Expansion of Kinematic Constraints in Linkage Mechanism with New Joints

N. Kimura[1], N. Iwatsuki[1] and I. Ikeda[1]
[1]*Department of Mechanical Engineering, School of Engineering, Tokyo Institute of Technology, Japan*
e-mail: kimura.n.ac@m.titech.ac.jp

Keywords: Linkage mechanism, Kinematic pair, Mechanism design

Linkage mechanisms, which are composed of limbs (links) and joints, are used in robots, industrial machinery and so on. Generally, kinematic joints used in linkage mechanisms have a surface contact between links. However, such kind of joints have low degree-of-freedom (DOF) and allow only simple relative motion between links. Thus, conventional linkage mechanisms with 1 DOF cannot completely generate the desired trajectory. In addition, linkage mechanisms with multiple DOF tend to have complex structure. In order to solve these problems, the geometrical constraints of the joints should be relaxed. Therefore, the authors proposed novel kinematic joints, which have point or line contact between links [1,2]. In this presentation, two previous lines of research about those joints, the spatial rolling contact joint [1] and the flexibly constrained revolute joint [2], are introduced.

Firstly, the research about the spatial rolling contact joint (SRCJ) is indroduced. In order to develop a linkage mechanism with 1 DOF which can completely generate the desired motion, the SRCJ has been developed [1]. This joint is composed of two links which are kept in contact at a line by many linear elastic elements as shown in Fig. 1. This joint is designed so that the two links roll relatively along the specified trajectory. Since this joint can completely generate the desired trajectory, linkage mechanisms with 1 DOF having the SRCJ can also completely generate the desired output motion. Actually, an example of the linkage mechanism with the SRCJ was designed and analyzed, and it was confirmed that the designed mechanism could completely generate the specified output motion.

Secondly, the research about the flexibly constraint revolute joint (FCRJ) is introduced. Conventional mechanisms of robots used in human daily life are rigid, so they are dangerous for people. Thus, flexibility should be incorporated into the mechanisms. However, since a lot of DOF is required to introduce the flexibility, the robots tend to have complex structure. Therefore, the FCRJ, which has both mobility for allowing relative motion and mobility for introducing flexibility, has been proposed [2]. This joint has a link with two same spherical surfaces and a link with the two same cam surfaces as shown in Fig.2. Each set of the spherical surface and cam surface is kept in contact at a point with linear springs. This joint has low stiffness in the 1-axial rotational direction, but has high stiffness (but not rigid) in the other directions. Therefore, this joint can be assumed as a revolute joint with flexibility in the constraint directions. By using the FCRJ, a flexible linkage mechanism with 2DOF was designed and fabricated, and it was confirmed that the linkage mechanism has both flexibility for safety and adequate accuracy to generate the desired output motion.

These joint mechanisms have good kinematic performance and they can expand motion of linkage mechanisms. However, their durability is not so good, because of wear of contact surfaces and high contact force caused by point or line contact. Therefore, in the future, appropriate materials or structure for these joint with self-lubrication ability should be found.

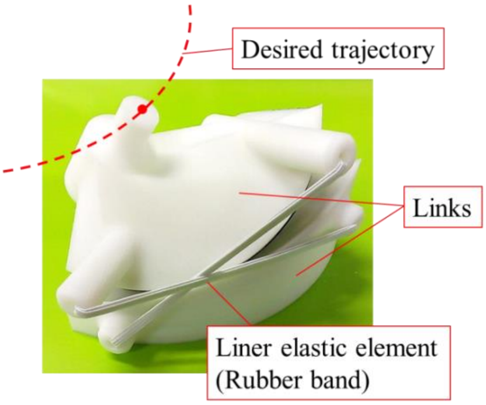

Fig.1 Spatial rolling contact joint (SRCJ)

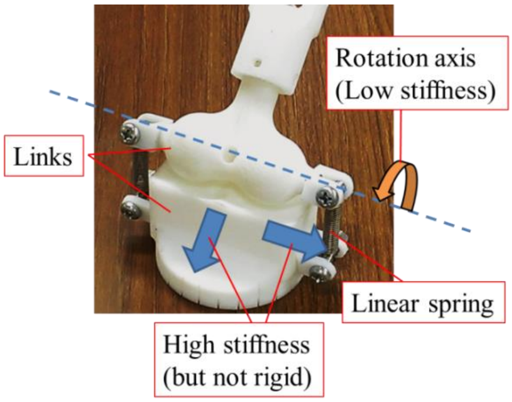

Fig.2 Flexibly constraind revolute joint (FCRJ)

[1] N. Kimura and N. Iwatsuki, "Spatial Rolling Contact Pair Generating the Specied Relative Motion between Links," Proc. of the 4th IFToMM Asian Conference on Mechanisms and Machine Science (IFToMM Asian MMS 2016), Vol. 408, No. 26, pp. 307-316, 2016.

[2] N. Kimura, N. Iwatsuki and I. Ikeda, "Flexibly Constrained Revolute Pair for Safe Robot Mechanisms," Proc. of the 21st International Conference on Mechatronics Technology (ICMT 2017), pp. 119-124, 2017.