Frictional Characteristics of Woven and Nonwoven Wipes

A. Das*, V. K. Kothari, and D. Mane

Department of Textile Technology, Indian Institute of Technology, New Delhi 110 016, India

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Abstract: Demand for the fabric wipes is growing continuously. Wipes in industry are used for cleaning purpose. Cleaning involves rubbing action, so it is very important to know how much frictional force is encountered during the cleaning action. In this study the effects of normal load, sliding speed on frictional characteristics of nonwoven and woven wipes, both dry and wetted with different liquids, against glass and floor tile surfaces have been reported. With the increase in the normal load the coefficient of friction goes on decreasing for both nonwoven and woven wipes and this trend is observed in both dry and wet wipes. The coefficient of friction of both nonwoven and woven wipes against glass surface is in general higher than the floor tile surface. The wipes wetted with water shows an increase in coefficient of friction as compared to dry sample, but there is reduction in the coefficient of friction when the wipe samples are wetted with vegetable oil. In case of dry wipes, the coefficient of friction in case of nonwoven wipe is higher than the woven wipe. In case of woven wipes, the ranges of coefficient of friction either due to change in liquid type, normal load or sliding speed are in general smaller than that in case of nonwoven fabrics.

Keywords: Coefficient of friction, Nonwoven wipe, Normal load, Sliding speed, Woven wipe

Introduction

There is huge demand for the wiping fabrics and these materials are very wide spread and have a lot of applications in terms of value added new products. According to market tracker Euromonitor, Chicago, IL, the global market for disposable consumer-oriented personal care wipes (including adult wipes, baby wipes, and cosmetic wipes such as facial cleansing and deodorant wipes) reached $3.8 billion in 2004. Euromonitor projects that steady growth will bring the worldwide market to $4.3 billion by 2009. Last year baby wipes were a solid $2.5 billion global market compared to $397 million for adult wipes and $886 million for cosmetic wipes. The wipe market is sub divided into three separate segments, i.e., wipes for industrial application, wipes used for personal care and household wipes. The consumer wipes business has the most potential in wipes because it is more driven by a need for value added products, while industrial wipes tend to be repetitious. The need of the consumers is not even identified until they see these new products. Now a days the manufactures have the crux of the consumer market providing a solution to an unknown need. These needs are also being seen in the house hold cleaning segment where applications can be found for floor cleaning, furniture polishing, antibacterial application and glass and window cleaning, to name a few. These products are replacing the use of reusable textiles in cleaning application by offering two-in-one or three-in-one products in the form of dry or pre-moisted substrates. Already some of the major household cleaning multinational companies have extended there popular brands to include wiping products. Wipes in industry are used for different purpose related to cleaning. Nonwoven wipes are used in large scale followed by the woven wipes. Cleaning involves rubbing action; where we must know the frictional force encountered to wipe a surface. In wiping of binocular lenses, watch screens, calculator screens, monitors, TV, mobile screens, spectacle lenses, glass articles, cars, tables etc. sometimes scratches are observed on the surface. So we must know with how much force can be applied to rub the above articles to avoid scratches. In industry, at least for the automated wipers, we must select the exact wiping material with required frictional force.

Friction is important factor in any kind of wiping action. A large number of studies [1-20] have been carried out on various aspects of fabric friction, but very little information is available with respect to textile wipes (dry or wet). So it is necessary to study the frictional characteristic of wipe fabric in more objective way. There is necessity to study the frictional characteristics of wipe so that one can wipe the required surface with less energy requirement and without damage to the surface. The friction at wiping is critical; if it's less than required there is no wiping of surface and if it exceeds then there is scratching type of problem during the wiping. So, it is important to know the frictional characteristics of woven and nonwoven wipes against various surfaces. The objective of the present study is to understand the frictional characteristics of woven and nonwoven wipes against two different surfaces, i.e., glass and floor tiles. Wiping friction was studied under dry condition as well as with wipes wetted by different types of liquids, i.e., water, petrol, vegetable oil and soap solution to simulate more practical situation. This present study will be helpful for the further research of drag resistance of fabric.

Materials and Methods

Two sets of commercial wipe fabrics, woven and nonwoven, were collected for the present study. The parameters of woven

*Corresponding author: apurba@textile.iitd.ernet.in

(ends/cm: 12, picks/cm: 18, warp linear density: 25 tex, weft linear density: 59 tex, weave type: plain, warp crimp: 2.66 %, weft crimp: 5.5 %, weight: 120 g/m^2, fibre composition: 100 % cotton, type of warp yarn: ring yarn, type of weft yarn: rotor brushed yarn) and nonwoven (fibre used: viscose, method of production: hydro-entangled, weight: 80 g/m^2, filament diameter: 0.02 mm) wipes were tested. The engineering surfaces against which the friction was measured were glass plate and floor tile and the liquids used were water, petrol, vegetable oil and soap solution.

