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Friction is not a devil

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Friction Coefficients of Selected Agricultural Soil and Agro-Products – A Review

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KEYWORDS

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ABSTRACT

Various friction coefficients have been reported on the agricultural materials, to support the agricultural productivity. However, the reliability and productivity of modern agricultural equipment, maintenance cost, energy cost, and the cost of the agricultural production depend on the intensity of the wear of the used components. The article presents a review of tribological properties of the selected environment and food material in agricultural production. Increase in friction of the agricultural materials will increase the tear and wear, energy usage as well as the cost. A simple example of few materials used in agriculture is investigated, focusing on the soil effect, agro-product, and agricultural machinery equipment.

1. Introduction

Friction coefficient (μ) of the biological material or any agro-product is important for agricultural production. Mohsenin (1970) [1] has listed a wide range of physical properties of agricultural materials. The μ is a dimensionless quantity and lies under two basic laws; i) The force of friction is directly proportional to the applied load, ii) The force of friction is independent of the apparent area of contact [2]. In agriculture application, the μ is very much system-dependent and varied in time (e.g. wear). Therefore, known condition for a specific test and applied problem must be addressed under tribosystem (e.g. temperature and moisture content). Friction from the contact surface transformed into dissipated heat or stored in the tribosystem in the form of energy [3].

Thus, the effect is, for instance, in the deformation, and work hardening. The most common soil condition and type, selected agro-product and machinery and implement used in Malaysia is presented in Table 1 with the friction coefficient values, and its condition requirement for science and engineering application.

2. Friction coefficient of selected materials

2.1 Soil and Environment

The soil derives its shear strength in two sources; (i) cohesion/adhesion and (ii) frictional resistance, which the latter factor is much dependent upon on the particle size of the soil. Moreover, the particle size also plays an important role in engaging the resistance to any agricultural tools. The occurrence of soil adhesion exists when the soil is in contact with a solid interface (e.g. tillage implements [13]). Sliding resistance created on the interface depends upon the acting stress normal to the surface and angle of friction. By reducing adhesion and soil friction angle, the sliding resistance of soil engaging implements is reduced. The shear strength of soil due to friction is measured in terms of internal friction angle (f) [4].

Reliability and productivity of modern agricultural equipment, maintenance cost, energy cost, and the cost of the agricultural production depend on the intensity of the wear of the used components. The cost of the repair depends upon the type of workload, duration utilized, the age of the machine, and working environment.

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Table 1: List of the common agricultural materials associated with friction coefficient values and its relative energy requirement.

Material	Friction Coefficient, (*μ*)	Condition
	Soil and environment	
Soil type Clay [4,16] Sand [5] Silt [5]	 0.30-0.50 0.45- 0.60 0.20-0.35	Field capacity, minimum of 70% soil moisture content (MC), steel
	Selected Agro-product	
Palm fronds [6]	0.70 – 1.50	0-50% MC, for fine and coarse particles, on steel-polymer coated
Rice Grain [7,8]	0.17-0.21 0.37-0.41 0.34-0.39	10% MC, on steel On wood On concrete
Starch [9]	0.25 – 0.60	At various viscosity × speed/load, steel
Straw and Husk [10]	0.30 – 0.40	High temperature, up to 300˚C
Corn Grain [11]	0.20-0.43 (static) 0.17-0.35 (dynamic)	6.5-10% MC, steel
Silage [12]	0.66 - 0.70	73% MC, steel, 426-1360 Pa

The producer often has to bear the cost for about 15-20% of the purchase price for the repair cost budget for a tractor under 80 horsepower (hp), and about 15-30% for the disk implement [14]. Thus, the producer has to make enough profit to overcome the losses.

The innovation of the product development, for instance using the plastic-based product or polymer-based product for bearing seal and sliding mechanism would help in using the agricultural tools and equipment used under heavy operation [15]. For instance, replacing with coated roller bearing on the disk-plough implement, would increase the lifespan of the equipment, thus reduce the repair and wear cost. Others found that with the enamel coating on the cage wheel, improve the performance of the power tiller under soft soil [16].

2.2 Agro product

Rice and field corn are the two common grains grown in Malaysia either for human consumption or for the livestock feed. The μ values are important in selecting a proper material properties. High in silica content (89-98%) in the rice husk may increase tear and wear on the machinery used during the rice cultivation (combine harvester) and at the mill processing plant. Recent study reported that, innovation of the rice husk transformation into good quality break pad to replace unsustainable resource of asbestos material [12]. Another example is the fabrication of the material flow on the galvanized steel for the feedstock.

3. Conclusion

The friction coefficient values are well established for science and engineering application. However, careful selection should be undertaken when doing the testing by taking into the other factors affecting measured properties especially working at micro or nano level.

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