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ENHANCING THE FRICTIONAL PERFORMANCE OF SPORT GLOVES

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ABSTRACT
The manufacturers of gloves need to enhance the gripping ability to develop their quality, where the adequate grip and tactile response under wide range of conditions are desired. It was recommended to cover the sport gloves by rubber layer fitted by small rubber circular discs on glove surface to improve gripping. In the present study, the effect of the cylindrical rubber protrusions proposed to be introduced in the surface of the gloves of the soccer goalkeeper, on friction coefficient is experimentally investigated. Friction coefficient displayed by the sliding of soccer ball on the rubber protrusions of different diameter and height at dry sliding is determined. Besides, the effect of the thickness of the rubber substrate is studied.

Based on the experimental observations, it was found that friction coefficient displayed by rubber protrusions showed significant increase with increasing the number and height of the protrusions. Friction values of the protruded rubber surfaces were much higher than that observed for smooth rubber surface. Added to that, it was revealed that the increased deformation of rubber is responsible for the contribution of friction, where, as the deformation increases, friction force increases. Rubber protrusions showed significant increase of friction coefficient with increasing substrate thickness. This behavior can be attributed to the increased deformation of rubber that increased the contact area.

KEYWORDS
Friction coefficient, rubber protrusion, sliding, soccer ball, goalkeeper, gloves.

INTRODUCTION
Gloves should enhance the ability of the goalkeeper to catch the ball. This can be achieved by controlling the friction between gloves and the ball. Friction coefficient of ten types of glove materials slid on the ball surfaces was determined, [1, 2]. Among them neoprene

coated glove displayed the highest friction coefficient. It was proposed to coat sport gloves by rubber layer to offer non-slip gripping. Several researches discussed the effect of friction, [3 – 10], where the friction force between the soccer ball and the goalkeeper gloves was determined. The effect of treads introduced in the surface of rubber on the friction coefficient, was discussed, [11]. At dry sliding, friction coefficient increased as the treads height increases. Tread grooves facilitate contact between the mating surfaces, [12 - 20]. They should be quite wide to allow better drainage capability on wet surfaces.

In soccer, catching and gripping of the ball are done by the palm of the goalkeeper gloves, while punching is made by the back of the gloves. It is recommended that the same friction coefficient values should be provided for both palm and backhand of the glove to prevent sliding of the ball on the glove surface, [21, 22]. That could achieved by developing the friction properties of the surface of the backhand of the sport glove to minimize the difference in friction coefficient between palm and backhand and provide efficient catching and punching of the soccer ball.

In the present work, the effect of cylindrical rubber protrusions of different diameters and heights introduced in the surface of rubber substrate on friction coefficient is experimentally investigated. The protrusions are intended to cover the glove of the goalkeeper to enhance the friction coefficient resulted from the sliding of soccer ball on the rubber protrusions at dry sliding.

