HIGH CAPACITY GETTER PUMP FOR UHV OPERATION

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Abstract

UHV pumps based on non evaporable getter coated strips find widespread use in particle accelerators, synchrotron radiation machines and nuclear fusion experimental devices. Depending on the geometric constraints, pressure operation conditions and the foreseen gas loads, optimized getter structures, such as modules and cartridges, can be designed and assembled into a high-efficiency pump. In the present paper, the design and performance of a newly conceived High Capacity Getter Pump (HCGP) based on sintered getter bodies, in the shape of blades instead of strips, is illustrated. The porosity and the specific surface area of the blades and their arrangement in the cartridge have been optimized to significantly increase sorption capacity at a given speed. These pumps are well suited for those applications where a very high gas load is expected during the machine operation. The sintered getter bodies increase surface area and capacity, requiring less frequent reactivation and facilitating greater overall life of the pump. A discussion of the experimental results in terms of sorption speed and capacity for various gases is presented.

I. INTRODUCTION

Non Evaporable Getter (NEG) pumps find widespread use for maintaining vacuum in a variety of UHV experimental machines such as storage rings, synchrotrons, particle accelerators, nuclear fusion devices. At present, commercially available NEG pumps make use of metallic strips upon which the getter powder is deposited and mechanically anchored by compression. These strips can be inserted in suitable regions connected to the vacuum chamber to provide an effective distributed pumping system [1],[2],[3]. Alternatively, they can be shaped in more complex structures, such as cartridges and modules [4][5], which can be assembled into high efficiency pumps to provide discrete pumping capabilities, as required for example in the crotches and absorbers regions of storage rings or synchrotron machines [6]. Some advantages of NEG pumps are high pumping speed, especially for hydrogen, absence of mechanical moving parts, no interference with the particle beam,low power consumption, low cost. Their main drawback is the finite sorption capacity for active gases, such as CO, N_2, CO_2 and H_2O, which requires periodical getter conditioning at moderate temperature (400 °C) to clean the surface by diffusion of the contaminants into the bulk. The frequency of getter conditioning depends on the gas load and the operating pressure conditions required for running the experiments. With this respect, next generation machines, such as high performances storage rings and B factories, will be characterized by increased thermal outgassing from the walls of the vacuum chamber and increased dynamic loads due to photon induced desorption [7]. Operating vacuum requirements will also become more stringent and pressure value lower than 1x10-9 torr necessary. In the present paper, the design and sorption characteristics of a newly conceived NEG pump, which can overcome above cited problems, are illustrated. This pump, which is based on the use of porous sintered getter, shows significantly larger sorption capacity and higher pumping speed per unit volume than NEG pumps making use of the coated strip. It is therefore particularly well suited for maintaining UHV standards under high gas load conditions.

II. DESIGN OF THE HIGH CAPACITY GETTER PUMP

NEG pumps based on modules and cartridges are highly optimized structures in which the surface area of the deposited getter material, as well as the effective sticking probability, i.e. the probability for a molecule entering into the gettering structure to be captured, are maximized. To further increase the sorption capacity per unit volume an approach has been pursued

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which is based on the use of porous sintered getter bodies instead of the coated strip. A sketch of the high capacity getter pump (HGCP) prototype, having the same size and flanges of a standard SAES GP 200 pump is shown in fig.1.

