RESEARCH OF PUMPING PROPERTIES OF ION PUMPS AND MANOMETRICAL CONVERTERS

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Dependences of speed of pumping of diod and triod ion pumps (SIP) in various modes of their work are investigated: periodic, continuous, with warming up and without it, at cooling of triod pump (TRION) with liquid nitrogen. Requirements to SIP for storage ring (N-100M) were determined.

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1. INTRODUCTION

In a vacuum chamber of N-100M, wich is closed high vacuum volume, for maintenance of dynamic pressure ~ 10^{-9} *Torr* will be used SIP and pumps on the basis of sprayed evaporable getter pump (EGP) and non-evaporated getters (NEG) [1]. One of the important parameters of any pump is its pumping speed $S_{eff} = Q/P$, where Q is a gassing stream due to thermodesorbtion, leaks and synchrotron radiations (SR).

When SIP is new or is regenerated with (warming up), a superficial layer of the cathode pure and gas reemission is small. In these conditions the pump is not saturated and value of S_{eff} due to all mechanisms of pumpings maximal. As number of molecules implanted into the cathode is increased reemission due to ionic bombardment is increased too. As consequence S_{eff} is decreased until balance between ionic implantation and gas desorbtion will set in. It results in "saturation" of the pump and S_{eff} will be determined by activity getter of the sprayed film from the cathode and is equal to half of pumping speed of a "nonsaturated" pump. Thus, the effect of saturation depends on quantity of molecules of gas implanted into a cathode, i.e. time of saturation will depend on pressure. The pressure is lower there is more time before saturation of the pump. It is shown in table [2].

Dependence of time of saturation $t_н$ SIP from pressure P

P, Torr	$5{\times}10^{-11}$	10^{-10}	$5{\times}10^{-10}$	10^{-9}	$5{\times}10^{-9}$	10^{-8}	10^{-7}	10^{-6}	10^{-5}	10^{-4}
$t_н$	650 days	320 days	70 days	35 days	7.3 day	3.7 day	0.4 day	7.7 min	6.2 min	0.75 min

It is seen from the table, that in an optimum mode a SIP is in operation for a long time (years) under conditions $P < 10^{-10}$ *Torr*, and it is necessary to start an operation at low pressure, in particular, provided with a turbo molecular pump (TMP) (~ 10^{-8} *Torr*).

2. EXPERIMENTAL RESEARCHES

On experimental bench [3] we investigated dependences of S_{eff} of a diod (SIP-0.25) and a triod (TRION -150) SIP, which were in long operation, at various modes of their work periodic, continuous, with warming up and without it, at cooling of TRION by water and liquid nitrogen, etc. Volume of experimental vacuum bench is $V = 73$ *l*, specific gassing evolution $q \approx 1.5\cdot10^{-12}$ $Torr{\cdot}l{\cdot}cm^{-2}{\cdot}s^{-1}$.

Fig. 1 shows pumping characteristics of a diod pump SIP-0.25 which incorporated to the measuring chamber through an equivalent aperture with conductivity $U = 60$ *l/s*. At periodic pumping (curve 1) S_{eff} grows from one experimental session, and after eighty hours of continuous pumping $S_{eff} = 20$ *l/s* at $P_{max} = 1\cdot10^{-9}$ *Torr*. From dependence $S_{eff} = f(P)$ at flooding of nitrogen as probe gas («the direct motion») (curve 2) one can see, that $S_{eff} = 42$ *l/s* at $P = 1\cdot10^{-8}$ *Torr*, and at reduction of a stream of gas ("reverse motion") $S_{eff} = f(p)$ (curve 3) does not coincide with variation of curve 2. Apparently, reduction of pumping speed of the pump is caused by its stay at pressume $P > 10^{-6}$ *Torr* for long time. Further at a continuose pumping S_{eff} is improved and achieves the initial value ~20 *l/s*. Curve 4 shows calculated value

$$S_{SIP} = (S_{eff} \cdot U)/(U - S_{eff}) = 150\ l/s$$

at pressure $P = 2\cdot10^{-8}$ *Torr*.

Similar researches of pumping properties of a TRION pump are shown on Fig. 2.

In a mode without liquid nitrogen $S_{eff} \approx 10$ *l/s* at $P_{max} \approx 3.8\cdot10^{-9}$ *Torr* (curve 1) the maximal speed of pumping (curves 2, 3) is achieved at $P \approx 2.5\cdot10^{-8}$ *Torr* and is equal to 50 *l/s*. In a mode with liquid nitrogen $S_{eff} \approx 50$ *l/s* at $P_{fin} \approx 8\cdot10^{-10}$ *Torr* (curve 4). At flooding gas $S_{max} \approx 280$ *l/s* at $P \approx 2\cdot10^{-8}$ *Torr*. At reduction of gas stream (reverse motion) essential reduction of pumping speed (hysteresis), curve 6 is observed. There, where at direct stream $S_{max} \approx 280$ *l/s* (at $P \approx 2\cdot10^{-8}$ *Torr*), $S_{eff} \approx 19$ *l/s*. Such reduction of pumping speed can be conditioned of work abnormalities of an ideal condensation pump. After the termination flooping in

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time, equal ~ to 1 hour, pumping speed is restored (curve 7).

