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CONSTRUCTION AND OPERATION OF A GAS TRANSPORT CO_2 LASER

by

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Construction and operation of a gas transport CO_2 laser

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Construction and operation of a gas transport CO_2 laser[1]

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Abstract: The construction and operation of a CO_2 gas transport laser with cylindrical geometry is presented. This work aims at small size and light weight gas transport laser at high output level. This has been accomplished by a single metallic cylinder for electric discharge, recirculation and the cooling of the gas mixture. More than 1kW laser power was obtained from a laser of the length of 1.45m, diameter 0.54m and cca weight 180 kg. Typical parameters were: pressure 40 Torr, CO_2:N_2: H_e = 1:8:11, discharge current 8 A, efficiency 12%, and laser spot 28 × 22mm^2.

1. Introduction

Gas transport lasers have high power output. But the lasers are bulky, heavy, and complicated in structure. They are not convenient to use is many application areas. In the previous article[1,2], we have discussed the feasibility of constructing small size, light weight gas transport lasers using single metallic cylinder containing recirculating cooling system and discharging system. This article describes the structure and performance parameters of this type of gas transport lasers.

2. Experiment setup

Fig. 1 and Fig. 2 are the cross sectional diagrams perpendicular and along the axis.

The laser chamber consists of water cooled stainless steel cylinder, which is 1400 mm long and 460 mm wide. There are two rectangular openings, 180 × 1300 mm^2. Two rectangular plates, 2 and 11, are used to cover the openings. On one plate is installed electrode assembly. On the other plated is installed 10 copper plate as heat exchanger. Air recirculation system consists of 6 two-blade fans. The fan has diameter 325mm, width 30mm, and gap 100 mm. These fans are mounted on a long axis. This axis is turned by a DC motor through a vacuum axial sealing.

The mixed gases flow to the discharge area through the passage between cylinder inner wall and metallic plate, number 13. The mixed gases are cooled by the side wall of the cylinder, 8 heat exchangers (number 5 in the diagram) of length 1300mm, and 10 copper tubes of diameter 12mm.

The electrodes assembly contains these three parts: two sets of separately arranged anodes of total length 1220mm (number 6 in the diagram), one copper tube cathode which is 10mm in

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diameter and 1290mm in length (number 8), and an auxiliary electrode (number 7). Fig. 3 shows the cross sectional diagram of one set of the anode assembly (610 × 120 × 30 mm^3).

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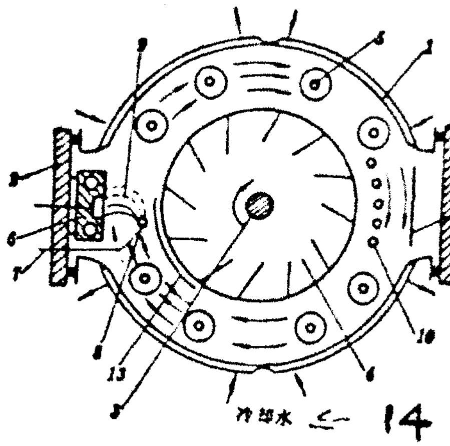

Fig. 1 Cross sectional diagram perpendicular to the axis of gas transport CO_2 laser. 1 - stainless steel cylinder, 2 - metallic plate supporting electrode assembly, 3 - axis of rotation, 4 - fan, 5 - heat exchanger, 6 - Anode, 7 - auxiliary electrode, 8 - cathode, 9 - discharge area, 10 - auxiliary exchanger, 11 - metallic plate, 12 - metallic flow guiding plate, 13 - metallic thin plate, 14 - cooling water.

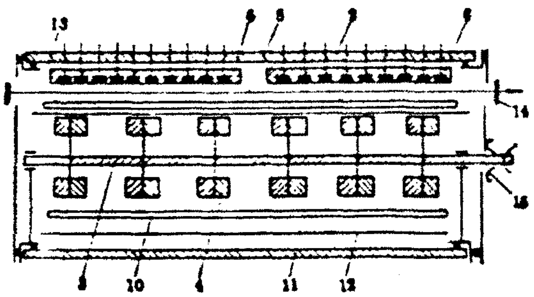

Fig. 2 Cross sectional diagram along the axis. 1 ~ 13 - same as in Fig. 1, 14 - exit mirror, 15 - vacuum axial sealing driver.

Each anode assembly has 30 anode strips. The surface area of each of these strips is 40 × 15 mm^2. The anodized aluminum plate (number 8) cools anode through ceramic plate. Anodized aluminum plate (number 8) cools anode through ceramic plate. Sealing is accomplished by the mixture of Al_2O_3 and sodium fluosilicate. Glass (number 6), ceramics (number 7) and epoxy resin (number 5) are used to provide good insulation for the anode. This assembly type of anode structure is convenient to make and easy to use. Each anode strip uses 2.5 kΩ resistor to limit current.

