High Yield F-18 Target for KOTRON-13 Cyclotron

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1. Introduction

Currently the domestic radiation market for medical diagnosis witnesses a high increase of the use of PET/CT for the purpose of cancer diagnosis, and the cases of cancer diagnosis using PET/CT increase by geometric progression every year. In case of domestic practice, full body scan is taken by using FDG medical isotope medicines mainly using F-18, but the necessity of various medical radioactive isotopes according to each medical purpose is increasing.

F-18 output yield is directly proportional to energy of protons and beam current, and has correlation with heat production rate in case of target and decides the function of target in accordance with the efficiency of a cooling device. [1]

At present, in case of most F-18 target, when one irradiates beam in O-18 water of about 0.2~5mL, one has to apply heat of over 300W, a high thermal energy per unit area is irradiated in target, which is easily damaged, and it has limitation in beam current. Currently, in case of commercial target, about 2,000W beam current is the maximum value, and in case of double-grid target developed by Korea Institute of Radiological and Medical Sciences in 2004, it was designed to stand up to about 1,000W theoretically, but in reality it can irradiate lower beam current than this because of the shortage of cooling efficiency. [2]

In general, the irradiation strength to produce radioactive isotopes given in the heat emission by target substance currently is limited to 50μA against target substance irradiated in 1.6mL. However, current KOTRON-13 cyclotron can accelerate proton beam with a high scope of strength marking 100μA thru 120μA by a continuous development. Therefore, it doesn't fully function compared with that of proton beam of KOTRON-13 cyclotron.[2], [4]

The solution about this is to get over the problem of cooling target substance of cavity in the production system of radioactive isotopes. Especially, one has to develop the method to cool target substance, and provide higher F-18 yield than existing target. Fig.1 shows the existing target.

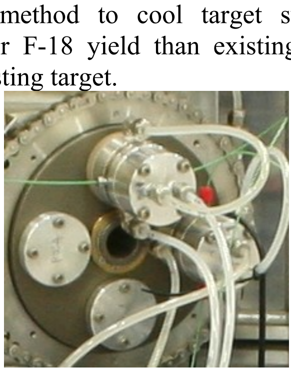

Fig.1. Existing F-18 target built in KOTRON-13

2. Methods and Results

High yield F-18 target of KOTRON-13 is composed of three parts such as grid part supporting the increasing pressure of O-18 cavity and playing the role to cool O-18 cavity foil in irradiating proton beam, O-18 cavity part storing O-18 water and water cavity to render O-18 water to be cooled.

2.1 Design of Grid of High Yield F-18 Target

First, the part which proton beam contacts first after irradiation is grid part, which is composed of holes of 2.2Φ inner diameter, the number of holes is 61 in an array of honeycomb shape. The interval between hole and hole is designed as 0.1mm, and the thickness of grid is designed as 8mm. The material of grid is of aluminum, and the outer diameter is designed as 70Φ. The beam irradiation efficiency of grid designed like this marks about 82%. And it was designed for peripheral part of grid to be cooled by cooling water to cool grid and O-18 cavity foil contacting grid heated by irradiated beam. Fig.2 shows grid of high yield F-18 target.

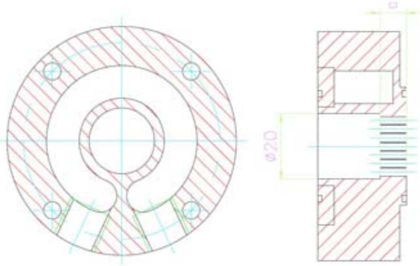

Fig.2. Grid of high yield O-18 target

2.2 O-18 Cavity of High Yield F-18 target

In front of O-18 cavity part 50μm Ti(titanium) foil is positioned, and the part confining O-18 water is designed with 16Φ area and 10mm deep. The inner capacity is 2mL. And the energy of irradiated beam can react O-18 and remain, so considering beam cut against 13MeV, the thickness of the back part has to be 1.0mm purely. [3]

If the cavity part is filled with O-18 water, beam energy reacts O-18, remaining beam energy disappears in the partition of the back phase of O-18 cavity, but if one irradiates beam energy in the state with O-18 water unfilled, air is filled, then beam energy passes through the partition of the back phase and radiates cooling water to cool the back phase of O-18 cavity. In order to prevent this, one designed the thickness of the partition of the back phase of O-18 cavity with no less than

0.8mm.

