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

Takahashi, M., Mitarai, O. (Tokai Univ.),
Ashikawa, N., Tamura, H., Ohdachi, S., Narushima, Y., Sagara, A.,
Kakudate, S., Takeda, N. (JAEA)

Introduction From social concern on reliability and safety, remote maintenance might become one of the key technologies to operate nuclear reactors. As is well-known, remote-controlled robots are used at hazardous places, and play the important roles in working instead of human workers. Then, the objective of this research is to construct a maintenance system for the FFHR by using mobile robots, which can achieve efficient inspection of every inner wall for the reactor core.

In the Tokamak reactor, the vehicle-type robot for maintenance, already has been developed, that can move on the circumferential railway along the torus. However, this kind of robots cannot be directly introduced to the FFHR because of the extreme complexity of the helical structure. Hence, different remote maintenance system by robots should be required for the FFHR.

In order to investigate a new concept of the remote maintenance with robots, this research studies feasibility of a "robot swarm", which consists of a number of the small robots moving in the reactor. The system by the robot swarm is expected to accomplish detailed inspection of every surface of the complex inner walls. Thus, a "three-legged robot" (TLR) is developed to be an agent of the above swarm. Through several experiments, the gait performance is confirmed, and some modifications are made to expand the activity area of the TLR.

The three-legged mobile robot Due to the helical structure, the mobile robots of the swarm have to climb the vertical and inverted walls. Hence, in this research, the legged-type is adopted for the inspecting robots, and the three-legged robot (TLR) is developed as shown in Figure 1 (Photograph).

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. Moreover, on the legs, the mechanisms for grasping are equipped, and the legs can be exploited as the arms. Therefore, it is possible to add some attachments in the hands (feet) to improve the function and performance of this TLR. The body length is 600 [mm], and the weight is 1.7 [kg]. Compared with a kind of humanoids of the same size, the TLR is relatively light and compact, and can perform various gaits, for example, bipedal walking, cartwheel and so on. Also, the TLR has fault-tolerance against failures in the legs. Even if one of the legs fails completely, the TLR can keep walking by the remaining two legs.

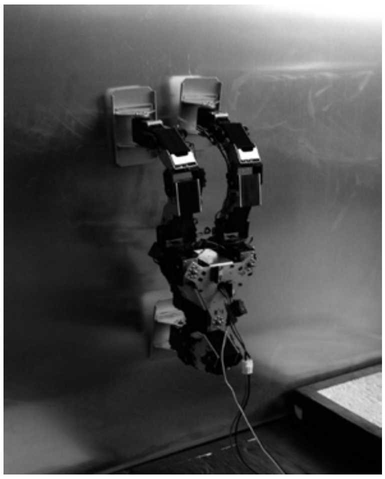

Fig. 1: The TLR climbing up a vertical wall by using the suckers.

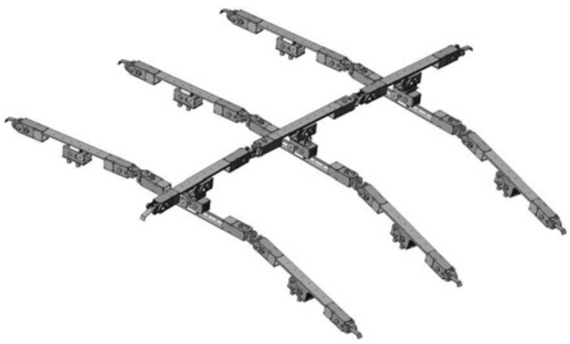

Fig. 2: The twelve link-type robots forming a six-legged robot like an insect.

Through the several experiments, it is verified that, by the cartwheel gait, the TLR can go up the stairs of 100 [mm] steps and also walk up the slope of 30 [deg]. Furthermore, by attaching the suckers to the feet, the TLR can climb up the vertical wall stably and successfully as shown in Figure 1. 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.

Future works Instead of the preceding suckers, a foot claw of the TLR is designed so as to catch crevice between blankets. Also, as shown in Figure 2, the link-type robots are designed, that combine each other to form the multi-legged robot (MLR) like an insect. The structure of the MLR can be changed by combination of the link robots. This flexibility can cope with the complexity of the inner walls of the FFHR. In our future works, both the claws for the TLR and the link-type robots will be built up, and the effectiveness would be confirmed through some experiments.

This work is supported by NIFS budget NIFS12KERF012.