CRYOGENIC ADSORPTION PUMPS FOR REB ACCELERRATORS

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It is known that in relativistic electron bunching (REB) accelerators the main residual gases are air components. Under irradiation in targets made of different materials being studied, a significant increase of a level of such gases as hydrocarbons, aqueous vapor and hydrogen is observed. Therefore, it is clear that for improvement of vacuum conditions for a REB accelerator it is necessary to apply pumps which should permit to realize a high rate of pumping out of main residual gases and those of them the level of which increases considerably in targets under irradiation. We propose to complete the available equipment for pumping of REB accelerators with cryogenic adsorption pumps. They are to be placed in accelerators so that they can serve as additional means for protection of the target chamber volume against hydrocarbon coming from the available pumping equipment. It will make it possible to improve significantly the initial vacuum conditions in the working volume, and, furthermore, to reduce the time between experimental pulses.

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1. INTRODUCTION

Vacuum conditions are of great importance for operating pulsed high-current accelerators of relativistic electron beams (REB). This is of particular value for operation of microsecond -duration accelerators**.** The beam of a few tens kJ energy either interacts with the target or gets the drift chamber wall. As a result, in the chamber a gas flame is formed that leads to shortening the beam duration, to reducing the lifetime of basic units of the accelerator, sputter-ion pumps etc.

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2. EXPERIMENTAL PART

The paper presents two constructions of cryogenic adsorption pumps designed for obtaining fine vacuum in the range of pressures from 760 mm Hg to 10^{-9} mm Hg.

The pumps can be recommended for pumping high-current pulse REB accelerators, as they are stable to vibration, as well as, to electric and magnetic fields.

Cryogenic pumping devices are among the few pumping means, which do not carry contaminants into the volume being pumped out. Cryogenic pumps can be applied not only for obtaining the high vacuum but also for performing the oil-free fore vacuum pumping out.

Applying in practice of cryogenic pumps requires development of new designs improving the effectiveness of cryogenic pumping out. Proceeding from the above, we offer a high-vacuum cryogenic adsorption pump operating on cooling agent with the effective use of releasing vapors that leads to increasing the operating life of the pump. Fig.1 shows a schematic diagram of the pump.

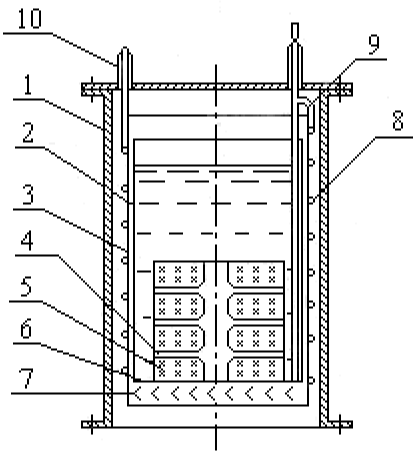

Fig.1

The pump comprises vertical body 1, in which a pumping element in the form of vessel 2 with cooling agent and screen 3 are located. In the bottom part of the vessel, chamber 4 is placed in which cassettes with adsorbent 5 are installed. Pumping of the major gas mass is performed by condensation on bottom 6 of vessel 2. Non-condensable part of gas after multiple collisions with the surfaces having the temperature of the cooling agent is absorbed by the adsorbent. Screen 3 with chevron 7 in its lower part is designed for protection of vessel 2 against external radiation and other thermal flows. Screen 3 is cooled due to releasing vapor of the cooling agent passing through its coil 8. Just here condensing components of the pumped gas are frozen. The surfaces of vessel 2 with cooling agent and screen elements are treated so that heat flows arriving to them were minimized. The screen and the vessel with cooling agent are suspended in the pump body on two pipes 9 and 10. So, the cooling agent is filled up and removed through branch pipe 9 and extraction and utilization of cooling agent vapors is realized through branch pipe 10.

The tests were conducted on the bench equipped with a system for preliminary pumping out and pumped gas filling up, as well as with vacuum gauges. For the study of a residual atmosphere an omegatronic mass-

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spectrometer was used. We have obtained characteristic mass spectra of not warmed vacuum system. They are presented in table where the first line corresponds to the pressure $1.2 \cdot 10^{-8}$ mm Hg, and the second line – to $6.2 \cdot 10^{-9}$ mm Hg.

№	Gas content, %							
	H_2	CH_4	H_2O	N_2	O_2	A_2	CO_2	ΣC_nH_n
1	44,5	4,5	7,8	25	2,8	4,3	7,1	4
2	56	3,1	12,4	16	2,1	3,2	5	2

In the case without warming up the pump being pumped the ambient air with the use of liquid nitrogen as a cooling agent the pressure of $1.8 \cdot 10^{-9}$ mm Hg was attained.

For pumping in the fore vacuum region of pressures one needs a pump operating in the rather wide pressure range and having insignificant consumption of a cooling agent. We offer the design of a cryogenic fore vacuum pump that can be used for preliminary pumping out of chambers having a large volume when it is necessary to obtain a fine vacuum for high-current pulse REB accelerators and to maintain it in the course of accelerator operation.

The pump has a body, which comprises a condensation element with a chamber for a cooling agent, a collector of condensate into which an adsorption cartridge is set. A condensation element has a valve installed in its chamber to have a possibility for pouring the cooling agent from the condensing element into the collector of liquid condensate with the adsorption cartridge. It leads to the full cooling of the adsorption cartridge and, as a consequence to increasing the efficiency of rest gases adsorption, that allows to obtain a limiting vacuum of 10-6 mm Hg without increasing the adsorbent mass. The valve stem being beyond the body borders makes it possible to control effectively the work operation.