EXPERIMENTAL

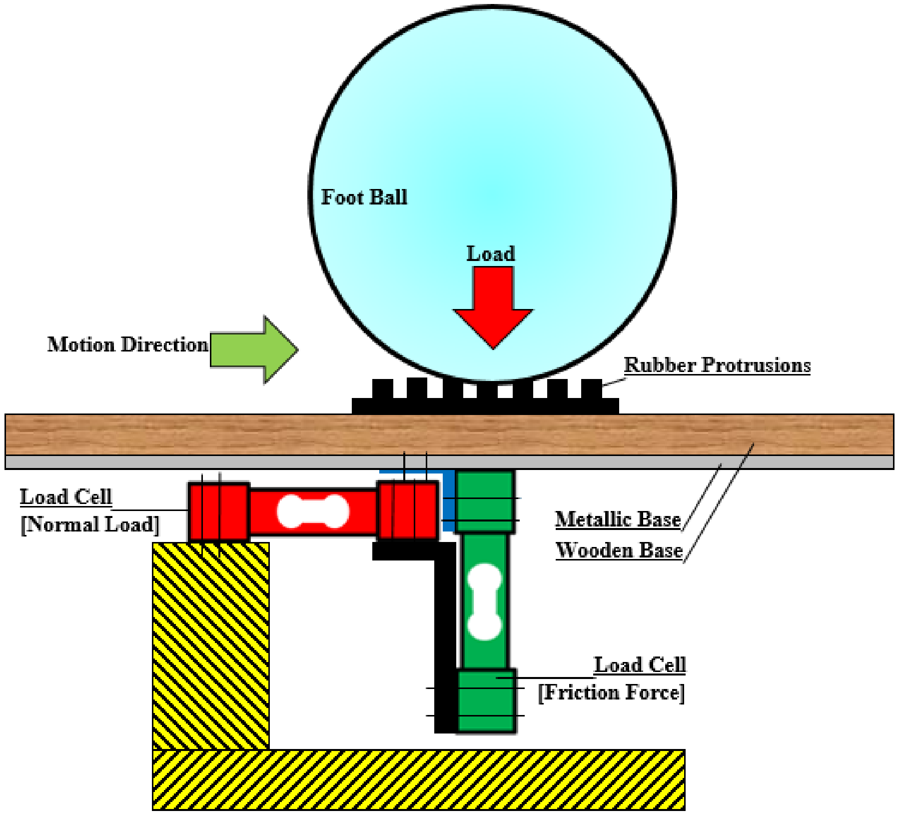

Fig. 1 Arrangement of the test rig.

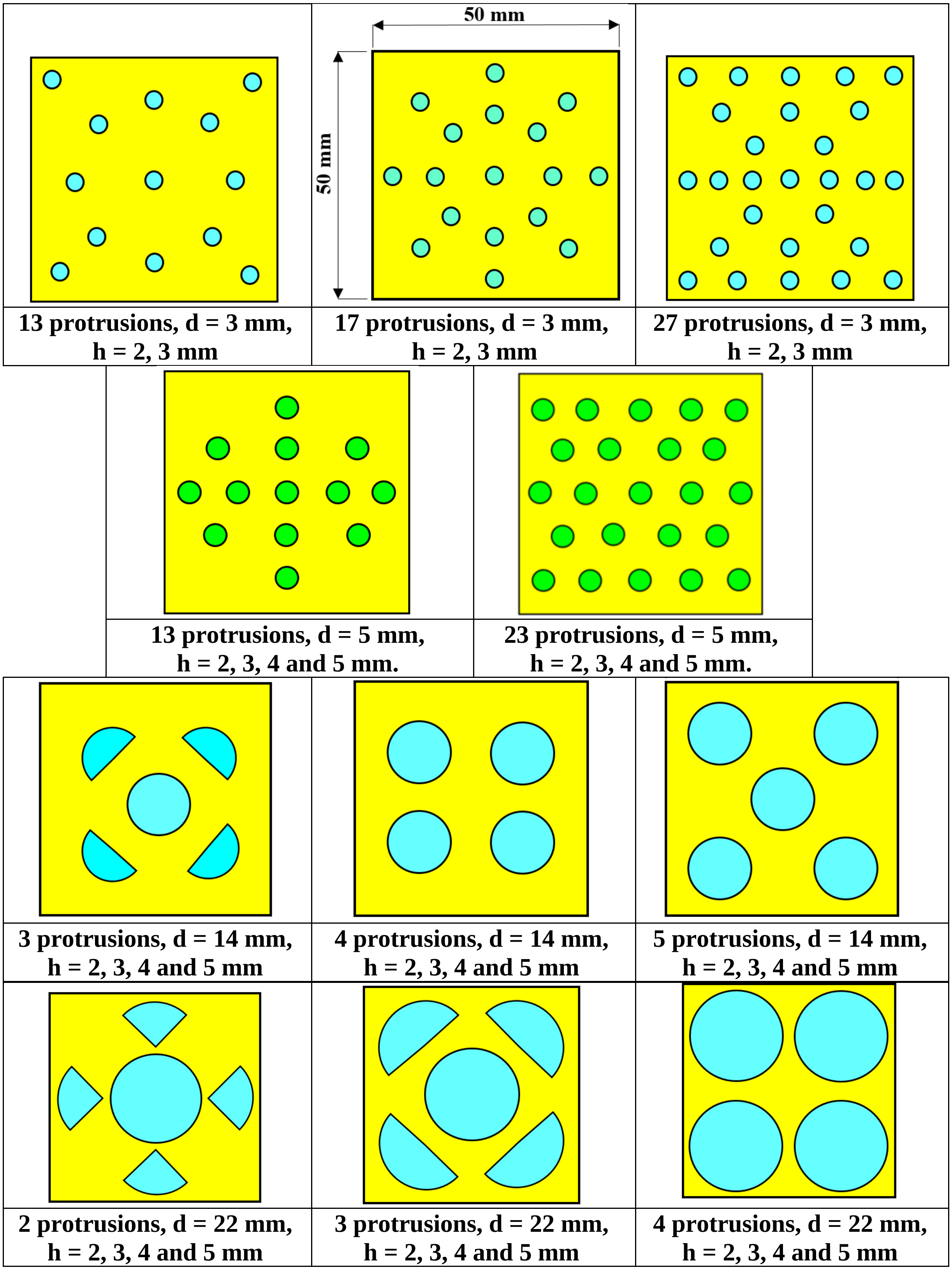

Fig. 2 Details of the rubber protrusions.

