate up to 0.6 mole/liter. Hence the alkaline concentration in BHP reduced from 4M to 2.8M in single pass. The chemical efficiency 25.4% and specific power 57 W per 1 cm^2 of the bubbler area were obtained for chlorine molar flow rate of 50.8 mmole/s and BHP volumetric rate of 178 cm^3/s. 12.5 W of output laser power per 1cm^3/s of BHP volumetric rate at chemical efficiency 22.7% was obtained when COIL output power was 1kW.

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