Vacuum Getter Pump for Compact Accelerators

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Abstract

The design and main parameters of the non-evaporable getter pump for compact accelerator is described. This type of vacuum unit has several advantages for particle accelerators and some other physical installations. The characteristics of a number of getter materials presently developed are reviewed. The pump includes four getter elements made in the form of a strip, surrounded by cylindrical heat screen. The getter pump is expected to ensure evacuating speed about 150 dm^3/s for hydrogen and 50 dm^3/s for active gases.

1. INTRODUCTION

In particle accelerators and storage rings ion pumps, turbomolecular pumps or sputter-ion pumps are mostly used for obtaining necessary vacuum conditions. Recently non-evaporable getters began to be used in these installations [1] as vacuum pumps, built-in accelerator working chambers. They can ensure so-called distribution evacuation as built-in ion pumps. The pumps with non-evaporable getters have several advantages: small sizes, economy, sufficiently high reliability, unnecessity of electric and magnetic fields, stability to vibration and radiation.

Design of sorbing structures in the form of effective traps is very simple and flexible in these pumps. As compared with built-in ion pumps they have more evacuating rate of hydrogen. More over they can be used as a heater for vacuum accelerator chamber outgassing.

This report concerns with development of getter pump for compact electron linear accelerator. Accelerating structure is fed from 10 GHz magnetron and ensures beam output energy within 1-3 MeV.

2. GETTER MATERIALS ANALYSIS

Getter materials are suitable for pumping all active gases and especially hydrogen and its isotopes. The hydrogen diffuses into the getter bulk, forming a solid solution. This solution is reversible. An increase of the getter temperature causes the release of some amount of hydrogen sorbed from the bulk. Unlike hydrogen active (such as O_2, CO, N_2) gases are permanently fixed by the getter. If the getter temperature is raised to 200-400°C, active gas molecules can diffuse into the bulk of getter after the chemical reaction on its surface.

Getter materials must be cleaned to become able to sorb gas molecules. It can be provided by heating of the material to a suitably high temperature under dynamic vacuum conditions (pressure less than 0.1 Pa). The heating required is usually obtained by passing AC or DC current through the getter element, made in the form of a strip. In some cases indirect heating can be applied. Duration of this process varies from several to tens minutes.

A number of porous getter materials are presently developed and commercially available. SAES GETTERS SPA produces Zr-Al alloy (trade name of ST101) and Zr-V-Fe alloy (trade name ST707), used in various electro-physical installations. The important advantage of ST707 getter is lower activation temperature 450°C instead of 850°C for ST101. Initial specific sorption speed of these getters is equal 10 m/s for hydrogen and about 2-5 m/s for active gases.

There are several getter materials developed in Russia. They are mostly based on titanium. Many getter elements made of powder pure titanium are widely used in different branches of industry. These materials have the same gettering characteristics as ST707: activation temperature of 450-500°C and specific sorption speed about 4-10 m/s. The quantity of gas sorbed before sharp speed decreasing is about $(1\text{-}3)\times10^3$ m Pa.

The new perspective getter material Ti-V alloy was recently developed [2]. It has activation temperature range from 250°C to 400°C and larger specific sorption speed than ST707. Table 1 shows measured values of initial specific sorption speed of Ti-V alloy for different activation temperatures.

Table 1.
Initial specific sorption speed of Ti-V alloy
Activation duration - 30 min
Working temperature - 200°C
Pressure - $(1\text{-}1.5)\ 10^{-5}$ Pa

Activation temperature, °C	Specific sorption speed, m/s	
	for hydrogen	for active gases
250	20	-
300	35	3.00
350	40	3.85
400	42	3.50
450	45	-

This material was chosen for the construction of the getter pump for compact linac.