To study the frictional force of wipes, a friction tester is used. The instrument consists of a horizontal platform and a flat fabric holder, which is connected with a load cell with the help of a connecting rod, is placed on it. The principle of the measurement of friction is based on the reciprocatory motion of a horizontal platform under the normal weight against stationary fabric sample. The engineering surface, against which the wipe friction will be measured, has to be clamped on the horizontal platform. The horizontal platform is given traversing motion with the help of speed regulating motor. The desired amount of normal load is applied on the fabric holder. When the bottom surface with engineering surface mounted over that moves under the wipe surface, because of frictional between the surfaces, a frictional pull/push will be acting on the top surface (wipe surface) along the direction of movement of the lower surface. The load cell gives a signal corresponding to the frictional force acting on the fabric. In the present study the size of wipe surface is 8 cm × 5 cm. First the sample is fixed on the detachable sample holder and then it is allowed to wet for 2 minutes. After that the slider is kept at 45° angles and allowed to drain extra liquid for 5 minutes. After this the samples are taken to the friction tester. For testing of effect of speed, four speeds used were 50 mm/min, 100 mm/min, 150 mm/min, and 200 mm/min keeping constant normal load of 100 g. When the effect of normal load was studied, the four normal loads used were 75 g, 100 g, 125 g, and 200 g with the constant traverse speed of 100 mm/min. As the wiping is a dynamic activity, the frictional coefficient which is considered in the present study is dynamic frictional coefficient. The dynamic coefficient is measured in a simplistic way, i.e., the frictional resistance encountered while the wipe is in motion is divided by the normal load.

Results and Discussion

Figures 1 and 2 show the effect of normal load on frictional coefficient of nonwoven wipes against glass and floor tiles respectively. From the Figure 1 it can be observed that there is decrease in the coefficient of friction as the normal load ranges from 75 g to 150 g. The similar trend has been observed by Kothari *et al.* [1] in case of woven cotton fabrics. The relationship between the frictional force and normal load is found to be logarithmic, as was found by Wilson [4]. The

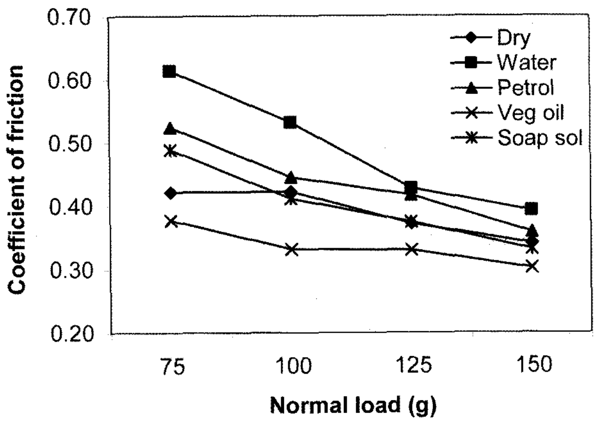

Figure 1. Effect of normal load on friction of nonwoven wipes wetted with different liquids against glass surface.

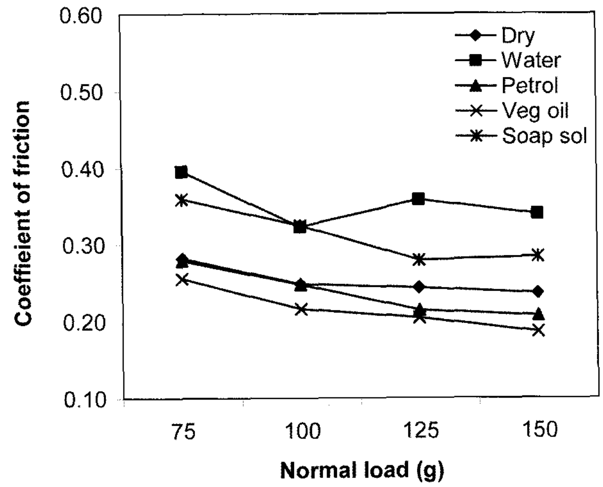

Figure 2. Effect of normal load on friction of nonwoven wipes wetted with different liquids against floor tile surface.

relationship is,

$$(F/A) = k\,(N/A)^n \text{ or, } \log(F/A) = \log k + n \log(N/A)$$

where, A is the area of contact, k is friction parameter and n is friction index.

This relation can be explained using adhesion theory of friction. According to this theory, with the increase in the normal pressure, there will be a reduction in the true area of contact. Here the relation between changes in the normal load to change in the real area of contact is nonlinear, causing reduction in the (F/N) value with the increase in the normal load. This may also be explained due to the bending of the surface fibres towards the fibre bulk, lateral compression of the fibrous mass at the higher pressure, i.e., flattening of the structure, the surface becomes more regular and there is a more uniform distribution of the load resulting in reduction of friction values.