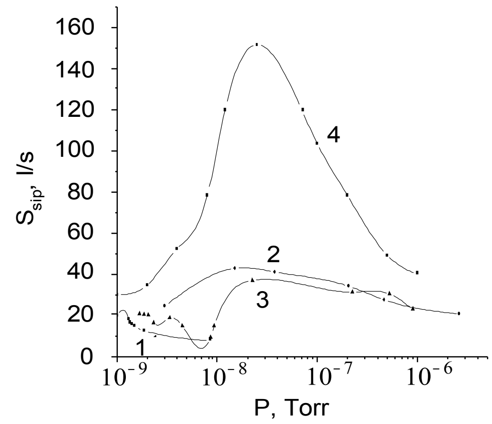

Fig. 1. *Pumpings characteristics of a diod pump*

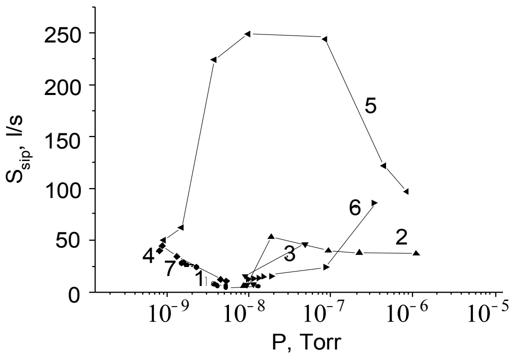

Fig. 2. *Pumping properties of a TRION pump*

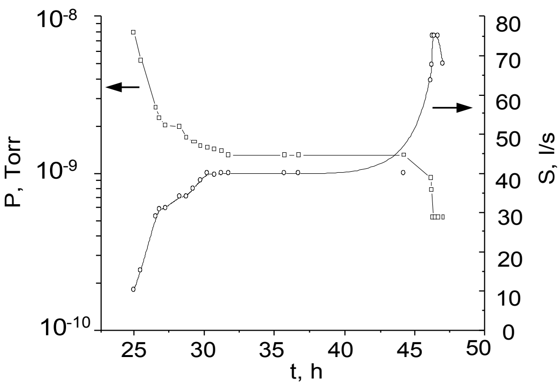

Fig. 3. *Pumping speed and pressure as vs. time*

A few continuous sessions of pumping with warming of practically all units and elements of the bench up to 200ºC have been carried out. Results of 52-hour session are shown on Fig. 3.

Preliminary pumping was carried out by TMP with liquid nitrogen (1,5 hours) up to pressure ~$7\cdot10^{-8}$ *Torr* at which warming up switched on for ~ 17 hours. After the warming end at $P\approx10^{-7}$ *Torr*, SIP-0.25 and TRION-150. Further, about 22 hours it continuous pumping by both pumps was conducted (TMP at this time has been switched off). During this time (see Fig. 3) S_{eff} was increasing with 7 *l/s* (at $P\approx7.9\cdot10^{-9}$ *Torr*) up to 29 *l/s* (at $P\approx1.3\cdot10^{-9}$ *Torr*).

This stationary condition was holding for about 16 hours then in TRION-150 nitrogen was filled. During 0.5 hour pressure has improved up to $P\approx5\cdot10^{-10}$ *Torr*, and pumping speed increased up to 74 *l/s* at this pressure.

Two day after that session (with warming) the system was not pumped out and was kept under residual gas pressure $10^{-4}\ldots10^{-6}$ *Torr*. After that the system was pumped out by the both pumps every during 8 hours session. If turned out, that keeping of the system at pressure $10^{-4}\ldots10^{-6}$ *Torr* resulted in practically full degradation of pumping speed. In 16 hours of parking the system was again pump out during 26 hours. Filling of liquid nitrogen resulted in increase of pumping speed up to ~ 45 *l/s* at $P_{fin}\approx3.8\cdot10^{-10}$ *Torr*.

Considering dates in Fig. 3 it is possible to make the following conclusions: warming up of the pumps and units of the installation results in increase of pumping speed (especially in a continuous mode) as without liquid nitrogen in TRION (from 14 *l/s* up to 29 *l/s*), and with liquid nitrogen (from 45 *l/s* up to 74*l/s*) at pressure in ranges 10^{-9} *Torr* without nitrogen and 10^{-10} *Torr* with nitrogen.

For various operating modes SIP the spectral structure of residual gas was investigated. As vacuum volumes of the bench were in operation for long time and the basic means of "cleaning" of vacuum surfaces were hydrocarbons (gasoline, acetone, spirit, etc.) that, except for active gases, rather big percentage (on occasion up to 50 %) is made with hydrocarbons (up to weights ~ 100). Their amount decreases at presence of liquid nitrogen in TRION up to ~ 15 %).

