Outgassing Rate of Magnetic Stainless Steel

Teruhiko BIZEN, Mituhiro MASAKI, Hiroshi SAEKI and Haruo OHKUMA

SPring-8, Kamigori, Ako-gun, Hyogo 678-12, Japan

1. Introduction

Magnetic stainless steel is one of the proper materials for the vacuum chamber of the injection section of the SPring-8 Storage Ring [1], so the simple measurements of the outgassing rate were carried out.

2. Experimental

The magnetic stainless steel has good magnetic characteristics, such as higher magnetic saturation field, higher permeability and lower coercive force. Table 1. shows the components of the magnetic stainless steel and SUS304 stainless steel as comparison.

The schematic diagram of experimental apparatus is shown in Fig.1. The magnetic stainless steel test chamber is the cylindrical tube of 1000 mm × ϕ 48 mm which applied hole machining, welding in the middle, and electrical polishing. The chamber was evacuated and baked out about 9 hours at 150℃ then cooled down to the room temperature to check the leakage, and again baked out 30 hours at 250℃ and cooled down. Then the gate valve of the vacuum pump was closed to make a build up test.

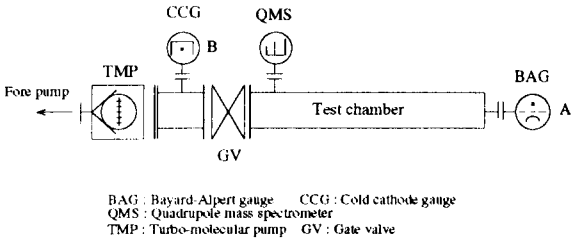

Fig. 1 Schematic diagram of experimental apparatus

3. Results and Discussion

The final pressure before closing the gate valve was 1.33E-7 Pa at gauge A and 1.02E-7 Pa at gauge B, and the pressure increase of the test chamber after closing the gate valve is shown in Fig.2.

3-1 Outgassing rate

The outgassing rate was estimated by different simple methods.

(1) Two points pressure method

The outgassing rate was calcurated 4.8E-9 Pa m^3/ m^2 s from the pressure difference between gauge A and gauge B by following formulas. The fundamental expression [3] for the pressure distribution is given by

$$Cu\frac{d^2P}{dX^2} + qu - SuP = 0$$

where Cu is the conductance per unit length, qu the outgassing rate per unit length, Su (= 0) the distributed pumping speed per unit length, and the solution is given by

$$Q = 2C(P1 - P2)$$

where Q is total outgassing rate, C is the conductance of the chamber, and $P1$-$P2$ is the pressure difference between both ends of the chamber. The result was not seriously over the outgassing rate of stainless steel such as SUS304 which is estimated 1.1E-9~4.2E-9 Pa m^3 / m^2 s by through put method[2].

(2) Build up method

The outgassing rate was calcurated 2.5E-10 Pa m^3/ m^2 s by following formulas. Assuming that the outgassing rate is equal at the moment before and after the valve closing, the outgassing rate is given by

$$Q = V\frac{dP}{dt}$$

where V is the volume of the chamber, $\frac{dP}{dt}$ is the differential of the pressure increase at the moment of the valve closing. It is said that the result of this method is very little compared to the through put method [4]. The result of this time has a same tendency compared to the two point method.

3-2 Gas spectra

The gas spectra of H_2, H_2O, CO, and CO_2 were observed in the residual gas of the test chamber before the valve was closed. Same gas spectra was also observed about 5 hours after the pressure increase was nearly saturated, but any other gas spectra appeared and the relative intensity of the peaks were almost same as before. These molecules are ordinal for other vacuum materials.

Table 1. Components of the materials

	C	Si	Mn	P	S	Cr	Al	Pb	Ni	Fe
Magnetic stainless steel	0.005	0.81	0.24	0.018	0.016	12.71	0.28	0.17	-	remaining
SUS304	<0.08	<1.0	<2.0	<0.04	<0.03	18~20	-	-	8~11	remaining

4. Conclusions

The accurate measurement of the outgassing rate needs to apply the through put method and to use the calibrated vacuum gauge, but this time simple measurements were made because the purpose is to check whether the magnetic stainless steel has serious problems for the vacuum of the Storage Ring. Based on these estimations, we conclude that the magnetic stainless steel has no problems for the vacuum compared to other stainless steel.

References

[1]K. Kumagai and S. Matsui, IEEE TRANSACTIONS ON MAGNETICS, **30**, 2134 (1994).

[2]H.A. Sakaue et al, KEK Proceedings 94-3 p.217, May (1994).

[3] T. Ikeguchi, M. matumoto and, S.Ueda : KEK Rep., 87-8 Aug. (1987).

[4] N. Yoshimura : J.Vac.Sci.Japan, **33**, 475 (1990).

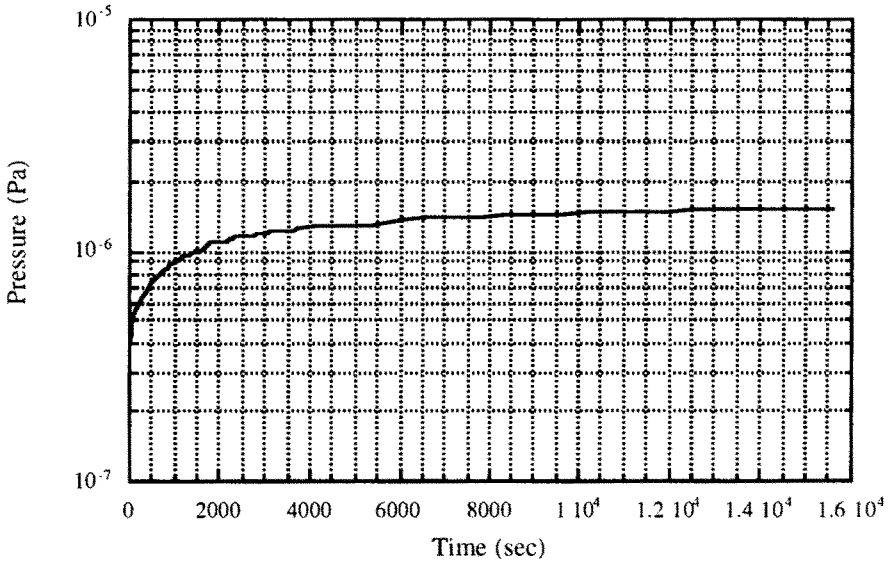

Fig. 2. Pressure increase from the valve closing