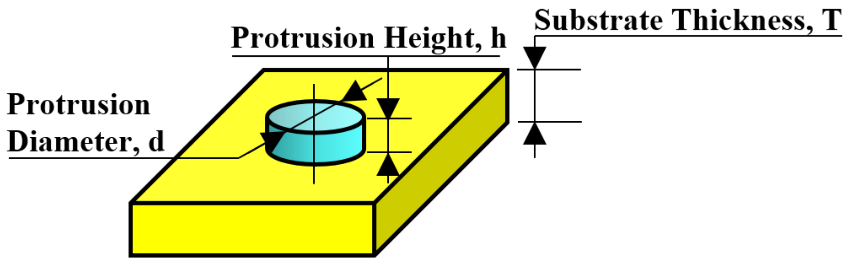

Fig. 3 Test specimens.

Experiments were carried out using a test rig designed and manufactured to measure the friction coefficient displayed by the sliding of the football against the rubber by measuring the friction force and the applied normal force. The tested rubber substrate of different protrusions were adhered to the base supported by two load cells to measure both the friction force and the applied load. Friction coefficient was determined by the ratio between the friction force and the applied load. The arrangement of the test rig is shown in Fig. 1, while the details of the rubber protrusion is shown in Fig. 2.

The tested rubber protrusions were in form of square sheets of 40 × 40 mm^2 and 3 mm thickness. Cylindrical protrusions are introduced in rubber surface of 22, 14, 5 and 3 mm diameter. The protrusion height was 2, 3, 4 and 5 mm for specimens of 22, 14 and 5 mm diameter, Fig. 3. While, specimens of 3 mm diameter the height was 1, 2 and 3 mm. the tested protrusions were adhered to rubber substrates of 3, 4 and 5 mm thickness. The hardness of the rubber was 43 ± 2 measured using a Shore-A hardness meter. The surfaces of the football and the rubber were thoroughly washed with detergent to remove the dirt and carefully were dried before the tests. Friction test was carried out at normal load of 50 N.

RESULTS AND DISCUSSION

Sport gloves should provide high efficient catching, holding and punching. The gripping and punching ability of the glove controls its quality. Under severe conditions, it should provide quite good grip, tactile and punching ability. The sport gloves should facilitate and enable the goalkeeper to successfully grip and punch the ball. This function is guaranteed by increasing adhesion between ball and the surface of the gloves. Recent experiments showed that neoprene coated glove offered relatively high values of friction coefficient. Recently, it was recommended to cover the sport gloves by rubber layer to provide non-slip gripping, [1, 2]. This can be achieved by introducing small rubber circular discs on glove surface to improve gripping.

The results of experiments carried in the present work to investigate the effect of the diameter and height of the rubber cylindrical protrusions on the friction coefficient are illustrated in Figs. 4 – 7. Friction coefficient displayed by rubber protrusions of 22 mm diameter showed increasing trend with increasing the number and height of the protrusions, Fig. 4. Test specimens of four protrusions of 5 mm height displayed the highest friction values. As the diameter of the protrusion decreased to 14 mm, friction coefficient values increased, Fig. 5. All the values of the protruded rubber surfaces were much higher than that observed for smooth rubber surface (0.6) at 50 N load. The highest

values recorded for 22 and 14 mm diameter were 1.1 and 1.3 respectively. The increased trend of friction coefficient with decreasing protrusion diameter was observed, Figs. 6 and 7, for protrusion diameter of 5 and 3 mm respectively.

