Heating of Accelerator Targets Behaviours

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1 Introduction

For the efficient use of ion beams, the heating of accelerator targets is one of the important problems to be overcome. Especially in cases that the higher beam currents yield the better results, it is necessary to know the thermal behaviours of the targets under irradiation and to perform the optimal design of the target cooling systems.

This study was started to obtain comprehensive knowledges about the thermal behaviours and characteristics of the targets under irradiation with high energy and high current ion beams and to prepare informations for the optimal design of a target system and for the optimal operation of an accelerator.

The preliminary results of the experiments would be described here and analytical works should be referred to the articles reported elsewhere.

2 Experiments

The simple one dimensional experiments were performed. Fig. 1 shows the aluminum cylindrical target mounted on the copper block which is cooled by water so much as to behave as a large heat sink. For measuring temperatures of the target cylinder, seventeen thermocouples (TC, 0.1 mm, Copper-Constantan) were set on the surface. The measuring positions are illutrated in the figure and all TCs were spot-welded on the target itself. The 10 mm slit was set in front of the target to achieve a uniform irradiation of the ion beam onto the top surface of the target. The allignment for slit-target combination on the beam line was carefully carried out to prevent the beam hitting the TCs directly. The species of ion beam was selected as proton and energy was fixed at 30 MeV, which provides approximately 10 mm thickness of the region with heat generation. Irradiations were performed with several different beam currents from 1 μA to 50 μA.

The multipen recorder was used to record the temperature signals. Since the recorder has 6 pens and one of them was used to record the beam current, five temperature signals could be recorded simultaneously. Among 17 TCs, appropariate 5 signals were selected to be recorded and the combinstions were changed from run to tun. The transient behaviours of the temperature were recorded from the onset of the irradiation untill the full saturation was observed. The signals recorded were traced and sampled out, and digitzed data were put into the file of the ACOS-77-900 computer at the Tohoku University Computer Center. Those data were converted to the temperature from mV values as outputs from thermocouples. Two kinds of curves were reconstructed for each run, which are the time trace of temperature at the measuring positions and the time variations of the temperature distribution in a target. The typical examples of the results are shown in Fig. 2 and 3.

For the analysis of these experimental results, the computer codes were made based on the one and two dimensional heat conduction theories. The details of these codes were reported elsewhere[1,2].

3 Results and Cinclusions

Those temperature variations show fairly good agreement with calculations for lower beam currents. However, for the higher beam currents, capacity of heat sink becomes less sufficient so that there arose a large difference on the boundary condition at the back side wall for the calculation, and as a result, the differences in absolute temperature values increased. As for the temperature distributions inside the region with heat generation, the resolution in position was not so good compared with the thickness of the region that any fine comparison and detailed discussion could not be performed.

For further study, the efforts should be made to modify boundary conditions in the computer codes and to improve the position resolution in temperature measurements.

References

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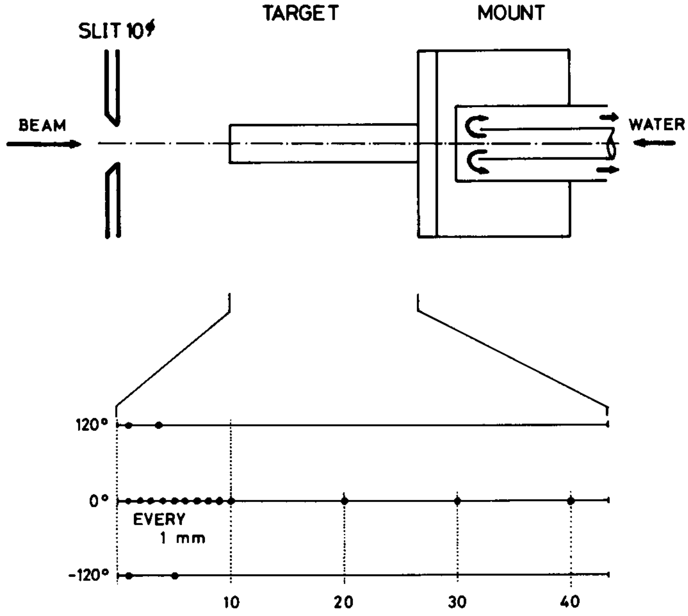

Fig. 1 Illustration of beam target allignment and the position of thermo-couples.

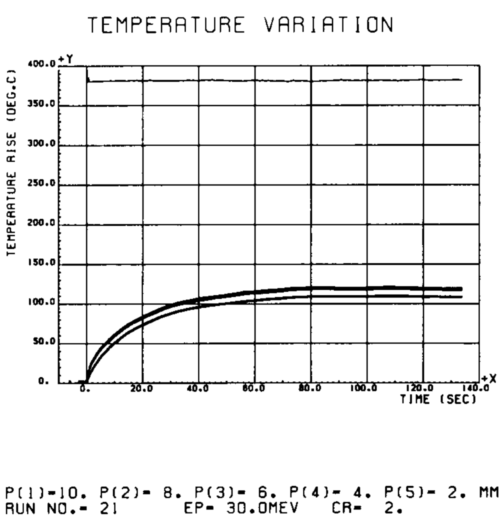

Fig. 2 Time variation of temperature. Proton beam of 30 MeV, 2 μA.

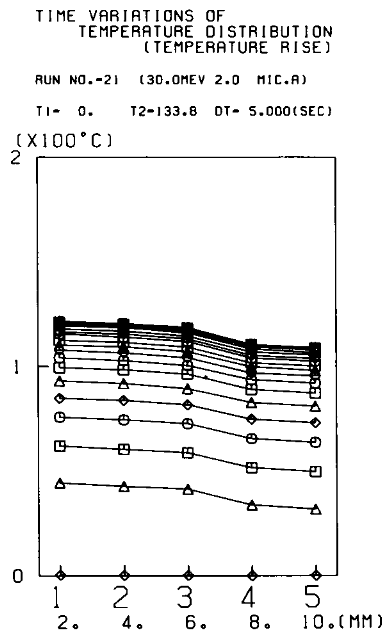

Fig. 3 Variation of temperature distributions. Modified from Fig. 2.