THE PERFORMANCE OF DOUBLE-GRID O-18 WATER TARGET FOR FDG PRODUCTION *

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Abstract

The main stream of our study about the target is increasing the lifetime of the target windows. Mainly we conduct our study to increase the cooling performance and secondly about the structural design of the targets and target window foils. We already had developed and had published the results of our research about O-18 double-grid water target, which had installed on our 13 MeV cyclotron KIRAMS-13. The beam size of the accelerated proton was 9 □×18 □ (0.35 in×0.7 in). The double-grid target shows relatively low pressure during irradiation and good yield of F-18. The average yield of F-18 after irradiation was more than 1 Ci at 12.5 MeV , around 26 μA. Additionally, we are conducting new research for new techniques to increase the performance of low energy double-grid target and a new state-of-the-art pleated double foil target.

INTRODUCTION

Since 1986, the Korea Institute of Radiological & Medical Sciences (KIRAMS) has operated MC-50 cyclotron for radioisotope production and neutron therapy. In 2002, KIRMAS imported another 30 MeV cyclotron for RI production and Laboratory of Accerator Development (LAD) in KIRAMS had delveloped KIRAMS-13, 13 MeV medical cyclotron, successfully by their own technology.

In 2003, KIRAMS start to supply KIRAMS-13 cyclotron to 8 regional cyclotron centers in Korea. Most of these centers are hospital so they need to produce RI products. For that reason, we start conduct researches to develope targets for RI production.

The target which we supply with cyclotron is double-grid O-18 water target for FDG production. This target desing to use for low-energy/high current cyclotrons [1].

Commonly O-18 water targets were developed for producing fluorine producing fluorine-18. These products are widely used radio-isotope in positron emission tomography.

The research about these targets were focused on the target material, shape of cavity for holding O-18 water and cooling mechanism to get higher yield of F-18 and maintain the performance without maintenances [2-5].

The typical structure of O-18 water target is double-foil target which use helium as a coolant for target window cooling [6]. Water-cooled grid support system has better structural strength and more simple than double-foil system [7].

The grid supported systems do not use any additional coolant, as helium. Only water cooling mechanisms are applied for cooling the target. And the grid which placed on the front window foil is substructure for preventing the deformation of the target window against heat and pressure. We had developed the double-grid [^{18}O]water titanium target to perform better cooling performance to get relatively higher F-18 saturation yield and strong structure.

Now these double-grid targets are using in two of eight regional cyclotron center in Korea where the KIRAMS-13 had installed and under operating.

These days, we started to conduct a new research for a new type of target which uses pleated double-foil for low or high energy and high current cyclotrons. We expect this newly designed target structure will show us a good performance in structural strength and F-18 saturation yield.

TARGET DESIGN

Double-Grid

The structures of double-grid target are shown in figurer 1.

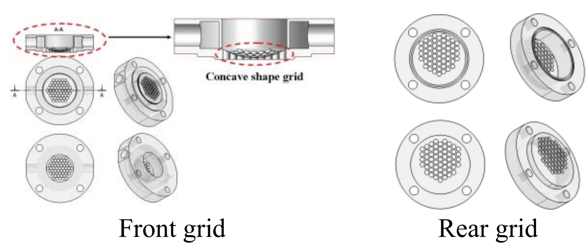

Figure 1: Grid design.

Material of gird is aluminium. Recently, we anodized the front grid in black to increase radiation heat-transfer rate in vacuum. CFD simulation was performed to result make sure that the front grid is safe under designed condition (Figure 2.).

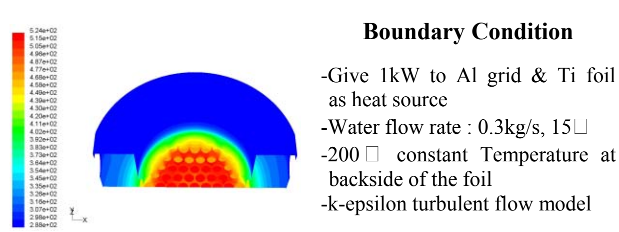

Figure 2: CFD simulation result of front grid.