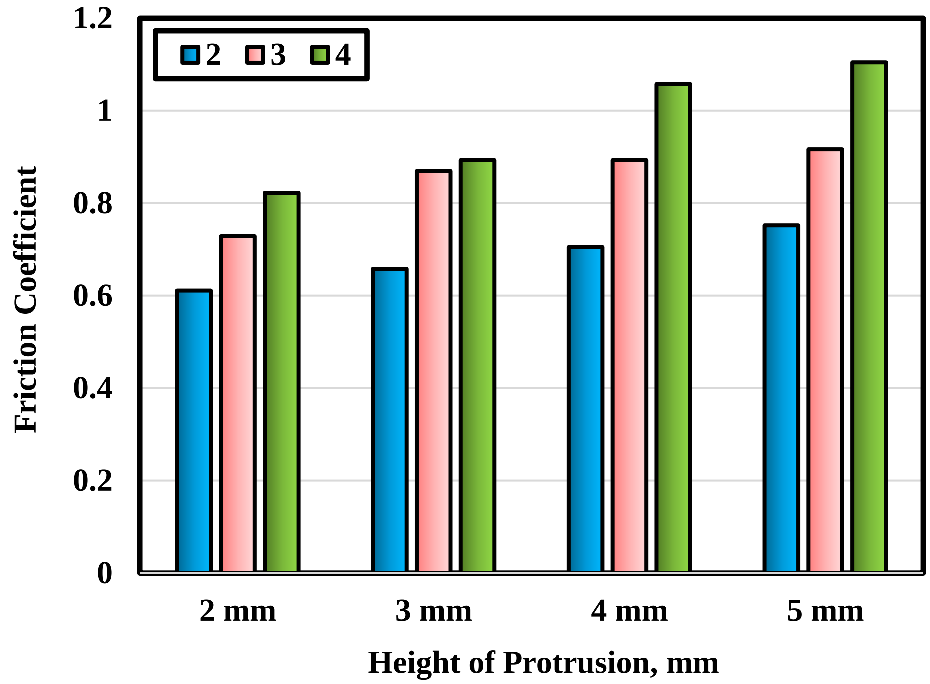

Fig. 4 Friction coefficient displayed by rubber protrusions of 22 mm diameter.

The frictional behavior can be interpreted on the bases of the mechanism of rubber friction. When a rubber block is sliding on a substrate, the rubber in the contact area sticks to the substrate, then the rubber will continue to move relative to the substrate so that the rubber gets deformed until it slips. After stick and slip, the rubber sticks to the substrate again. The steps of the mechanism are concluded in stick, deformation and slip, Fig. 8. The shear stress acting in the deformation process is the contribution of friction of rubber, where as the deformation increases, friction force increases. Friction coefficient can be expressed as follows:

$$\mu = \mu_A + \mu_D$$

Where μ_A is the adhesion component resulted from the molecular interaction between rubber and substrate. This component occurs under dry sliding and is reduced in the presence of lubricant and fluids. Smooth substrate surface increases the contact area and consequently the friction force increases due to the low elastic modulus of rubber. μ_D is the deformation component that originates from the deformation of rubber. As result of squeeze action of rubber surface, the contact area increases leading to an increase in the friction force. This effect is dominating for smooth surfaces, while rough ones show lower values due to the smaller contact area. It seems that presence of rubber protrusions increased the deformation of the rubber and consequently its contribution to the friction coefficient value increased. This can explain the best behavior of protrusion of the smaller diameter and higher height.

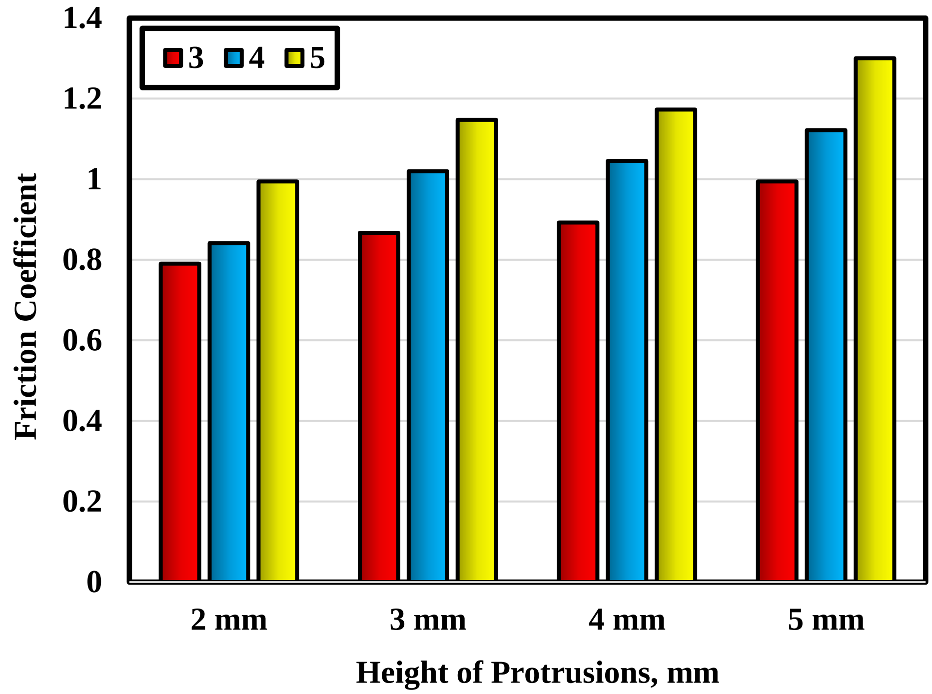

Fig. 5 Friction coefficient displayed by rubber protrusions of 14 mm diameter.

