PROTOTYPE OF HIGH TEMPERATURE INTENSE NEUTRON TARGET*

M.S. Avilov, K.V. Gubin, P.V. Logatchev, P.V. Martyshkin, S.V. Shiyankov, BINP, Novosibirsk, Russia,
J. Esposito, L. Tecchio, LNL INFN, Legnaro, Italy

Abstract.
The design of the prototype of high temperature neutron target is proposed as well as the experimental test program. The prototype comprises the rotating disk with the graphite rim fixed. The main goal of experiments is the thermo-mechanical test of the prototype in the heating regime close to operating one. The prototype heating is carrying out by the high power electron beam.

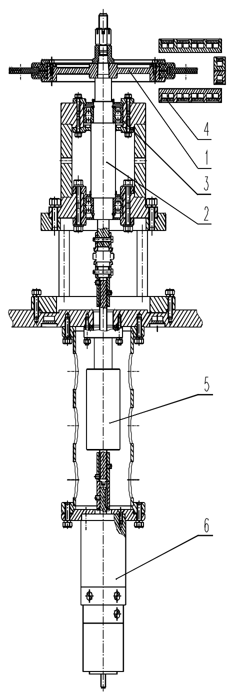

Figure 1: Sketch of prototype. 1 – rotating disk with converter; 2 – shaft; 3 – bearings; 4 – cooling panels; 5 – rotation feed-through; 6 – DC motor

1. INTRODUCTION

In the framework of SPES project [1] in INFN LNL, Legnaro, Italy, the source of radioactive ion beams is under development. One of the most important part of this facility is the intense neutron target which could produce up to 10^{13} – 10^{14} of fast neutrons per second. In BINP, Novosibirsk, Russia, the project of hot neutron target is proposed. The target should be exposed to the high power (up to 150 kW) proton beam. The problem of power dissipation could be solved, if the target converter is cooled by thermal radiation. The proposed target design comprises the converter assembled with graphite plates, which are fastened to the rotating metal disk 1 m in diameter. Preliminary calculations show the practicability of the present design, if disk rotation frequency is around 30 – 50 Hz. In this frequency range the temperature of graphite plates may reach 1700 – 1800^{0}C.

2. PROTOTYPE DESIGN

In order to specify the basic technical and technological decisions and, in particular, to carry out the thermo-mechanical test of construction, the target prototype was developed. It was designed for the power of 40 - 50 kW. Its main difference from the basic design is the smaller diameter of rotating disk as small as 30 cm. The sketch of the prototype is shown in Fig.1. The disk (1, see also Fig.2) is mounted on the shaft (2) equipped with bearings (3) and rotating feed-through (5). The shaft is driven by DC motor (6). Graphite plates of converter are fixed on the metal disk by means of the clamp (Fig.3) made of graphite. Graphite grips provide the thermal isolation between the hot converter plate and the metal disk. The converter is coated with aluminium water cooling panels (Fig.4 –5). The device is set inside the vacuum chamber (Fig.6) with water cooling and pumping outlet. The chamber has the optical view port for temperature measurements and a number of outlets for various diagnostics.

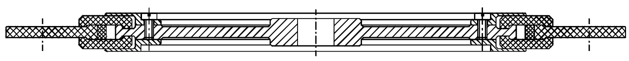

Figure 2: Profile of rotating disk with converter.

3. EXPERIMENTAL PROGRAM

Experiments with the prototype of the neutron target include the wide range of tests of all the future target systems. Main subjects for prototyping are following:

a) Hot graphite elements operation:

* work supported by ISTC (project #2257)

- Target elements operation in nominal thermo-mechanical regime;
- Target heating up and cooling down regimes;
- Adjacent target elements jointing technique;
- Axial and radial permissible mechanical loads for target elements.

Test of target elements will be held both on the static test bench and on the rotating disk prototype. Heating of elements will be carried out by the electron beam (1-1.4 MeV energy, up to 100 kW power) of ELV-6 accelerator available in BINP [3].

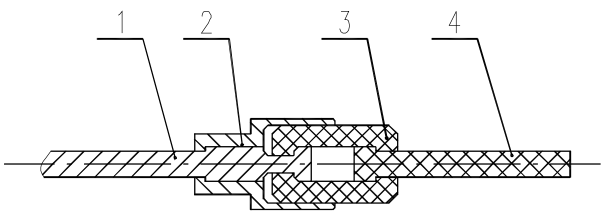

Figure 3: Clamping device. 1 – metal disk; 2 – metal clamp; 3 – graphite grips; 4 – converter element

b) Hot graphite-to-metal disk joint:
   - Minimization of thermal flux from the hot target to the metal disk;
   - Reliable hot target element mounting on the metal disk from thermal and mechanical points of view (resistance to thermocycles and vibrations)

