Tape high power neutron producing target for NCT

V. Kononov[a], G. Smirnov[b], S. Taskaev[c]

[a] *Institute of Physics and Power Engineering, Obninsk, Russia*

[b] *Russian Federal Nuclear Center – Institute of Technical Physics, Snezhinsk, Russia*

[c] *Budker Institute of Nuclear Physics, Novosibirsk, Russia*

Solid lithium targets with intense liquid cooling are used now for accelerator based boron neutron capture therapy. Typical power of available proton beam is within 5 kW, the one of the accelerators under construction – 25 kW. Innovative lithium target using energy accumulation for more high power proton beams is described.

1. Introduction

The Budker Institute of Nuclear Physics and the Institute of Physics and Power Engineering, Obninsk, have proposed an accelerator based neutron source for neutron capture and fast neutron therapy at hospital (Bayanov, 1998). Pilot facility is under construction now at the Budker Institute of Nuclear Physics. One of the main elements of the facility is lithium target, that produces neutrons via threshold ^{7}Li(p,n)^{7}Be reaction at proton beam with energies 1.915 MeV or 2.5 MeV. Stationary 25 kW neutron producing target for this facility is described in a report at this Symposium (Bayanov, 2004).

A new approach in target conception is needed for more high power proton beam providing decrease of treatment time. Tape lithium target described is able to provide neutron generation for proton beam up to 100 kW by simple, safe, and practically feasible way.

2. Discussion

Lithium targets are optimal for accelerator based boron neutron capture therapy (Nigg, 1999). Prevailing schemes of lithium targets are based on solid lithium with beam absorber cooled intensively by liquid thermo carrier (Belov, 2002; Brown, 2002). These targets are reliable for about 10 kW power. For more high power proton beam, a new approach in target conception is needed.

Main physicotechnical parameters of neutron producing layers are presented in Tabl. 1. Lithium nitride and lithium oxide layers are resistant in the air under heating up to 300 ºC, whereas lithium hydride layer needs dry gas medium. So, lithium nitride and lithium oxide are preferable because of simple technology and safety.

Table1

Material	Density ρ, g cm^{-3}	Melting temperature, T, ºC	Neutron yield, arb. units	Resistance
Li	0.534	180.5	1	in kerosene
LiH	0.78	691	0.875	in dry air
Li_3N	2.3	813	0.6	resisting
Li_2O	2.01	1727	0.47	resisting

Lithium targets with rotating disk are not quite effective for two reasons: i) inner convective cooling has problems with safety and reliability because of lead-in of liquid heat carrier in rotating unit; ii) radiation cooling of target is available for lithium oxide layer only. But lithium oxide reacts with most of constructional materials at the temperature of about 1000 ºC. Neutron yield in this case is half of the one for pure lithium.

3. Target design

Safe and practically feasible solution of target heated up to 100 kW is tape lithium target. Target design is presented in Fig. 1. The target is made of 0.5 mm thick 60 mm width flexible carbon fiber tape. Its moving device relative to charged particle beam directed to the target contains tape transport mechanism with magazines for tape introduction and receiving with winding drums. This tape can be made by coating the layer of neutron producing matter (hydride, nitride, oxide or fluoride of lithium) on the substrate. The active matter layer can be covered by protective film, of lithium oxide, for example to prevent from mechanical damage. To improve the heat removal from the operating part the substrate can be made of the substance with high thermal conductivity, of aluminum, for instance. In case if coefficient of thermal expansion of active material and substrate matter are different the active material can be put on substrate (tape) in fragments along the tape with their length comparable with the tape width. The patent was received for this target (Smirnov, 2003).

Prototype of tape target is under design and construction now. Special drive from cosmic technique will be used for operating in vacuum under up to 500 ºC temperature. Optimal active lithium powders, high thermo conductivity substrate materials will be used in target prototype also. Probable 10 kg tape will be enough for investigations of 5 MJ accumulation under 10 kW proton beam. Tape velocity of 0.5 m s^{-1} is needed in this case.

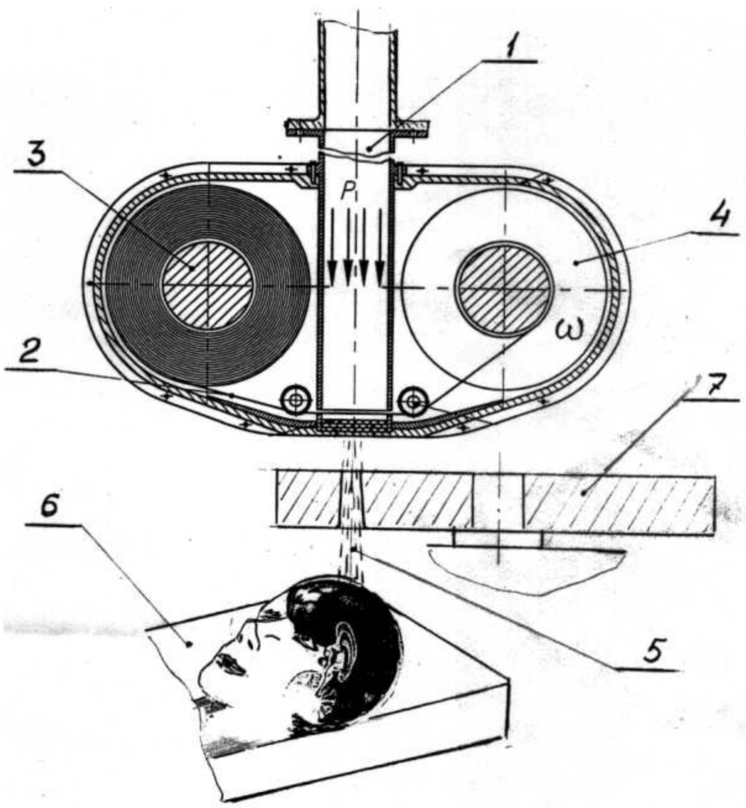

Fig. 1. Tape target design. 1– inlet window, 2 – outlet window, 3 – feeding drum, 4 – receiving drum, 5 – therapeutically neutron beam, 6 – patient, 7 – collimator.

4. Conclusion

New conception of high power neutron producing target is proposed. Main idea is based on energy accumulation at movable tape. This target will be investigated in nearest future.

Acknowledgements

The authors would like to thank the financial support from International Science and Technology Center to take out a patent.

References

Bayanov, B. *et al.*, 1998. Accelerator based neutron source for the neutron-capture and fast neutron therapy at hospital, Nucl. Instr. and Meth. in Phys. Res. A 413, pp. 397-426.

Bayanov, B. *et al.*, 2004. Optimization of lithium target for epithermal neutrons generation. Symposium on BNCT, Novosibirsk.

Belov, V. *et al.*, 2002. Neutron producing target for accelerator based neutron source for NCT. Research and Development in Neutron Capture Therapy. Eds.: W. Sauerwein, R. Moss, and A. Wittig. Monduzzi Editore, 2002, p. 247-252.

Brown, A., Forcey, K., Scott, V., 2002. The Design and Testing of a High Power Lithium Target for Accelerator-based Boron Neutron Capture Therapy. Research and Development in Neutron Capture Therapy. Eds.: W. Sauerwein, R. Moss, and A. Wittig. Monduzzi Editore, pp. 277-282.

Nigg, D., 1999. Some recent trends and progress in the physics and biophysics of NCT. Report INEE/EXT-9900855, Ang.

Smirnov, G., Kononov, V., Silvestrov, G., Taskaev, S., 2003. Neutron producing target unit. PCT/RU 03/00288.