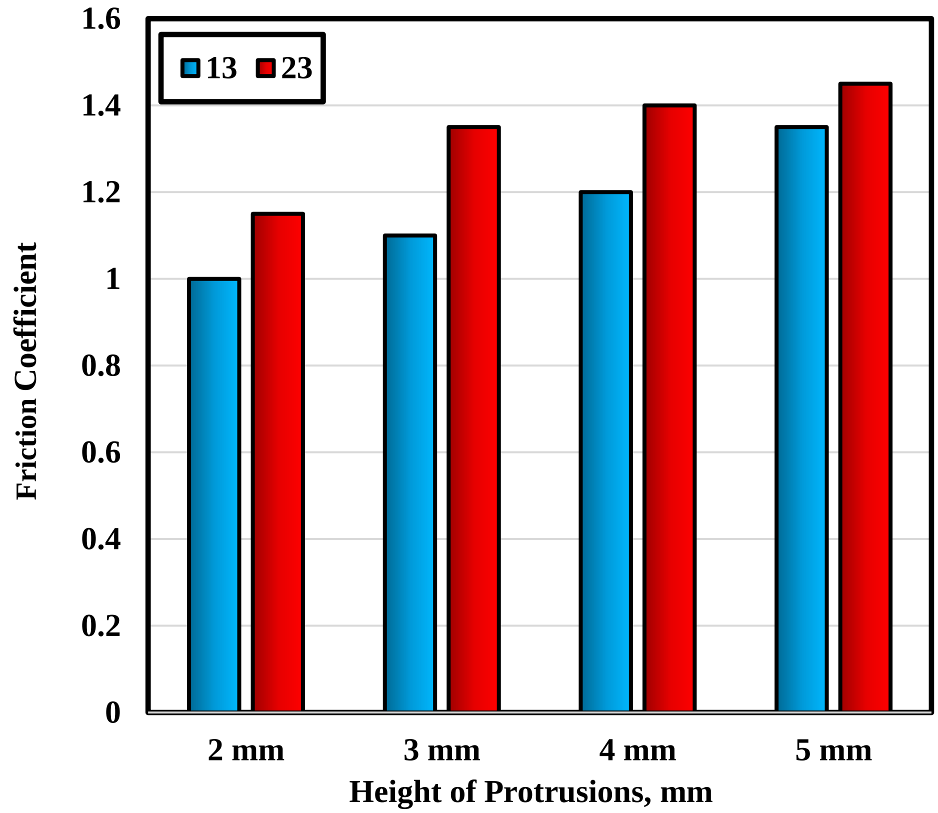

Fig. 6 Friction coefficient displayed by rubber protrusions of 5 mm diameter.

