

THEORETICAL EVALUATION OF THE PUMPING PERFORMANCE OF THE CRYO-PANELS FOR THE K500 SUPERCONDUCTING CYCLOTRON

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Abstract

Three liquid helium cooled cryo-panels are designed for UHV in acceleration chamber for the Super-Conducting Cyclotron. The vacuum system of K500 Super-Conducting cyclotron, which is under commissioning consists of three turbo pumping modules and three cryo-panels. The turbo pumps are able to achieve less than 1×10^{-6} mbar pressure. For attaining still lower pressure three liquid helium cooled cryo-panels are designed for UHV in acceleration chamber for the Super-Conducting Cyclotron. The goal of this paper is to theoretically evaluate the molecular conductance of the chevron type baffles and the pumping speed of the cryo-panel. Analogy between heat transfer and molecular flow is used for obtaining the molecular conductance of the chevron baffle.

INTRODUCTION

Three cryo-panels are installed within the median plane valley of the beam chamber. The shape of the cryo-panel is determined by the shape of the cavity with small clearance. The pressure expected to be achieved by the use of cryo-panel is $<1.0 \times 10^{-7}$ mbar. Liquid Nitrogen and liquid Helium are used to attain low panel temperatures. The pumping mechanism of various gas species are mainly cryo-condensation and cryo-adsorption. The liquid Nitrogen Cooled panels pump moisture and higher molecular weight gas species. The liquid Helium cooled panels pump mainly Nitrogen, oxygen and argon. The bottom surfaces of the liquid cooled panels are bonded with activated charcoal for pumping lightest gases, hydrogen, helium, and neon mainly by cryo-adsorption. The liquid Helium cooled panel is protected by direct heat source from room temperature surfaces by the use of optically opaque chevron baffles cooled by liquid nitrogen.

THEORITICAL BASIS

Cryo-pumping occurs when gas molecules striking a surface lose enough of its kinetic energy to remain adsorbed on the surface by the van der waal forces. The cryopump design equation (1) shows that the pumping speed is dependent on the temperature T , pump cross section area A , the properties of the gas being pumped,

and the sticking coefficient c of the gas to the pump surface.

$$S = c \cdot A \cdot \sqrt{\frac{R_0 T}{2\pi M}} \quad (1)$$

The sticking coefficient for H_2O , and N_2 is almost unity for and relatively smaller for H_2 and He. The table below shows the sticking coefficient of a commercial refrigerator cryopump [1].

Table 1: Characteristic parameters for a standard refrigerator cryopump

Gas	c	Where and how pumped
H ₂ O	1.0	At the inlet baffle by condensation
N ₂	1.0	At the cryo-panel front side
H ₂	0.6	At the cryo-panel back side by cryosorption
He	0.05	At the cryo-panel back side by cryosorption

The effective pumping speed is obtained by adding the resistance to flow by the chevron baffles whose conductance is given by C. Hence

$$\frac{1}{S_{eff}} = \frac{1}{C} + \frac{1}{S} \quad (2)$$

Conductance calculation in molecular flow range relies on the fact that molecular gas flow is physically analogous to radiation heat transfer as described in reference [2] and [3]. In the analogy gas pressure P is equivalent to radiation temperature T^4 and the gas flow Φ is equivalent to radiation heat flow Q . For obtaining the conductance values of the chevron baffles, an arbitrary pumping speed of 1 l/sec is chosen and the gas load is given at the other end open to vacuum. The average pressure obtained at the inlet and outlet of the geometry is used to estimate the molecular conductance.

RESULTS

The Cryo-panel Configuration is shown in Figure 1 below and the chevron configuration is shown in Figure 2. The Conductance of the Chevron baffles configuration as obtained from the radiation heat flow analogy is summarized below.

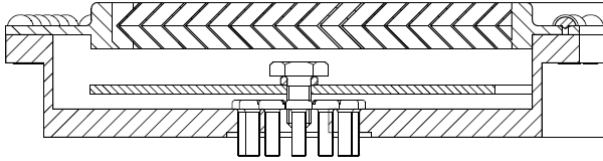


Figure 1: Cryo-panel Configuration for the SCC

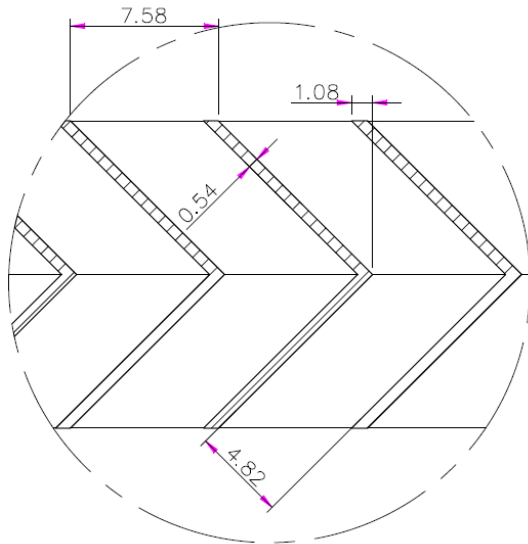


Figure 2: Chevron baffle Configuration

Table 2: Conductance of the Chevron baffles for various gases

Gas	Conductance (l/s)
N ₂	2770
H ₂	10363
He	7328

And the effective pumping speed of the cryopump as calculated is summarized below:

Table 3: Effective pumping speed of the cryo-panel

Gas	Pumping Speed (l/s)
H ₂ O	11875
N ₂	2685
H ₂	9845
He	4499

FUTURE WORKS

This work estimates the pumping speed of the cryo-panels theoretically. The results are needed to be experimentally verified established.

REFERENCES

- [1] C. Day, "Basics and applications of cryopumps," CERN Accelerator School Proceedings on 'Vacuum in Accelerators' 2006
- [2] M. LaFontaine, "Calculation of Molecular flow Using the heat transfer Analogy," ANSYS Conf. Proc., 1998, pp. 1.371-378
- [3] M. LaFontaine, "Modelling Photo resist Outgassing Pressure Distribution Using the Finite-Element Method".