Evaluating Contacts between Rope and Pulley

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Abstract
The rope is used for various machines. For example, a crane is a representative machine to use rope. To use these machines more safely, it is necessary to perform the behavior analysis of the rope and pulley. Therefore the contact behavior analysis of a rope and a pulley is important. In this study, numerical model which is composed of a flexible body that can express motion with large deformation and large displacement is used. This flexible body is expressed in Absolute Nodal Coordinate Formulation (ANCF). And this model is built into normal reaction force and a friction force between rope and the pulley. A normal force is expressed using spring and damping element and friction force is expressed using Quinn method. The advantage of Quinn method is that the numerical problems associated with the discontinuities in Coulomb friction at zero velocity is reduced. By performing numerical simulation, the method that demonstrates the contact between rope and pulley was confirmed. First, identification experiment for bending elasticity is performed. From the result in Fig.1, it is found that the shape of the numerical result is corresponding to shape of the experimental result.

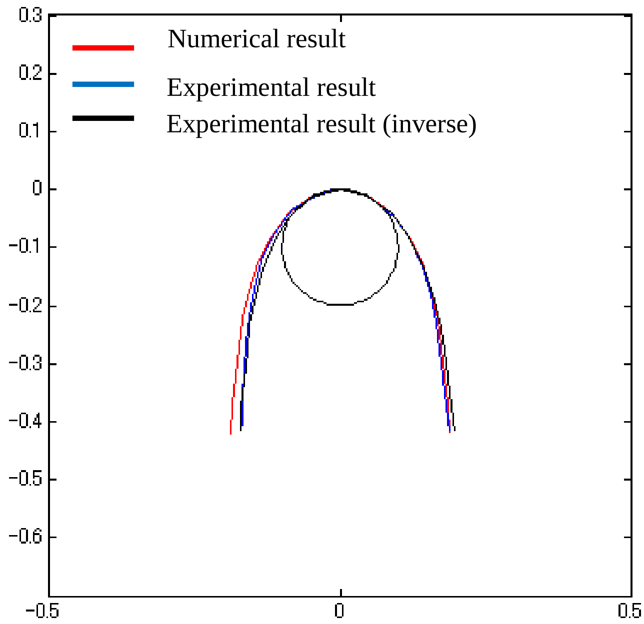

Figure 1: Shape of Rope.

Next, the distance of the slip when the friction coefficient of pulley is changed and the pulley has reciprocal motion is investigated. The comparison of the number of slips in the experimental result and the results of numerical simulations when the friction coefficient is changed is shown in Fig. 2. The friction coefficient used in the numerical simulations is 0.1, 0.12 and 0.2. The other parameters are the same as those shown in Table 1. In Fig. 2, four results of numerical simulations are compared, and it is revealed that the number of slips decreases when the ratio of tension is low and the friction coefficient is high.

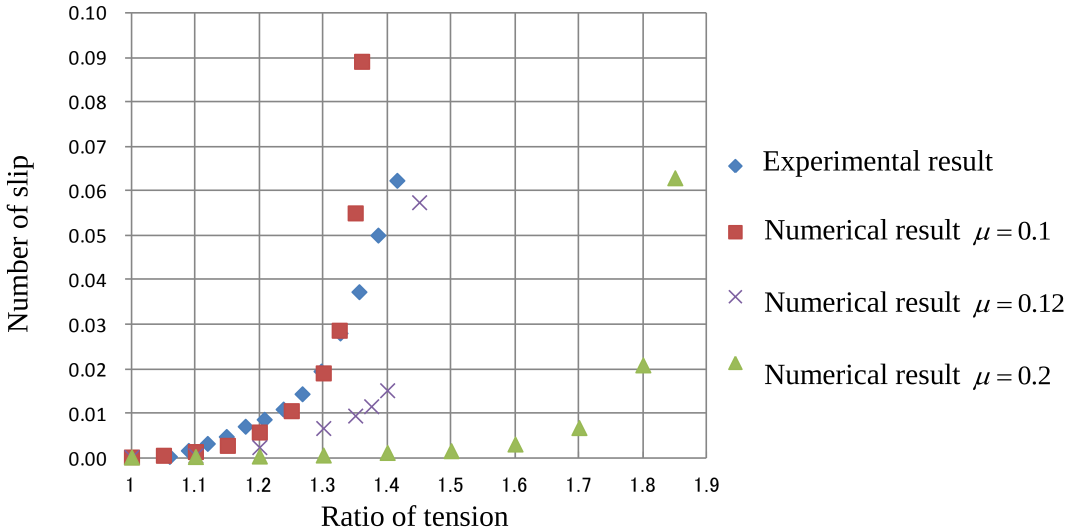

Figure 2: Ratio of tension vs. number of slips when friction coefficient changes

Table 1. Parameters for numerical simulation

l	Length of lope	m	2.40
m_l, m_r	Mass	kg	294.7
E_e	Coefficient of longitudinal elasticity	N/m^2	2.91×10^{10}
E_b	Coefficient of bending elasticity	N/m^2	6.00×10^{8}
ρ	Density of lope	kg/m^3	1091
R	Diameter of pulley	m	0.100
k_p	Spring constant of pulley	N/m	2.00×10^{6}
k_{p2}	Spring constant of pulley at edge	N/m	2.00×10^{5}
c_p	Damping constant of pulley	N/(m/s)	5.00×10^{3}
μ	Frictional coefficient	-	0.100
ε	velocity in micro velocity area	m/s	0.0500

References

[1] Shabana, A.A.: Finite Element Incremental Approach and Exact Rigid Body Inertia. Transactions of the ASME, Journal of Mechanical Design, Vol. 118, No. 1, pp. 171-178, 1996.

[2] Quinn, D. D.: A New Regularization of Coulomb Friction. Transactions of the ASME, Journal of Vibration and Acoustics, Vol. 126, No. 3, pp. 391-397, 2004.