§17. Development of Mobile Robots for Remote Maintenance of the LHD-Type Reactor

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Previous works. In development of a remote maintenance system for the FFHR, the difficulty arises on extremely complex internal structure of the reactor core. Hence, with NIFS, based on the technical research and discussions about inner walls, this project has investigated feasibility of small legged robots, that can walk everywhere in the reactor. Also, the new concept of "robot swarm" of numerous inspecting robots has been introduced to accomplish efficient and detailed inspection of the reactor. As an agent of the above-mentioned robot swarm, a "three-legged robot" (TLR), has been built up as shown in Figure 1. The TLR has a triangle body, and each vertex has a leg of the same structure. The length of each leg is 200 [mm], and has seven joints. The body length is 600 [mm], and the weight is 1.7 [kg]. Through the several experiments, it is verified that, the TLR can go up the stairs of 100 [mm] steps and also walk up the slope of 30 [deg] by the manner of the cartwheel gait. Furthermore, the attachments of suckers to foot, have been developed for the TLR to climb up vertical walls. The TLR can remove the suckers from the wall by himself (the degree of freedom of the legs), and no air compressor for the suckers is necessary. Using the suckers, the TLR can successfully walk on the vertical wall.

However, due to the helical structure of the FFHR, the TLR have to move on roofs, curved surfaces and so on. Thus, in this research, to confirm the movability of the TLR, some experiments against roofs and curved surfaces are explored. Moreover, modifications of the attachment and the gait are considered.

Experiments and developments. In this research, the two kinds of gait experiments on the roof of the aluminum plate (Figure 1) and the curved surface of SUS304 (Figure 2), are explored.

Regarding the inverted walking on the roof, although the influence of gravity, makes the gait unstable, the attachments of the suckers can stick to the roof well and the servo motors of the legs can lift the body up. Thus, the TLR can move stably on the roof. This experiment means that the TLR with the suckers, can walk on walls of any angles, $0 \sim 180$ [deg].

Figure 2 shows the curved surface whose curvature is similar to the reactor. This experimental field is lent from NIFS. In the experiments, the flexibility of the resin suckers copes with the curved surface adaptively and passively, and thus the TLR can climb up stably.

Fig. 1: The inverted walking on the roof by using the suckers.

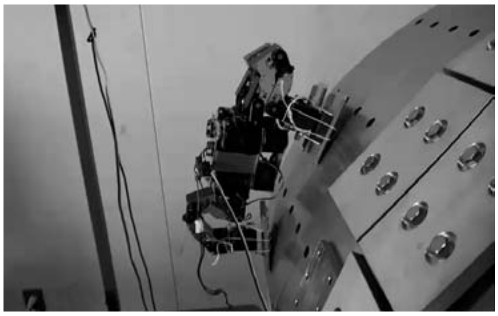

Fig. 2: The TLR climbing up the curved wall.

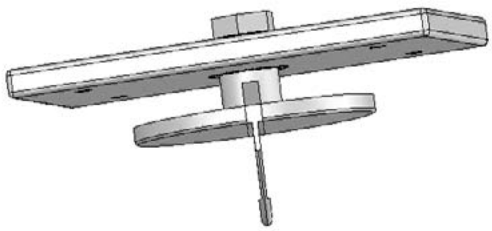

Fig. 3: The new attachment of the flexible crow.

From these results, the attachments of the suckers play an important role in climbing up the walls. However, generally, the sticking force of the sucker depends on the smoothness of the wall. Hence, in the practical situations, the suckers may not be preferred. In addition, in a vacuum, the suckers are useless. Then, this research presents a new attachment designed as shown in Figure 3. This attachment of the flexible crow can catch the crevice between blankets. In our future works, it will be built up, and its effectiveness will be confirmed through experiments.

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