

Numerical studies on various corrugation development mechanisms in a rolling disk on flexible rail

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1 INTRODUCTION

It is well known that corrugation occurs on the surface with the rolling contact between two bodies, for example, two rolling disks, rail/wheels systems and so on. In such systems, corrugations are produced by repeated contact at the same point with a time lag and with contact force fluctuation.

Considering wear development process, we conduct numerical and analytical analysis for a two kind of corrugation. These systems consist of upper and lower disks with rotating contact, and a rolling disk and a flexible beam regarded as wheel and rail. It seems that corrugation in these systems is formed with different mechanism. To investigate the development mechanism of two kinds of corrugations, the effects of rotation or rolling speed of the disk, the support stiffness or the beam flexibility, and the contact rigidity between two bodies on pattern formation are examined both analytically and numerically. In numerical approach, the contact constraints are recalculated for each rotation by using the contact force, slip rate and wear rate.

2 CORRUGATION DEVELOPMENT ON CIRCUMSTANCE SURFACE IN ROLLING DISKS

Figure 1 illustrates the analytical model of two rotating disks. The contact rigidity depends on the fluctuation of the contact force in accordance with Hertz theory. The mechanism of the corrugation development is governed by the characteristics of self-excited systems with a time-lag [1,2]. Figure 2 shows the unstable formed polygon number of the lower disk, which depends on the rotation speed. Infinite and countable eigenvalues exist in such systems. Based on the numerical results, during the corrugation development process, the wave length changes. For example, initially, both short and long-pitch corrugations are visible on the circumference of the disk. After 30,000 revolutions, however, only long-pitch corrugation remains. Also it is pointed out that wave length of corrugation varies on the circumference of the disk. On the bottleneck part of the circumference surface, the corrugation pitch is different from ones on the other part. This phenomenon preserves the development condition of the corrugation.

3 CORRUGATION DEVELOPMENT ON FLEXIBLE RAIL

In order to develop fundamental modeling and formulation for the motion of a rolling disk on worn flexible beam, the analytical model consists of the rolling disk and the flexible beam supported at its both ends simply. The contact rigidity between the disk and the beam, the slip motion of the disk, the flexibility of the beam and the wear on the

beam surface are taken into consideration. For the wear development, the virtual monitoring points for the profile of the surface are set on the beam elements as shown in Figure 3. For repeated passages of the rolling disk, some numerical results of corrugation development are calculated, comparing the cases given various disturbance with the phase difference between the contact force and the profile of worn surface on the beam. It is supposed that the phase shift between the contact force and wavy surface during repeated passages causes to preserve the development condition of the corrugation. As shown in Figure 4, even if the system has the large phase difference $3\pi/4$, the corrugation develops once without disappearing.

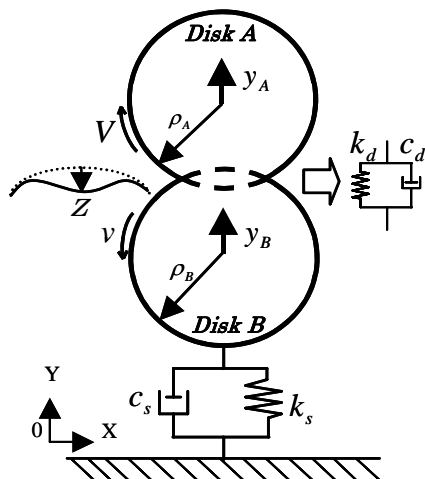


Fig. 1 Two rolling disks model

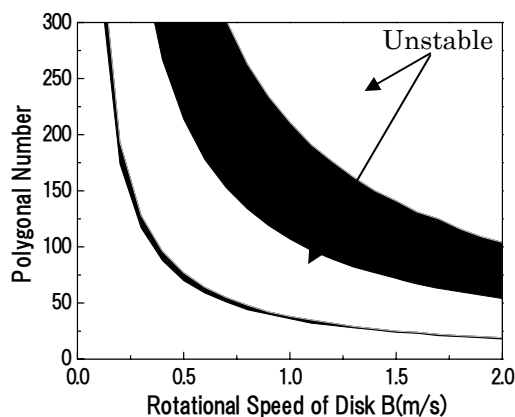


Fig. 2 Stability of formed polygonal number for rotational speed

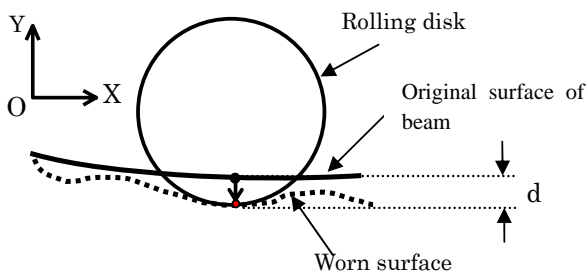


Fig. 3 Configuration for numerical approach for disk/beam model

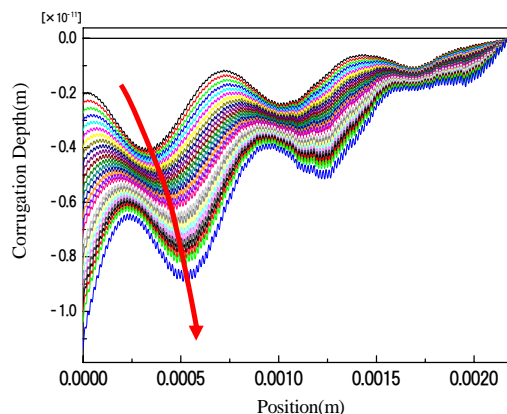


Fig. 4 Corrugation development with large phase difference between contact force and wavy surface

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