At small gasing maintaining in vacuum system of pressure over the range $10^{-5}\ldots10^{-6}$ *Torr* (for start SIP without use TMP when liquid nitrogen is necessary) is possible to use pumping properties ion pump a pressure unit (IMG-46 or IMG-32). From a balance equation:

$$Q = PS = -\frac{d}{dt}(PV) \qquad (1)$$

at V = Const it is possible to receive

$$P = P_i e^{-\frac{St}{V}} \qquad (2)$$

or

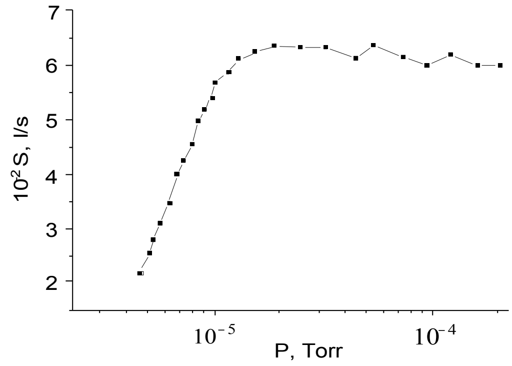

Fig. 4. *Association* $S_{IMG-46} = f(P)$ *vs pressure P*

$$S = \frac{V \ln(P_i / P)}{t}, \qquad (3)$$

where V is volume of vacuum system; P_i is initial pressure; P is the current pressure; S is rate of pumping; t is the current time (in seconds).

On Fig. 4 association $S_{IMG-46} = f(P)$ received according Eq. (3) is given. It can be seen that $S_{max} \approx 6.4 \cdot 10^{-2}$ *l/s* is conserved over the range pressures $10^{-5}…10^{-6}$ *Torr*. At these measuring specific gas-making q was equal to$1.5 \cdot 10^{-12}$ *Torr·l·cm*$^{-2}$·*s*$^{-1}$, and a stream Q=$2.7 \cdot 10^{-8}$ *Torr·l·s*$^{-1}$. These sizes have been measured in vacuum volume of the stand by standard methods. At the long-lived pump-down by valve IMG-46 pressure $P \approx 9 \cdot 10^{-7}$ *Torr* that meets to rate of pumping at this pressure $S_{lim} \approx Q/P_{lim} \approx 3 \cdot 10^{-2}$ *l/s* received. At collateral pump-down by valves IMG-46 (in the big camera) IMG-32 (in the small camera) [3] at pressure $1.5 \cdot 10^{-5}$ *Torr* integral rate of pumping S_{Σ} = $10.4 \cdot 10^{-2}$ *l/s*, i.e. of a pumping speed IMG-32 $S_{IMG-32} \approx 4 \cdot 10^{-2}$ *l/s* is received.

3. CONCLUSIONS

The experimental investigation of pumping properties of ion pumps allows make a number of conclusions:

– to use new or not earlier in long operation SIP as well diod, as triod types in a continuous operating mode and an opportunity of warming of both pumps, and units and elements of vacuum volume;

– at physical and chemical methods of processing (cleaning) of vacuum surfaces to reduce to a minimum use of hydrocarbonic solvents.

– for start of SIP to use a station of preliminary pumping on basis of TMP with liquid nitrogen, i.e. at $P < 10^{-7}$ *Torr*. For well degassed chambers ($q < 2 \cdot 10^{-12}$ *Torr·l/cm*$^{-2}$·*s*$^{-1}$) at preliminary pumping from $P \approx 10^{-3}…10^{-4}$ *Torr* up to pressure 10^{-6} *Torr* it is possible to use ion pump gauges of pressure IMG-46. The measured pumping speed in a range of pressure $10^{-4}…10^{-5}$ *Torr* was equal to 0.06 *l/s* and our volume (~ 73 *l*) was pumped out from pressure 10^{-4} *Torr* up to pressure $9 \cdot 10^{-7}$ *Torr* for 5 hours.

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ИССЛЕДОВАНИЕ ОТКАЧНЫХ СВОЙСТВ МАГНИТОРАЗРЯДНЫХ НАСОСОВ И МАНОМЕТРИЧЕСКИХ ПРЕОБРАЗОВАТЕЛЕЙ

В.Г. Гревцев, Н.И. Мочешников, В.П. Козин

Исследованы зависимости скорости откачки диодного и триодного магниторазрядных насосов (МРН) в различных режимах их работы: периодическом, непрерывном, с прогревом и без него, при охлаждении триодного насоса (ТРИОН) жидким азотом. Выработаны требования к МРН для накопителя Н-100М.

ДОСЛІДЖЕННЯ ВІДКАЧНИХ ВЛАСТИВОСТЕЙ МАГНІТОРОЗРЯДНИХ НАСОСІВ ТА МАНОМЕТРИЧНИХ ПЕРЕТВОРЮВАЧІВ

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Досліджено залежності швидкості відкачування діодного та тріодного магніторазрядних насосів (МРН) в різних режимах їх роботи: періодичному, безперервному, з прогрівом та без нього, при охолодженні тріодного насоса (ТРІОН) скрапленим азотом. Вироблено вимоги до МРН для накопичувача Н-100М.