The nonwoven wipe sample wetted with water shows higher coefficient of friction, even higher than dry, and the sample wetted with the vegetable oil is showing least coefficient of friction (Figures 1 and 2). For the sample wetted with water there is highest coefficient of friction. There is swelling of the fibre with the absorption of the water. The samples which are used for the experiment are hygroscopic in nature and there is absorption of water which leads to high frictional force. Glass water interface will having higher energy and breaking of these bonds requires higher frictional force. During wiping of wetted wipes the liquid-solid interaction force also try to resist the sliding of wipes over any surface. On the other hand the liquid also acts as a lubricant which in turn tries to reduce the sliding resistance. The observed phenomenon may be due to the fact that in case of water the former reason is playing the dominant role and increases the frictional resistance, where as in case of vegetable oil the later reason plays a dominant role. Figure 2 also shows that there is decrease in coefficient of friction of nonwoven wipe against floor tile surface as the normal load increases. Also the wetting with different types of liquids has almost similar trend on friction. But, the overall coefficient of friction against floor tile is lower than in case of glass surface. This is because the surface of the floor tile was textured, causing lower contact area which results lower frictional resistance.

The effect of sliding speed on frictional coefficient of nonwoven wipes against glass and floor tiles is shown in Figures 3 and 4 respectively. Figures 3 and 4 show that in general there is decrease in the coefficient of friction against glass and floor tile surfaces with the increase in sliding speed. For studying the effect of speed on friction a constant normal load 100 g is used. As there is increase in the traverse speed there is decrease in time of contact between sliding members. Frictional characteristics are time dependent. At higher speed of sliding there is there will be less number of actual contact points. So, the bonds at the junction points are broken easily resulting less frictional coefficient. It can also be observe from the Figures 3 and 4 that for the sample

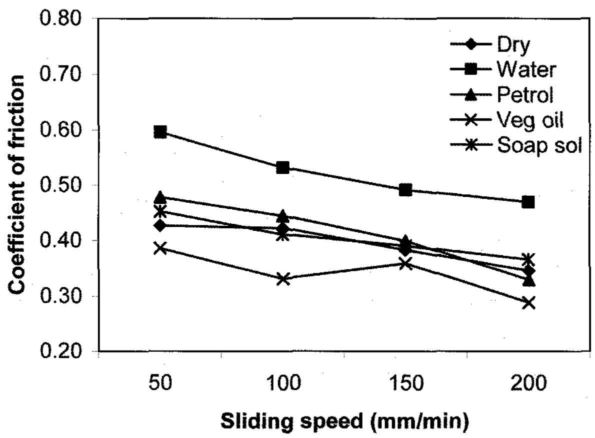

Figure 3. Effect of sliding speed on friction of nonwoven wipe wetted with different liquids against glass surface.

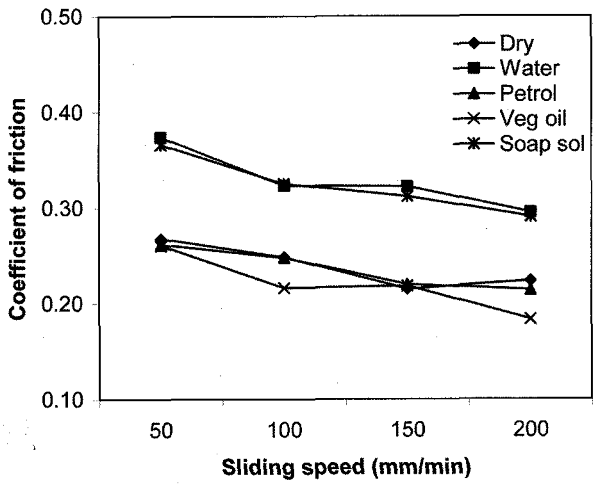

Figure 4. Effect of sliding speed on friction of nonwoven wipe wetted with different liquids against floor tile surface.

wetted with vegetable oil there is lower coefficient of friction and for the sample wetted with water there is higher coefficient of friction than the dry samples. The reason for the same has been explained earlier. The overall coefficient of friction against floor tile is also lower than in case of glass surface for all the level of sliding speed, as observed in case of normal load.