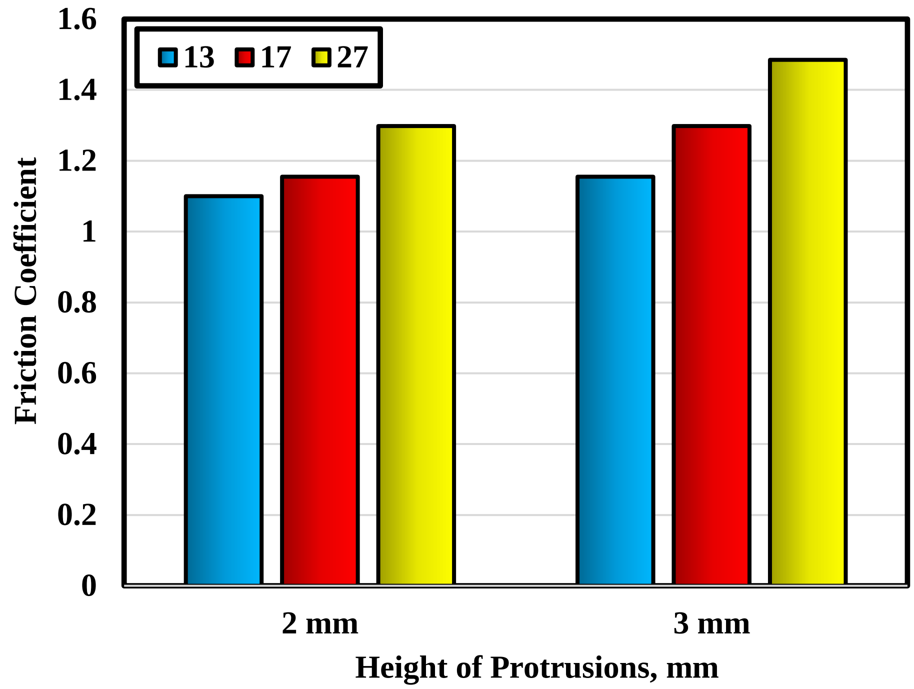

Fig. 7 Friction coefficient displayed by rubber protrusions of 3 mm diameter.

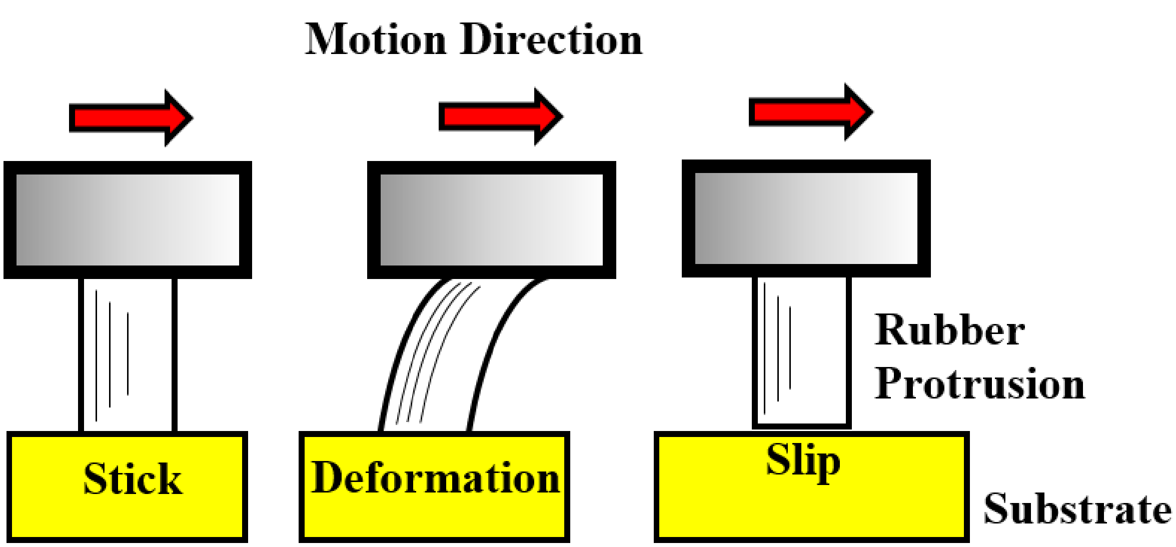

Fig. 8 Illustration of the mechanism of friction rubber.

