ABSTRACT

It is widely known that a rubber friction shows not only a rate- and state-dependency but also a pressure-dependency, which is induced by surface roughness [1]. A friction model capable of properly describing above-mentioned dependency is an essential to conduct numerical simulations of frictional contact boundary value problems. One of authors has been proposed the rate- and state-dependent friction model based on the elastoplastic analogy formulation [2]. In addition, its validity was also verified by comparing with experiments [2]. In the formulation, however, Coulomb’s frictional criterion, i.e. the constant friction coefficient, was adopted, and thus, the pressure-dependency cannot be described.

In this study, we propose the rate- and state-dependent friction model based on the elastoplastic formulation, in which the pressure-dependent frictional criterion is incorporated. In the formulation, we also prescribe evolution rules for microscopic sliding and rate-dependency. Furthermore, to demonstrate the validity of proposed model, we compare frictional responses with the experiment of sliding contact between rough rubber surface and rigid smooth plane [1].

In the formulation, we focus on only an adhesion friction. Then, we assume the isotropic sliding surface in traction space (frictional criterion) as follows:

\[ \| f_n \| = \tau S_n (\| f_n \|, \| \bar{u}^p \|, \phi) , \]

(1)

where \( f_n \), \( \tau \) and \( S_n \) are the tangential traction vector, the shear stress of adhesion and the ratio of real contact area to the apparent contact area, respectively. As shown in Eq.(1), \( S_n \) is the function of \( f_n \), \( \bar{u}^p \) and \( \phi \). Here, \( f_n \) is the normal traction vector, \( \bar{u}^p \) is the plastic (nonreversible) sliding displacement, and \( \phi \) is the state variable (which corresponds to time). To describe the microscopic sliding due to the change of traction inside the sliding surface, we adopt the concept of unconventional plasticity [2] and incorporate the subloading-sliding surface as follows:

\[ \| f_n \| = R \tau S_n (\| f_n \|, \| \bar{u}^p \|, \phi) , \]

(2)

where \( R \) (0 \leq R \leq 1) is called the normal-sliding ratio.

Figure 1 shows variation of friction force with elapsed time under several normal load conditions. It is confirmed that the pressure-dependency of friction can be described by the present model.

Fig.1 Time changes in friction force (pressure-dependency).

REFERENCES