The frictional characteristics of woven wipe fabrics against glass and floor tile surfaces are shown in Figures 5-8. From these figures it is clear that the trend in frictional characteristics with the change in the normal load, sliding speed and type of wetting liquid is almost similar to that of nonwoven wipes. Only difference is observed is that in case of woven wipes the ranges of coefficient of friction either due to change in liquid type, normal load or sliding speed are in general smaller than that in case of nonwoven fabrics. This may be due to the fact that the nonwoven fabrics are more absorbent and also the there are more structural deformations take place due

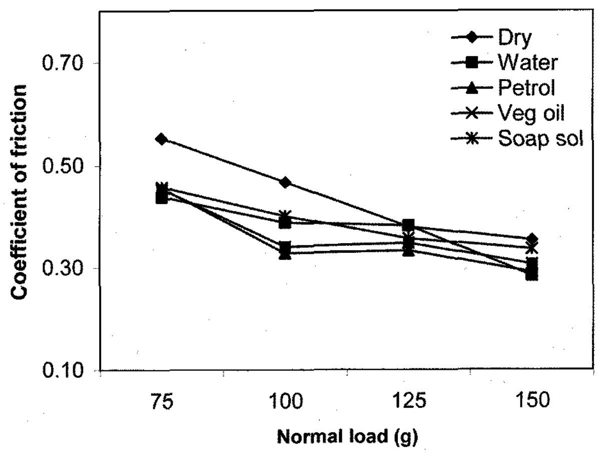

Figure 5. Effect of normal load on friction of woven wipes wetted with different liquids against glass surface.

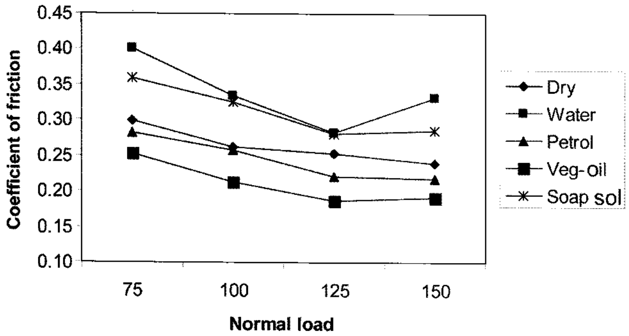

Figure 6. Effect of normal load on friction of woven wipes wetted with different liquids against floor tile.

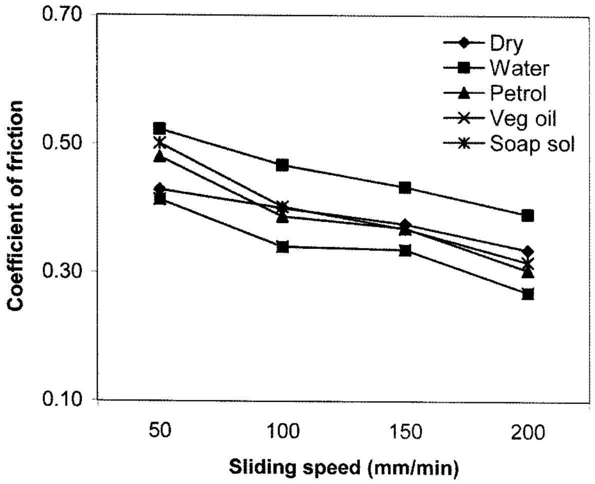

Figure 7. Effect of sliding speed on friction of woven wipe wetted with different liquids against glass surface.

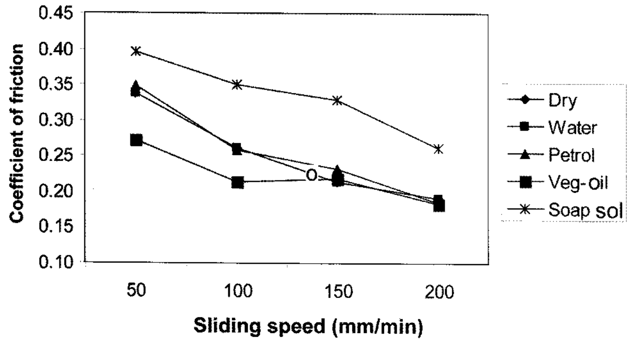

Figure 8. Effect of sliding speed on friction of woven wipe wetted with different liquids against floor tile surface.

to normal loading. By considering the dry sample frictional curves it can be observed that there is higher coefficient of friction for the nonwoven wipe than woven wipe. This can be due to the surface characteristics and constructional difference between these two samples. The woven wipe sample is a hairy one so obviously that will give the lesser coefficient of friction, as the no of contact points will be less due to hairs.

Conclusions

With the increase in the normal load the coefficient of friction goes on decreasing for both nonwoven and woven wipes and this trend is observed in both dry and wet wipes. The coefficient of friction of both nonwoven and woven wipes against glass surface is in general higher than the floor tile surface. The wipes wetted with water shows an increase in coefficient of friction as compared to dry sample, but there is reduction in the coefficient of friction when the wipe samples are wetted with vegetable oil. In case of dry wipes the coefficient of friction in case of nonwoven wipe is higher than the woven wipe. In case of woven wipes the ranges of coefficient of friction either due to change in liquid type, normal load or sliding speed are in general smaller than that in case of nonwoven fabrics.

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