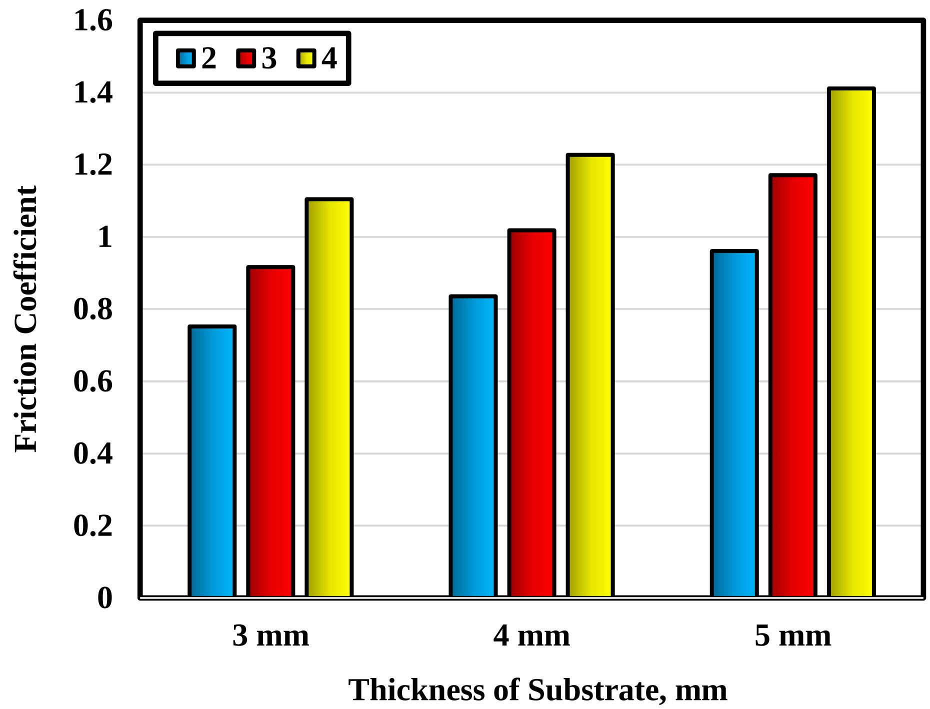

Fig. 9 Friction coefficient displayed by rubber protrusions of 22 mm diameter.

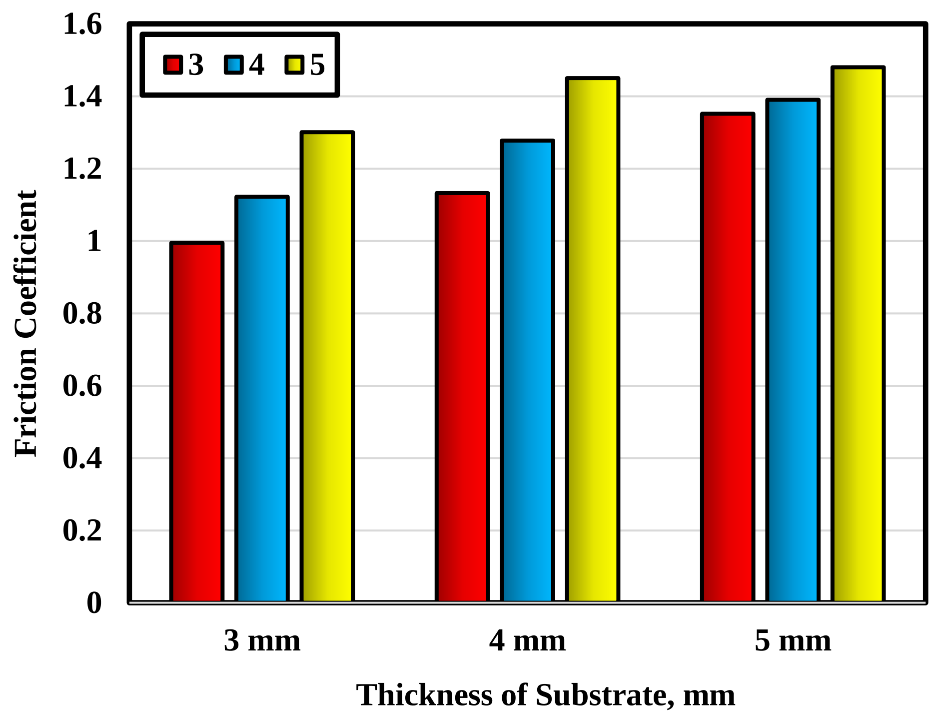

Fig. 10 Friction coefficient displayed by rubber protrusions of 14 mm diameter.