It should be noted, that the vacuum of this order could be obtained with using two independent pumps - condensation one and adsorption one, which are cooled by liquid cooling agent. But the coolant consumption would be much greater. Note also, that the installation having two independent pumps will be very complicated.

The pump offered (fig.2) comprises body 1 containing in it cooled condensation element 2 with a chamber for a coolant. In the bottom part of the pump under the condensation element there is condensate collector 3 where adsorption cartridge 4 is set. The valve mounted in the chamber of the condensation element is made in the form of locking cone 5 with guide pin 6 the regulation of which is made from the outside of body 1.The pump is connected to the volume to be pumped out via vacuum conductor 9.

The course of pump operation is the following. Firstly, valves 7 and 8 are closed, adsorption pump 4 is preliminary regenerated. Condensation element 2 is cooled with nitrogen by simultaneous pumping its vapors with the help of a mechanical pump. The ambient air being in the internal volume of the chamber of body 1 and condensate collector 3 is condensing on element 5. The obtained liquid condensate falls into the collectors.

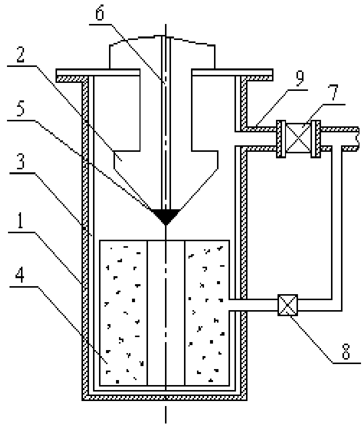

Fig.2

Then valve 7 is opened and the gas from the volume being pumped out passing through vacuum conductor 9 is condensing on element 2. The obtained liquid condensate also trickles down into collector 3. When the pressure in the pumped volume is decreased to the triple point pressure, the condensate flowing down from condensation element 2 stopped. After that valve 7 is closed and valve 5 installed in the chamber of the condensation element is opened. The cooling agent falls into condensate collector 3 providing the fool cooling of the adsorption cartridge 4. As soon as, the raising of the pressure in the volume of body 1 terminates, valve 5 is closed and pumping of vapors releasing from condensation element 2 is continuing. After that valve 7 is opened. Simultaneously the pressure in the volume being pumped out decreases and the temperature of the adsorption cartridge is lowering. The presence of the condensate-coolant mixture allows one to cool the adsorbent in the adsorption cartridge without disconnection of the condensate collector from the body chamber. Besides, the circulation of the condensate between the collector and condensation element is reduced to minimum. If one uses, as a condensate, liquid nitrogen the temperature of which is decreased by means of a mechanical pump, then the rate of vapors pumped out from the pump's chamber can be significantly decreased. After reaching the pressure of 10^{-2} mm Hg in the volume being pumped out valve 7 is closed and valve 8 is opened. The starting of the adsorption cartridge cooled with the liquid condensate and the coolant allows one to decrease the pressure in the volume being pumped up to 10^{-6} mm Hg.

3. CONCLUSION

As a the result of the work done the high-vacuum cryogenic adsorption pump operating on one cooling agent with the effective use of released vapors was constructed.

The characteristic mass-spectra of non-warmed vacuum system for different pressures are obtained.

The design of the high-effective pump operating in the wide pressure range is offered.

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КРИОГЕННЫЕ АДСОРБЦИОННЫЕ НАСОСЫ ДЛЯ УСКОРИТЕЛЕЙ РЭП

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Известно, что в ускорителях РЭП основными остаточными газами являются компоненты воздуха. При облучении исследуемых мишеней из различных материалов наблюдается значительное повышение уровня таких газов, как углеводороды, водяные пары и водород. Поэтому очевидно, что для улучшения вакуумных условий ускорителя РЭП необходимо применение насосов, которые бы позволяли реализовывать большую быстроту откачки основных остаточных газов, так и тех из них, уровень которых существенно возрастает при облучении мишеней. Нами предлагается дополнить наличные средства откачки ускорителей РЭП криогенными адсорбционными насосами, при этом размещать их в ускорителях так, чтобы они стали дополнительным средством защиты объема камеры мишени от поступления углеводородов со стороны наличных средств откачки. Это позволит значительно улучшить начальные вакуумные условия в рабочем объеме, а с другой стороны, сократить время между экспериментальными импульсами.

КРІОГЕННІ АДСОРБЦІЙНІ НАСОСИ ДЛЯ ПРИСКОРЮВАЧІВ РЕП

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Відомо, що в прискорювачах РЕП основними залишковими газами є гази повітря. При опромінюванні досліджуємих мішеней із різноманітних матеріалів спостерігається значне підвищення рівню таких газів, як вуглеводні, водяні пари і водень. Тому для поліпшення вакуумних умов прискорювачів РЕП необхідно використання насосів, які би мали велику швидкість відкачки основних залишкових газів, і тих із них, рівень яких суттєво зростає при опромінюванні мішеней. Нами пропонується доповнити існуючи засоби відкачки прискорювачів РЕП кріогенними адсорбційними насосами, які розташовуються в прискорювачах таким чином, щоби вони стали допоміжним засобом захисту об'єму від поступаючих вуглеводню та інших газів з мішені. Це дозволить значно поліпшити початкові вакуумні умови і привести до суттєвого скорочення часу між імпульсами.