Cavity

The shape of titanium cavity has two different geometries along incident direction of beam (Figure 3.). The front volume has a cylinder shape and the back cavity has a fan shape with larger volume to gather ascent vapour bubbles on the top and increase heat transfer area. Total volume of cavity is 1.6 ml.

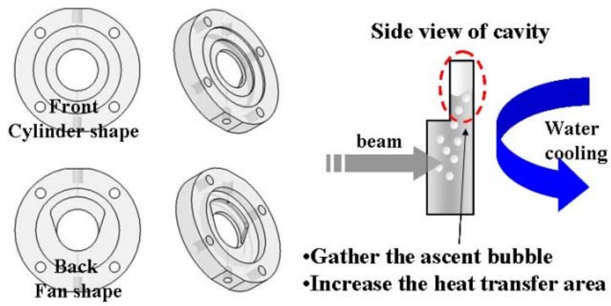

Figure 3: Cavity design.

Target assembly & cooling mechanism

Assembly of the target are represented in figure 4.

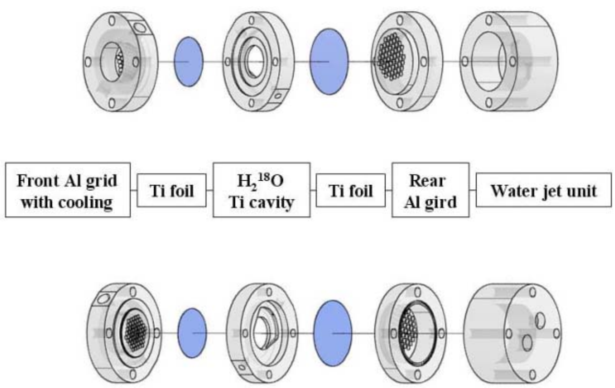

Figure 4: Target assembly.

Both open sides of cavity are blocked with 50 µm titanium foils. Two aluminium grids are placed out side of each foil. Front water cooled type gird is directly place in the vacuum beam line. Grids were adapted to cool foils and prevent their thermal expansion under high pressure.

Foils are welded on the both sides of cavity and between other pats viton O-rings were inserted.

Cooling mechanisms of target is described in figure 5.

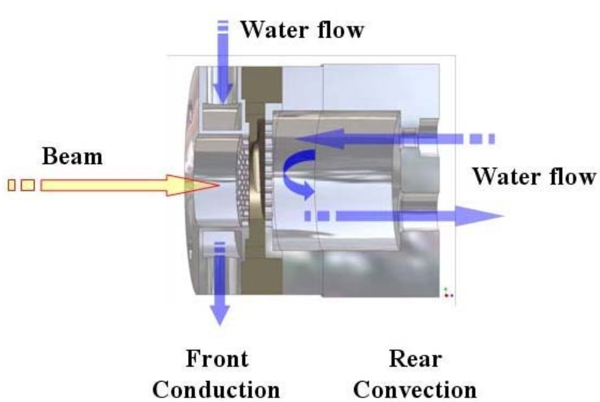

Figure 5: Cooling mechanisms.

Pleated double foil target

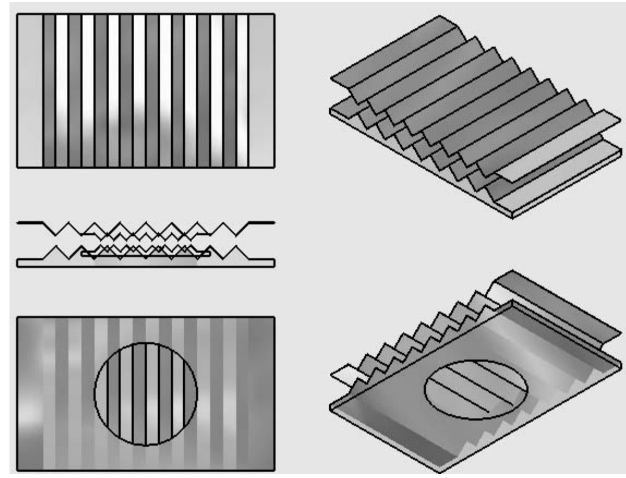

Figure 6: Pleated double foil.