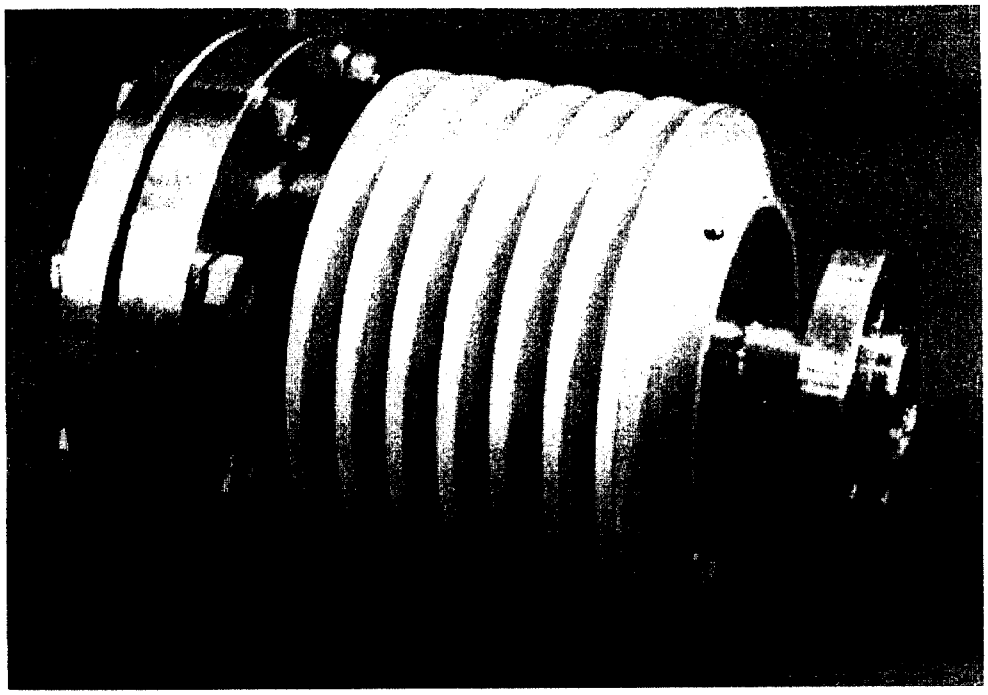

Figure 1. Overall view of the getter pump.

3. DESCRIPTION OF THE DESIGN

The pump is carried out in the form of cylindrical body with two flanges, one of which serves for connection to the vacuum tube of accelerator. The assembly of getter elements and electric lead-in for heating of them are mounted on the other flange. Getter elements are fixed in holders, which are installed on two spaced discs having common bar. The getter element is a strip made of porous getter material with sizes 90 mm × 30 mm and thickness 0.8-1.0 mm. For decreasing the current value required for getter activation in such assembly, there are several cuts from both sides of every strip. Length of cuts and space between them were chosen so that mechanical solidity of elements to be ensured.

The number of getter elements is four and they can be connected both in parallel and series. To decrease heat flow from getter elements to the body of the pump, a thin metal cylindrical screen is mounted. To check up the temperature of the getter elements, a thermocouple is spot welded to the strip. A simple AC or DC power supply is used for activation and operation of the pump. It may consist of a variable transformer 220 V - 9 A and transformer 220/24 V connected to the pump output connector via ammeter and voltmeter. The choice between series and parallel strip connections depends upon the maximum available values of the current and voltage. The compulsory air cooling of the pump is ensured by fan. The radiator with ribs increases the cooling efficiency. The overall view of the pump is shown in fig. 1. The unit has the following sizes: diameter — 125 mm and total length — 160 mm.

The pump connects to the vacuum system of the accelerator via T-piece pipe fitting. One of the flange of this fitting is used for connection of the auxiliary ion pump, which evacuates gases released from the bulk and the surface of the getter during activation process.

Getter elements of this pump is expected to ensure evacuation speed about 150 dm^3 /s for hydrogen and 50-60 dm^3/s for active gases. Working period of the pump without changing getter elements will be about 1000 hours.

4. REFERENCES

[1] B. Ferrario, I. Rosai, P. della Porte, "Distributed pumping by non-evaporable getters in particle accelerators", IEEE Trans. on Nucl. Sci. vol. NS-28,pp. 3333-3335, 1981.

[2] V. Stoljarov, "Development of Non-Evaporable Getters and Design of High Production Vacuum Pumps for Technological and Experimental Physical Equipment", Moscow Institute of Electron Engineering Industry, Moscow, Russia, Ph. D. Dissertation, 1989.