Investigation of the distribution of remaining tritium in divertor in the Large Helical Device

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In this study, amounts of the remaining tritium (T) in divertor tiles in the Large Helical Device (LHD) are measured by using an imaging plate (IP) technique [1] and a thermal desorption method to investigate the distribution of remaining T in the helical divertor. Depth profiles of the remaining T in divertor tiles are estimated by using the combination the IP technique and the glow discharge optical emission spectroscopy (GD-OES). The distribution of positions of high-energy triton loss on the divertor is calculated by using a Lorentz orbit following code (LORBIT) [1] to compare to the distribution of remaining T in the divertor.

In LHD, a portion of tritons generated by deuterium-deuterium (DD) fusion reactions is lost without collisions with background plasma particles to the divertor region with high energy up to 1.01 MeV, and the portion is approximately 40 % in the case of the standard magnetic configuration [2]. On the other hand, evacuated gas analyses showed that approximately 35.5 % of the generated T was evacuated, and approximately 60 % of the generated T could remain in the vacuum vessel in the case of the first D plasma experimental campaign in 2017 [3]. These results suggest that more than 66 % of the remaining T in the vacuum vessel could be in the divertor. The total plasma surface area of divertor tiles is approximately less than 10 % of the total plasma surface area of the vacuum vessel. Therefore, the T densities in divertor tiles can be much larger than in the first wall. Indeed the results of the IP measurement conducted after the first D plasma campaign showed much larger T density on surfaces of the divertor tiles than that on first wall panels [4]. However, the IP technique can measure the T remaining within the depth shallower than the escape depth of β-rays from T decay, less than 1 μm, and thus depth profiles and total amounts of remaining T in divertor tiles are necessary to know the distribution of remaining T in the divertor. The measurement of depth profiles of remaining T in divertor tiles, which are made of graphite, using the GD-OES and the IP has been conducted. A result of the measurement shows that the profile has a peak at approximately 5 μm from the surface, and the remaining T decreases to approximately 10 % of the peak value at around 10 μm from the surface. This result suggests that the remaining T in the tile is the lost high-energy triton, and the estimated remaining amount from results of the IP measurement can make underestimation.

In the presentation, total amounts and the distribution of remaining T in the divertor are shown. Results of the calculation of LORBIT considering divertor tiles are compared to the distribution, and the mechanism of the formation of the distribution is discussed.