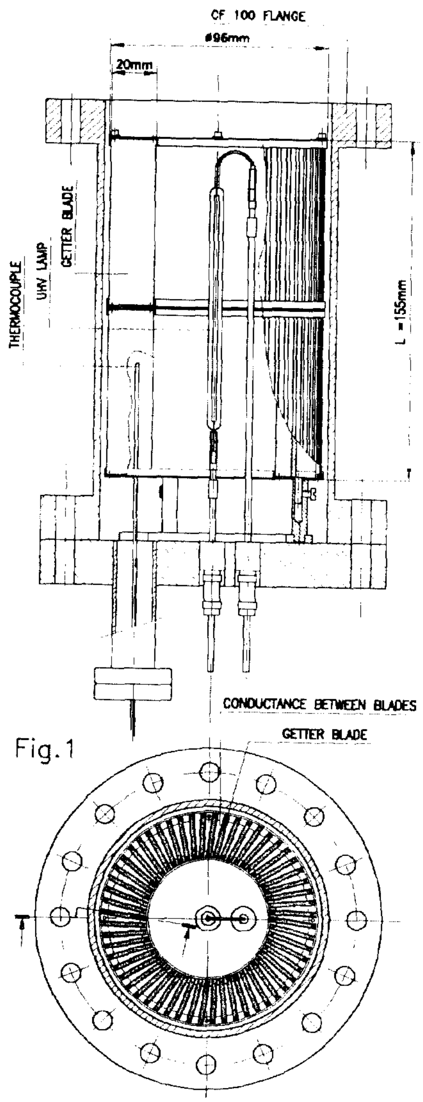

FIG. 1 - Cut and top views of the high capacity getter pump prototype

The getter cartridge is composed of a cylindrical array of nearly parallel rectangular porous blades which are inserted in a stainless steel retaining structure and act as the gettering elements. Gas molecules reach the gettering structure directly from the top surface of the pump or from the large central inner conductance. The blades are prepared by mixing and sintering proper amount of St 707 (Zr70%- V24.5%- Fe 5.5%) and zirconium powder. The microstructure of the sintered getters has been specifically optimized during the manufacturing process to enhance porosity, thus providing a better accessibility for the gas molecules to the available gettering surface area. The geometrical arrangement of the blades inside the cartridge, as well as their number and size, has also been optimized in order to ensure both large gas conductance between adjacent blades and high trapping efficiency for the molecules which have entered the gettering structure. Knowing the intrinsic sorption properties for the sintered getters and applying a mathematical model based on Pisani's method [8], a quite accurate prediction of the sorption performances for HCGP can be made as a function of several parameters of interest, such as pump size and geometry, number and dimension of blades. This approach can be followed for designing high capacity pumps of specific desired performances. A detailed discussion of these aspects will be presented elsewhere. It is also worthwhile noticing that the use of porous getters allows to allocate a quantity of getter material inside the pump which is about 3.5 times higher than that available in a comparable size GP 200 (600 vs 180 grams). Moreover, the arrangement in blades of the getter material is such that the bigger amount of alloy, while remarkably increasing sorption capacity and speed, does not pose specific handling problems. Heating of the getter material during the activation process and the pump operation is accomplished in the prototype of fig.1 by means of a UHV lamp. The getter operating temperature is controlled by means of a thermocouple. Thanks to the relatively limited amount of getter material full activation to 500°C only requires 250 watts. External heating, even though less attractive, can be also provided.

III. PERFORMANCES OF THE HIGH CAPACITY GETTER PUMP

The HCGP has been tested according to the dynamic flow method, as described in detail in reference [9]. Activation of the getter material was carried out at 500°C for 60 minutes. Purity of the test gases, admitted to the getter pump through the known conductance was better than 99.99%.

Since hydrogen can be reversibly sorbed by the getter alloy, the pump was first tested for this gas and then, after successive

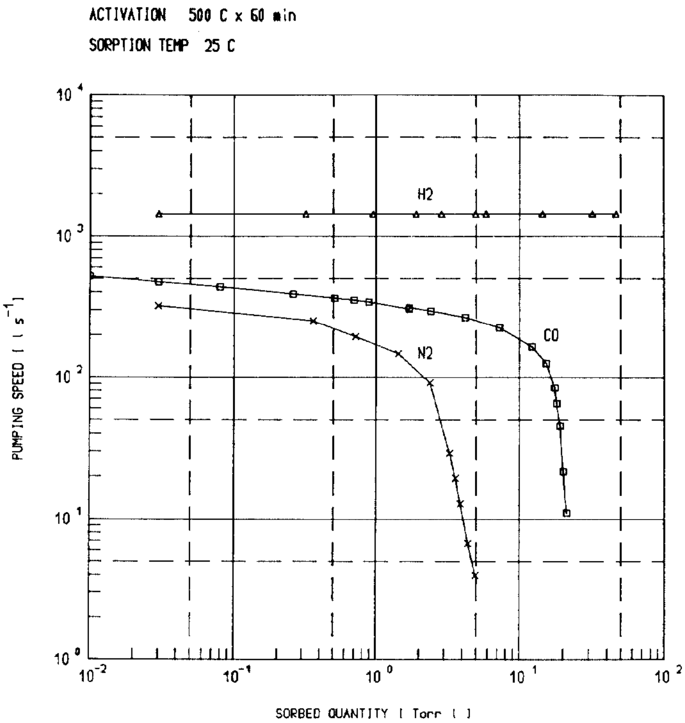

FIG.2 room temperature sorption curves (CO, N_2 and H_2) for the HCGP prototype

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regenerations, for CO and N_2. Sorption tests were carried out at room temperature. Experimental results are shown in fig.2. Initial pumping speeds of the HCGP for CO, N_2 and hydrogen are about 500, 300 and 1300 l/s respectively. The CO sorption curve decreases slowly with the sorbed quantity up to about 10 torrl and then it rapidly drops. This behaviour is a clear indication of the porous nature of the getter blades and the high conductance of the cartridge structure. The optimization of these two parameters results in a continuous and efficient sorption process which goes on till the getter surface is nearly saturated. For higher gas load, an abrupt decrease in pumping speed takes place, since only few active sites are still available for chemisorption and room temperature diffusion is negligible. Similar behaviour is shown by nitrogen. Differently from CO and N_2, and in agreement with literature data, no decrease in the pumping speed for hydrogen has been measured up to the test dose. In fact thanks to the high diffusivity of hydrogen into the alloy lattice, the pump capacity for this gas is extremely high, being practically limited by the embrittlement value only. A comparison between the sorption curves for CO, N_2 and H_2 of the present HCGP [10] and those of the GP 200 pump, based on the pleated strip concept [11], indicates a substantial increase in pumping speed (a factor two) and capacity (a factor fifteen at 100l/s). This pump is therefore particularly well suited for those applications where a high gas load or prolonged machine operating cycles are foreseen.

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