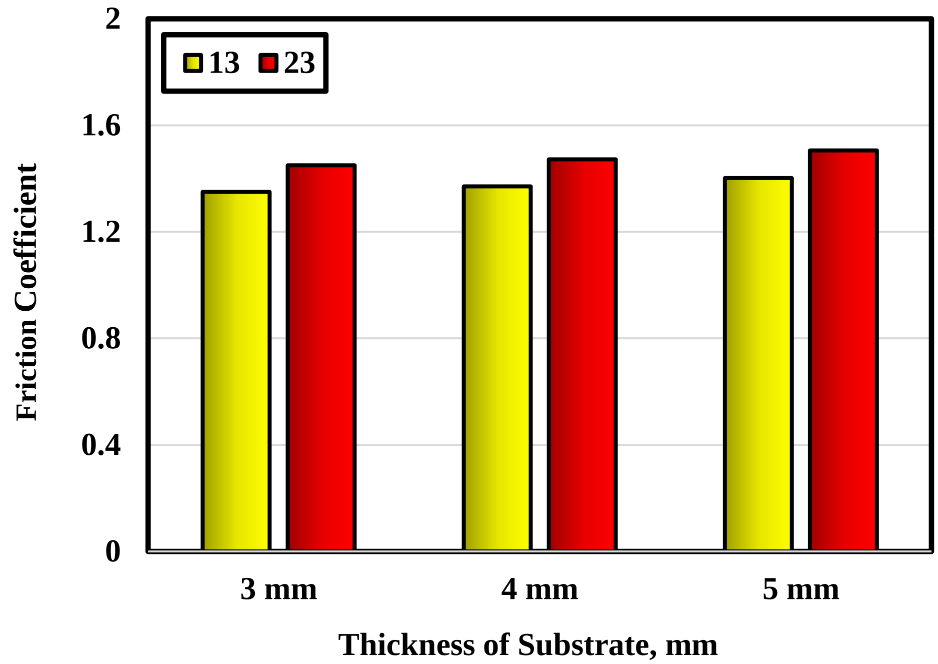

Fig. 11 Friction coefficient displayed by rubber protrusions of 5 mm diameter.

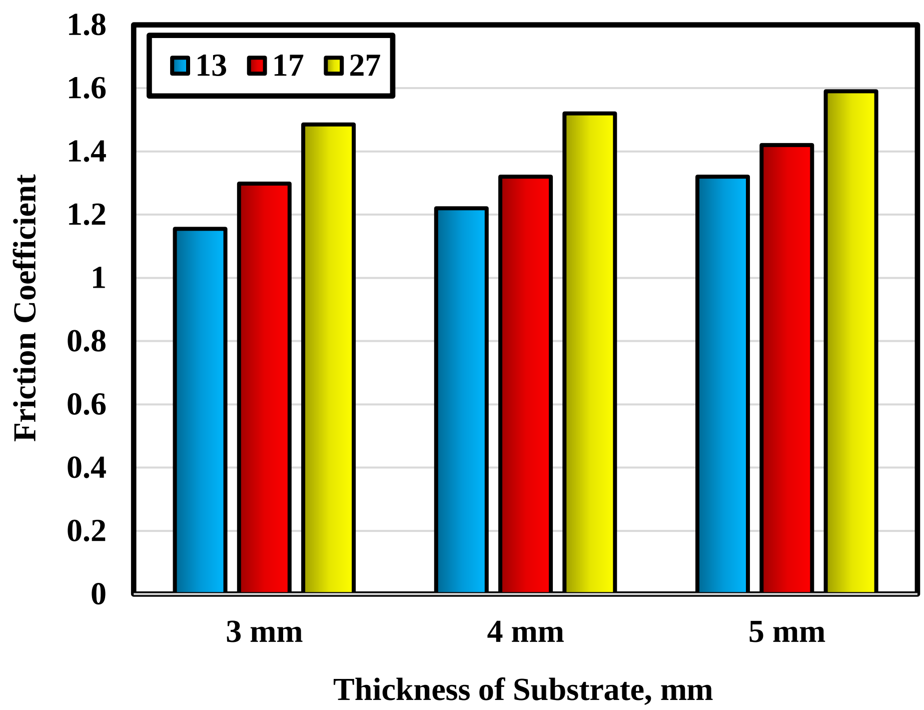

Fig. 12 Friction coefficient displayed by rubber protrusions of 3 mm diameter.

The effect of the substrate thickness on friction coefficient is shown in Figs. 9 – 12. Rubber protrusions of 22 mm diameter showed significant increasing trend of friction coefficient with increasing substrate thickness, Fig. 9. This behavior can be attributed to the increased deformation of rubber where contact area increased. The highest friction values were displayed by 5.0 mm substrate thickness. Decreasing the diameter of the protrusion gave relatively higher friction coefficient due to the increased deformation of contact asperities, Fig. 10. Further friction increase was observed for protrusions of 5.0 and 3.0 mm diameter is shown in Figs. 11 and 12 respectively. Friction of rubber depends on the relatively low elastic modulus and the high internal friction. The friction force between rubber and glove surface is divided into adhesion and deformation. The deformation components results from the internal rubber friction that increases with increasing substrate thickness. Adhesion will deform the rubber at the sliding surface, that increases the friction force.

CONCLUSIONS

1. Friction coefficient displayed by rubber protrusions showed significant increase with increasing the number and height of the protrusions.
2. The values of friction coefficient determined for the protruded rubber surfaces were much higher than that observed for smooth rubber surface.
3. The increased deformation of rubber is responsible for the contribution of friction. As the deformation increases, friction force increases.
4. Rubber protrusions showed significant increasing trend of friction coefficient with increasing substrate thickness. This behavior can be attributed to the increased deformation of rubber where contact area increased

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