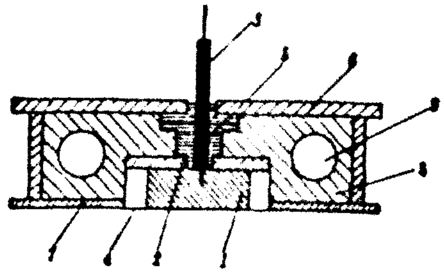

Fig. 3 Anode structural diagram. 1 - anode strip, 2 - ceramic plate, 3 - wire lead, 4 - aluminum oxide powder, 5 - epoxy resin, 6 - glass plate, 7 - ceramic plate, 8 - anodized aluminum plate, 9 - cooling passage.

The auxiliary discharge system consists of 60 copper wires of diameter 1mm. Each copper wire corresponds to one anode strip. After discharging on contact, the copper wires are used as preparatory ionization source. Each copper wire uses 0.8 MΩ resistor to limit current. The branch current is 1.5 mA.

The resonance chamber consists of two mirrors; one is a gold plated copper mirror with diameter 50 mm and radius of curvature 5 m; the other is a GaAs plane mirror, whose light penetration rate is 23% and the effective light passing diameter ϕ is 35 mm. These chamber mirrors are mounted on two metallic plates separately. They are fixed by four struts to provide mechanical stability.

The gas leaking rate of the laser is less than 1 Torr/24 hour period.

3. Experimental results

The gas mixture flow characteristics for two different fan rotation rates (i.e. 1400 r.p.m and 1800 r.p.m) are shown in Fig. 4. The flow speed is measured at different positions along the light axis.

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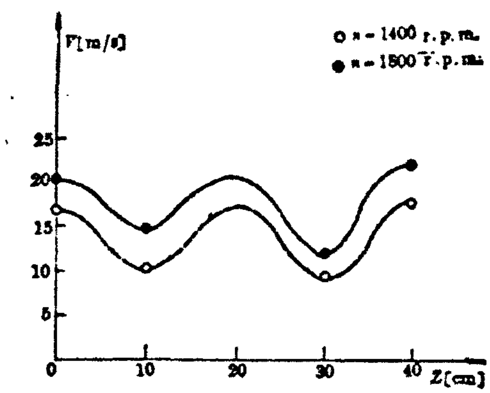

Fig. 4 Gas flow speed distribution along the discharging region. (Z=0 corresponds to the center of the cylinder)

The measured flow speed indicates that at the 1800 r.p.m rotation rate, the largest flow speed (at a position just ahead the fan blade) is V_{max} = 25 m/s, the smallest flow speed (in between the two fans) is V_{min} = 15 m/s, and the average speed approximates 20 m/s or equivalent to 3000 m^3/hour volume flow rate. In order to improve the uniformness of the flow, several secondary aerodynamic designs have been tried but the structure was made too complicated.

Other details about the gas circulation system are discussed in Ref [2].

Fig. 5 shows the laser power curves corresponding to different fan speeds. When the rotation rate is increased from 1200 r.p.m to 1600 r.p.m, the laser power is increased by 60%.

At high rotation rate, the laser power increases nearly linearly with the discharge current. At low rotation rate, there is a saturation tendency. Fig. 6 shows typical curves corresponding to two different gas mixture pressures.

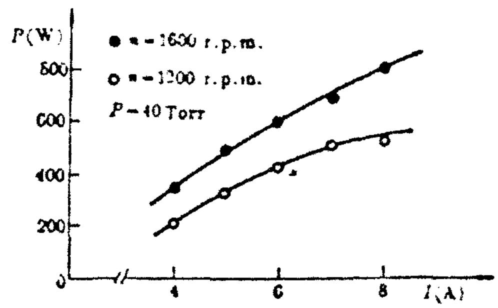

Fig. 5 The relationship between the laser power and the discharging current under two different flow rate. (P=40 Torr, CO_2:N_2:He =1:8:11, R=5m)

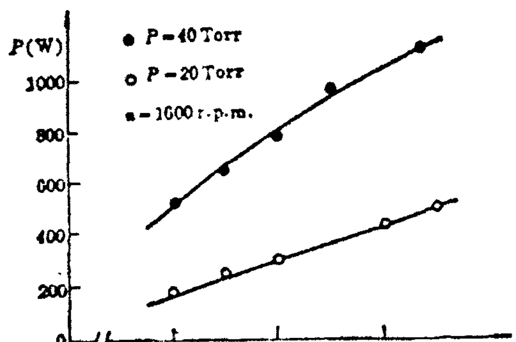

Fig. 6 The relationship between the laser power and the discharging current under two different gas pressures. (N=1600 r.p.m., CO_2:N_2:He=1:8:11, B=5m (copper reflection mirror), light spot sizes 28 × 22 mm^2, sealed operation)

The output power is 1100 W under the conditions that the gas mixture ratios are CO_2:N_2:He=1:8:11, that the gas pressure is at 40 Torr, that the fan rotation rate is at 1600 r.p.m, that the working voltage is at 1050 V, and that the discharging current is 8.5 A. The electricity-light conversion efficiency is 12%. The laser light spot is 28×22 mm^2 in size.

The curves shown in the figure also indicate that the working pressure has a big influence on the output power. When the pressure increases from 20 Torr to 40 Torr, the output power more than doubles.

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References

[1] I. Gutu et al., Rev. Roum. Phys., 1978, 23, No. 5, 447.

[2] V. Draganescu et al., Rev. Boum. Phys., to be published.

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