Our target research step back to the double foil design but to overcome the structural defect of the thin foil, we pleated the thin window foils (Figure 6.). It is undeniable true that structural strength of the pleated foil is stronger than the flat foil. But the outer shape of target must be rectangular. It is because of the structural characteristic. It is very difficult to make a circle shape with pleated foil.

Numerical simulations (FEM, CFD) are performing to optimise the shape and the whole structure.

RESULT AND DISCUSSION

Figure 7. shows the F-18 saturation yield of the double-gird target. The open area of the front gird is about 80% and the proton beam from KIRAMS-13 was 12.5 MeV, around 26 µA. The volume of O-18 water which the cavity holds is 1.6 l. Through 50 µm titanium foil energy of 11.9 MeV reach to O-18 water.

The real average data of saturation yield about normal and focused beam to target were compared with the theoretical value including consideration of the 80% open area of the front grid.

The irradiation time was 2 hour. In case we consider the open area of 80%, average F-18 saturation yields are 57% and 76% for each normal beam and focused beam of the theoretical saturation yield.

In figure 7. the bold solid line is the theoretical F-18 saturation yield when 11.9 MeV reach the O-18 water and the dotted line is the saturation yield when the open area of 80% is considered.

Empty square is the saturation yield values when the focused proton beam was irradiated and the solid gray circle is the saturation yield values when the normal proton beam was irradiated from KIRAMS-13.

The grid, because of the limitation of the open area, makes a loss of beam current. The purpose of newly performing research about pleated double-foil target is developing a target with excellent structural strength like grid target but no current loss.

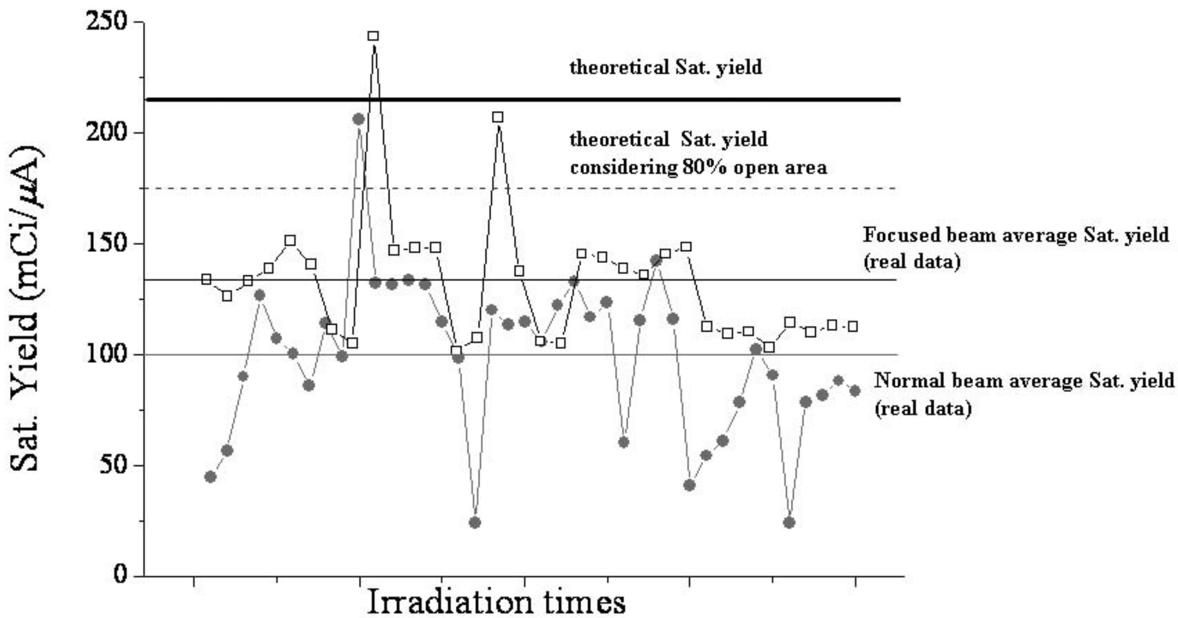

Figure 7: F-18 saturation yield of double-grid target.

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