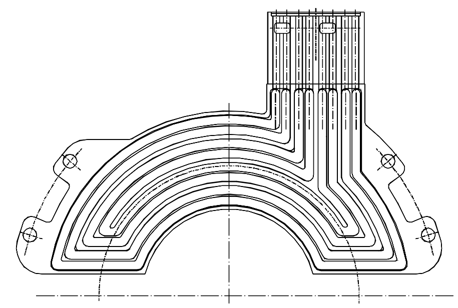

Figure 4: Cooling panel

c) Shaft temperature and bearing operation:
   - Shaft cooling and heat transfer to bearing;
   - Bearing heating up due to mechanical friction at maximum rotation speed;
   - Bearing frame heating up as a way to predict jamming;
   - Driving gear rotating moment control helps to predict jamming.

d) Cooling panels; surface and geometry:
   - Surface processing for maximum emissivity. Anodized aluminium with emissivity ε = 0.92 should be used;
   - Increase the roughness of the surface by means of sand jet processing;
   - Channels geometry adjustment in order to minimize the maximum temperature gradients inside the panel;
   - Reducing of vibration level due to turbulence

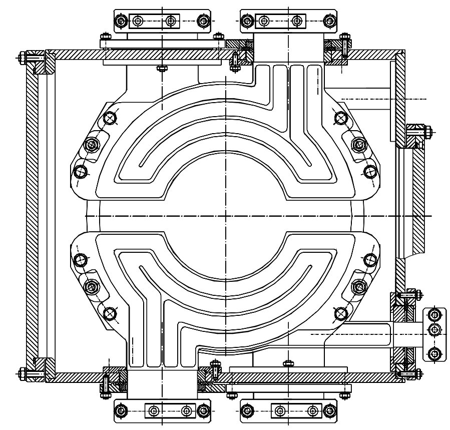

Figure 5: Cooling panels in assembly

e) Safety and diagnostic system:
   - Emergency driving beam dump;
   - On-line electron beam profile measurements system;
   - Optical view port with shielding for optical temperature measurements;
   - Thermo-emission measurements from the hot target;
   - Thermocouple hot target temperature sensor.

4. CURRENT STATUS AND TIME SCHEDULE

By now the materials for converter are selected and successfully tested. These are dense graphite and specially developed material on ^{13}C base [2]. The temperature of 2000^0C and the temperature gradient of 100^0C/mm are reached. A model of prototype, which is the sector of the metal disk with the converter element, is manufactured and currently under thermo-mechanical test. Heating of element is carried out by thermal radiation of tungsten wires. These tests allow to specify the prototype parameters and to create the model of heat contacts, which provide a good agreement between computation model and measured temperature distribution.

To date a complete set of drawings is available, a part of the prototype assemblies is already fabricated or purchased.

By September 2004 the prototype assemblies fabrication has to be completed in LNL.

September 2004 to January 2005 – delivery to BINP, assembling and testing.

February 2005 to April 2005 – full-scale experiments.

July 31, 2005 – project completion.

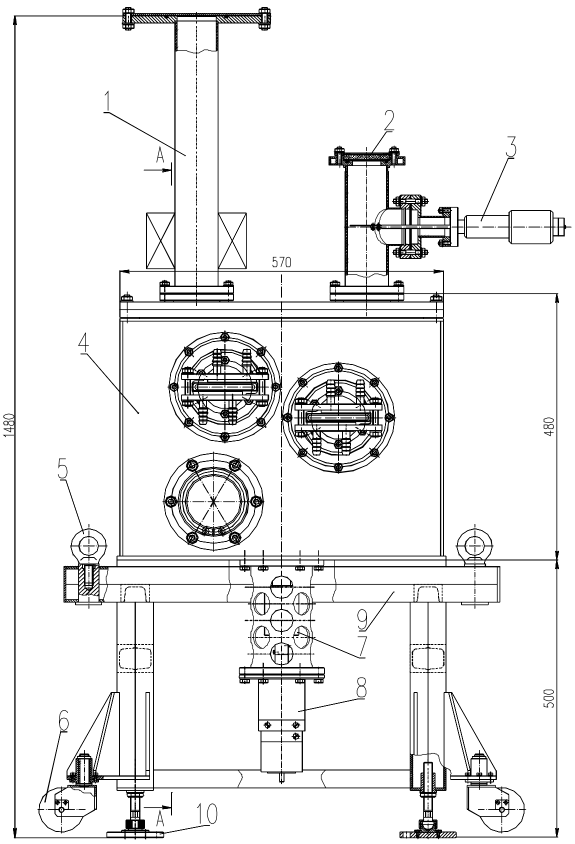

Figure 6: Prototype inside the vacuum chamber. 1 – drift tube of ELV-6 accelerator with focusing lens; 2 – optical window; 3 – movable shielding screen for window; 4 – vacuum chamber; 5 – set-up for lifting; 6 – wheels for set-up moving; 7 – rotating feed-through; 8 –driving DC motor; 9 – support; 10 – support adjustment tool.

REFERENCES

[1]. L.Tecchio et. al. "Project of a Next-generation ISOL Facility for Exotic Beams at LNL". EPAC2000, June 25-30 2000, Vienna.

[2]. M.S. Avilov et. al. "Test of Materials for the High Temperature Neutron Target Converter". This Conference.

[3]. R.A. Salimov et. al. "DC High Power Electron Accelerators of ELV-series: Status, Development, Applications". Radiation Physics and Chemistry, 2000, Vol.57, Iss. 3-6, pp. 661-665.