Development of Transportable Accelerator-driven Neutron Source in XJTU

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1. Introduction

Neutrons have been widely used in many applications [1]. Due to the low cost, small size, short construction time, and acceptable neutron yield for many purposes, the development of Compact Accelerator-driven Neutron Source (CANS) technology has progressed worldwide in recent years. And outdoor neutron non-destructive testing is likely to be realized by developing a Transportable Accelerator-driven Neutron Source (TANS) based on existing CANS facilities for some specific situations, like bridge and road detection. The project of TANS in Xi'an Jiaotong University (XJTU) has been carried out. The progress about compact accelerator, target design, shielding structure and neutron backscattering radiography system is stated as follow. And the layout of every consistence is shown in Fig. 1.

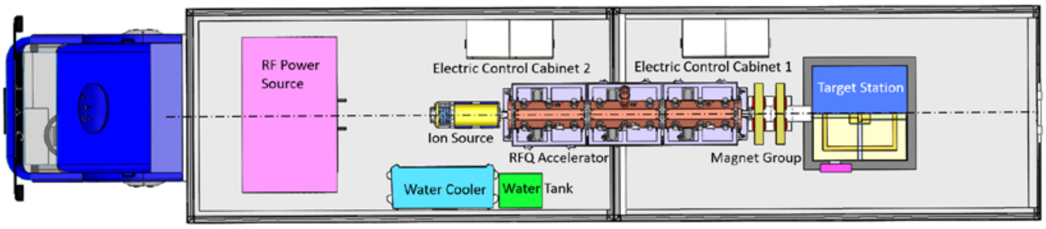

Fig. 1. Structure of the TANS

2. RFQ accelerator, target, and shielding structure

The four-vane RFQ accelerator has been adopted as its compact structure and high transmission efficiency. The whole accelerator system consists of RFQ cavity, RF power source, cooling machine, vacuum as well as generator. The working frequency of 325MHz has been selected with compromise between power consumption, cavity size and weight, as well as feasibility of construction. The RFQ was designed to accelerate the proton beam with peak current of 12mA to 2.5MeV in the acceleration efficiency above 93.2%. The RFQ length and weight were 2.6m and 1.5t, respectively. We chose the ^{7}Li (p, n)^{7}Be reaction due to its high neutron yield. Aiming at minimization on reduction in neutron attenuation and enough cooling, we proposed a new cooling configuration for a target featuring edge-cooling without flowing water in the back side to be applicable for TAN. Based on the simulation by Monte Carle code and finite element method software, the effect on neutron attenuation and cooling effect have been evaluated, and the structure and size are optimized. We optimized the reflector and the shielding design of the target station for TANS. A high-performance reflector material was selected by comparing several candidates, which aimed at enhancing the fast neutron intensity for the non-destructive testing. A compact and light-weight shielding design was optimized through a multi-objective optimization way based on NSGA-MC [2].

3. Neutron Backscattering Radiography System Based on TANS

Fig. 2 shows the simulation results of defects detection. Defects depth is 10cm, size is 5*5*5cm. Detector size is 30px*30px, pixel size is 0.5cm. Water can reflect more thermal neutron than other material, while void can hardly reflect neutron, thus, NBR can distinguish void and water by means of backscattering neutron flux and energy.

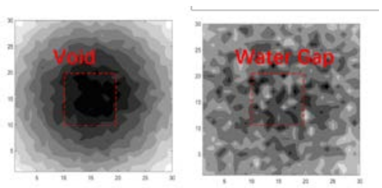

Fig. 2. NBR Simulation of Void and Water Defects

References

[1] L. Xu, W. Schultz, C. Huiszoon, Petrophysics 51(3), 184 (2010).

[2] Ma B , Song L , Yan M , et al. Multi-objective Optimization Shielding Design for Compact Accelerator-driven Neutron Sources by Application of NSGA-II and MCNP[J]. IEEE Transactions on Nuclear Science, 2020, PP(99):1-1.