And, existing F-18 targets failed to cool the peripheral part of O-18 cavity and brought about the loss of F-18 target owing to the falling of F-18 yield and the rise of pressure arising from the rise of accumulated heat by beam irradiation. So one designed high yield F-18 target to cool the peripheral part O-18 cavity to improve heat efficiency. The material of used O-18 cavity is titanium, with 70Φ of outer diameter designed. Fig.3 shows O-18 cavity of high yield F-18 target. [4], [5]

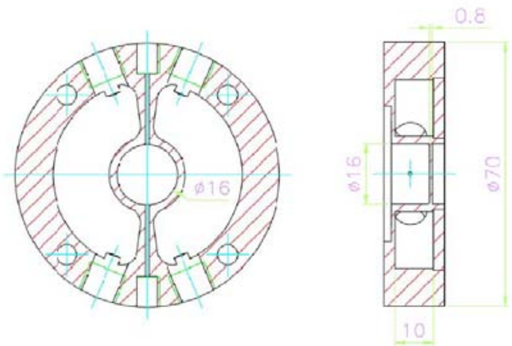

Fig.3. O-18 cavity of high yield F-18 target

2.3 Water Cavity

Water cavity is to remove heat in O-18 cavity, by cooling with circulating water, and it was designed that the flow of cooling water enters straight into the right center of the back phase, to cool the center part generating the most of heat and goes out through the upper part of the cavity. The material of used water cavity is aluminum, with 70Φ of outer diameter designed. Fig. 4 shows water cavity of high yield F-18 target.

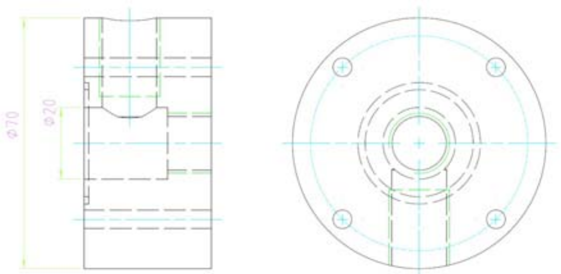

Fig.4. Water cavity of high yield F-18 target

In this experiment using KOTRON-13 cyclotron, beam current of average 30μA was irradiated for 110 minutes considering that half-life of F-18 is 109.8 minutes. The results of experiment with 20 times beam irradiations are shown in Fig.5. Two curves represent the yields of existing target and those of high yield target respectively. [2], [4]

While existing F-18 target produced average 1,574mCi, high yield F-18 target produced average 2,866mCi and witnessed the results of more excellent performance in the production than existing F-18 target on the same conditions. Fig. 6 shows the assembly of high yield F-18 target.

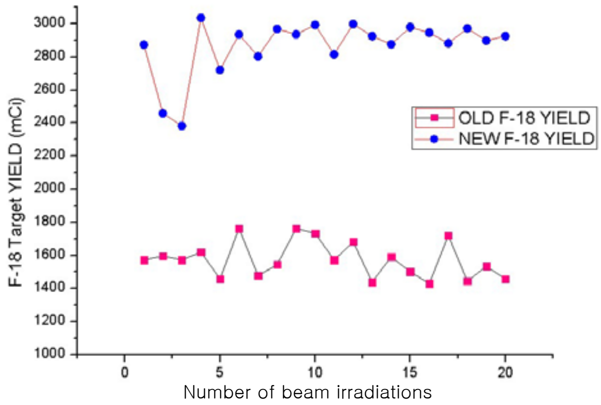

Fig.5. Comparison of yield between existing F-18 target and high yield F-18 target in KOTRON-13

Fig.6. High yield F-18 target

3. Conclusions

High yield F-18 target is efficiently designed in accord with the proton beam size in KOTRON-13. Cooling efficiency is improved greatly over existing F-18 target and the volume of production of F-18 is also improved by double compared with existing target. At present, High Yield Target can produce F-18 by average 5,731mCi.

ACKNOWLEDGMENTS

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