Brakes and Wheel Rail Friction

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Abstract

This paper presents a discussion of one of the issues associated with braking on materials handling machines, that is, the friction between the wheel and the rail. As explained in this paper, if the brakes are applied and the wheels start to slide or skid, the coefficient of friction for the sliding body can be significantly less than the coefficient of friction for the static body. This means that the machine can continue to move (via skidding) even though the brakes are applied. Skidding can be initiated by having the brake torque set too high and being unable to get sufficient traction between the wheels and the rail or by having an external body (such as grease or coal dust) on the rails which reduces the coefficient of friction.

1. Introduction

Friction between two solid bodies can be considered as two types – static and dynamic.

The static friction coefficient (μ_s) between two solid surfaces is defined as the ratio of the tangential force (F) required to produce sliding divided by the normal force between the surfaces (N) – refer to Figure 1 and Equation 1:

$$\mu_s = \frac{F}{N} \qquad \text{Equation (1)}$$

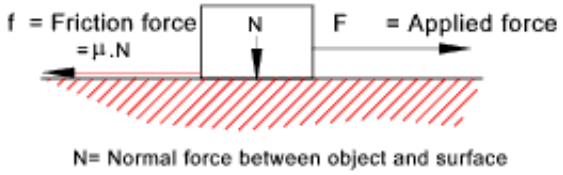

Figure 1 - Friction forces between two solid bodies

2. Friction Forces

When the tangential force, F, overcomes the frictional force between two surfaces then the surfaces begin to slide relative to each other. The sliding frictional resistance is normally different to the static frictional resistance. The coefficient of sliding friction is expressed using the same formula as the static coefficient and is generally lower than the static coefficient of friction.

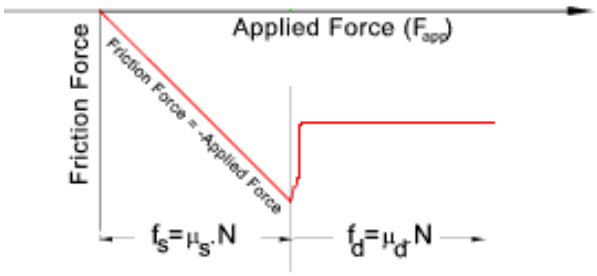

Figure 2 - Friction force vs applied force

Coefficients of friction are sensitive to atmospheric dust and humidity, oxide films, surface finish, velocity of sliding, temperature, vibration, and extent of contamination. In many cases the degree of contamination is perhaps the most important single variable.

Typical values of friction presented in the reference literature are:

For dry conditions:

$$\mu_{static} = 0.74$$
$$\mu_{dynamic} = 0.42$$

For lubricated conditions:

$$\mu_{static} = 0.05 - 0.11$$
$$\mu_{dynamic} = 0.029 - 0.12$$

This compares to the recommended friction value of 0.14 from the Australian design standard for materials handling machines.

It is very important to note that the friction coefficients are rough guides. Figure 3 shows experimental results demonstrating that the friction coefficient for steel on steel can vary from 0.0001 to 3.

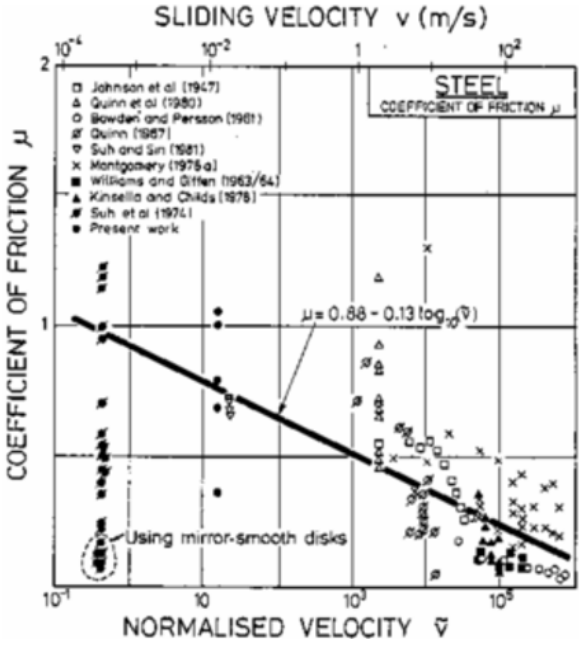

Figure 3 – Experimental measurements showing varying values for friction coefficient for steel

3. In Summary

It is possible to overcome the static coefficient of friction and cause wheels to slide either by the brake torque being set too high or the drives applying excessive torque and causing the wheels to slide on the rails.

Once the wheels have begun to slide, the coefficient of friction can reduce significantly. The presence of a third body layer such as grease, coal and water can mean that the dynamic coefficient of friction can drop to a very low value. There is evidence in the literature that the dynamic coefficient of friction can be less than 0.01.

4. References

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