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Contact analysis of slit at inlet of mobility device utilizing tether extension and winding

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Abstract

Recently, advancements in space technology have opened up more opportunities for human beings to work in outer space. It is expected that upsizing of manned space facilities, such as the International Space Station, will further this trend. Therefore, a unique means of transportation is necessary to ensure that human beings can move about effectively in microgravity environments. Various systems such as tethered space robots[1] have been proposed. In the present study, we propose a tether-based mobility system[2], which moves the user by winding a tether attached to a structure at the destination. However, there is a problem in that the attitude of the user becomes unstable during winding of the tether. Therefore, a Tether Space Mobility Device (TSMD) attitude control method for winding a tether is examined through numerical analysis. The proposed analytical model consists of one flexible body and three rigid bodies. The contact force between the tether and the inlet is considered. We verified the validity of the proposed model through experiments. Furthermore, we proposed a TSMD attitude control method during tether winding while focusing on changes in the system's rotational kinetic energy. Using the proposed analytical model, the angular velocity of a rigid body system is confirmed to converge to 0 deg/s when control is applied[3].

Figure 1 shows analytical model of TSMD. This model consists of flexible body and three rigid bodies. Flexible body is formulated using Absolute Nodal Coordinate Formulation[4]. The system is formulated using Augmented Formulation[5]. Then contact force between the tether and the inlet is defined by spring and damper elements. The shape of slit of inlet is shown in Figure 2. In this figure, tether is wound from left side to right side. Three type slits which shape with a uniform slit width, a shape with a narrowed tip, and a shape with a widened suction port tip were set. In case of width of slit is changed, numerical analysis is performed.

Figure 3 shows time history of angle of TSMD with attitude control method during tether winding while focusing on changes in the system's rotational kinetic energy. In this figure, it is conformed that the attitude control method is effective in all slit shape. Moreover, it was showed that the response of the control effect was good under conditions where the slit was narrow. This suggests that there is a relationship between the slit shape and the response of the control effect. Therefore, we compared the contact force inside the rigid body and the contact force at the rigid body tip, and clarified the mechanism concerning the slit shape and the response of the control effect.

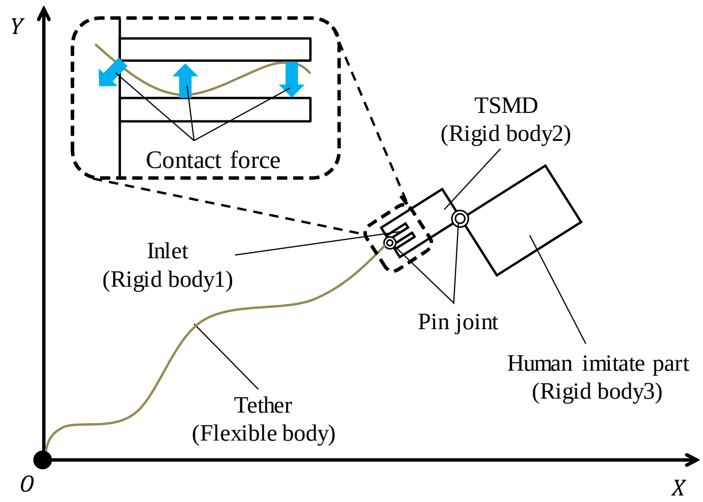

Figure 1: Outline of the analytical model

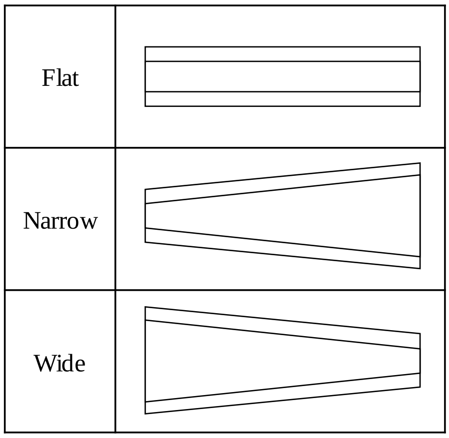

Figure 2: The shape of slit at inlet

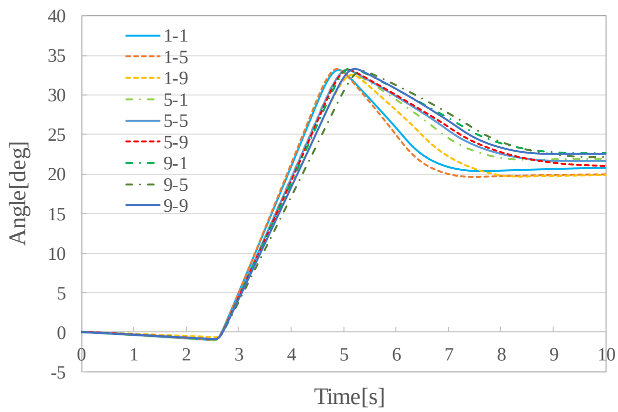

Figure 3: Time history of Angle (with control)

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