5 - 16  R&D of the First Principle Prototype of the Granular Flow Spallation Target for ADS


Spallation target is one of the key constituent parts of the Accelerator Driven Sub-critical System (ADS), but the existing spallation targets are difficult to satisfy the power requirements of the commercial ADS in the future. In order to solve this problem, the scientists of the Institute of Modern Physics (IMP) originally proposed a new concept — the granular flow spallation target[1] which is quite different from the current spallation targets in the world. This novel spallation target with complete intellectual property rights incorporates the advantages of existing solid spallation targets and liquid metal spallation targets. Solid particles are delivered to the outside of the target area for heat transfer. It allows the granular flow target to form a compact bundle area with the ability to withstand the beam power of tens megawatts (MW). This type of the spallation target also avoids a series of the problems such as the limitation of target materials for traditional spallation targets, the short lifetime of the structural materials due to the thermal shocks initiated by the beams and so on. Therefore, the granular flow spallation target is a kind of high power spallation target with great potential for development to the future ADS.

After hard works for more than two years, a series of key technologies were broken through and then the first principle prototype of a granular flow spallation target in the world for ADS was successively developed and commissioned. Overall, the prototype consists of hoisting system, heat-exchang system, heating process simulation system, sifting system, vacuum and helium environment system, granule storage system, simulated target coupling area flow measurement and control system, etc. According to the relevant functional requirements and working conditions of the granular flow spallation target, as well as the convenience of operation and maintenance, the whole prototype is divided into three circuits which are respectively for the reliability study of the large flow granular flow circulation system, the heat transfer study of the small flow granular flow circulation system, as well as the recovery and storage of the experimental granules. These three circuits share the hoisting system and the specific loop of the granular flow experiment can be achieved through the loop on the valve on/off. In fact, in order to meet various test conditions and complete the research processes the granular flow spallation target prototype I (mechanical hoisting method) and II (electromagnetic hoisting method) were developed respectively according to the different ways to upgrade(Figs. 1 and 2). And a special tungsten alloy (W alloy) was used as the current material of the spallation target and the coolant.

Fig. 1 (color online) Photos of the granular flow spallation target prototype I (mechanical hoisting method).
Fig. 2 (color online) Photos of the granular flow spallation target prototype II (electromagnetic hoisting method).
Using this principle prototype, we conducted several experiments of the granular flow spallation target such as controlling flow pattern, flow regulation and heat transfer, etc. The experimental results showed that the prototypes I and II were proper functioning, and the related principle and design of the granular flow spallation target were verified.

Reference


5 - 17 Granular Waterfall Target for a Muon-Decay Neutrino Beam Facility

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For a muon-decay neutrino beam facility, such as the long-baseline neutrino factory (NF) and the medium-baseline MOMENT (MuOn-decay MEdium-baseline NeuTrino beam facility), the requirement of high intensity muon source requires that the target station be capable of surviving with the bombardment of a proton beam with multi-even tens-of-MW power. The high beam power and the small target size lead to an extremely high power density, which poses significant challenges to the target station. For the NF, it is believed that the mercury jet target can handle the power deposition of a 4 MW proton beam. However, the temperature will not be much lower than the boiling point of mercury (~357 °C). When a much more powerful beam is mandatory, just like what has been proposed (15 MW even more) for the MOMENT project, it is unlikely that a liquid metal jet target can meet the requirement.

We propose here a new target solution, the granular waterfall target, as shown in Fig. 1, for a muon-decay neutrino beam facility. This kind of target concept adopts a grain waterfall to serve as the target body. Due to its high power-processing ability, the granular waterfall target has the potential to operate with the 15 MW cw proton beam of the MOMENT. In addition, because of its relatively simple working mechanism, this kind of target concept also can be chosen as an alternative to the traditional mercury jet target.

As shown in Fig. 1, the solid granular particles flow through the narrow outlet of an upright cubic hopper to form a waterfall of grains. From the hopper outlet, the waterfall is accelerated by gravity to pass through the beam-target interaction region quickly. When the waterfall falls to the inner surface of the shielding, the grains will flow through the incline chute to reach the downstream pool and circulate in a loop system which contains a heat exchanger, a grain filter, a lift device and a degassing/decontamination equipment. In the incline chute, the grain flow can act as a beam dump as well as a second target.

As shown in Fig. 2, for the granular waterfall target, the temperature rise is much smaller than the traditional jet target. With a temperature rise of less than 200 °C for the 4 MW beam power, the granular waterfall target is shown to possess significant advantages to act as the target of a muon-decay neutrino beam facility.