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ENHANCING THE ABILITY OF FOOTBALL GOALKEEPER TO CATCH THE BALL

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ABSTRACT

The information provided by this investigation can develop the friction performance of gloves designed for football goalkeepers to enhance catching and holding the ball. The outer layer of the gloves is made of latex, while the outer layer of the football is coated by polyurethane (PU) or polyacrylonitrile butadiene styrene (ABS). The development depends on reinforcing latex by iron particles, carbon fibers (CFs) and carbon nanoparticles. The aim of the present work is to investigate the effect of reinforcing latex by the proposed materials on friction coefficient displayed by sliding of latex (surface of the gloves) on PU and ABS coatings (surface of the football).

It was found that, friction coefficient displayed by latex filled by iron particles sliding on ABS slightly increased, while sliding of latex on PU displayed relatively higher friction than that observed for ABS. The effect of iron particles on friction was more pronounced. Besides, combining carbon nanoparticles and CFs to reinforce latex sliding on ABS displayed significant friction increase, where 60 % of the sheets area covered by CFs represented the highest friction values. The friction increase can be explained on the fact that presence of iron particles, CFs and carbon nanoparticles generated magnetic field that increased the adhesion force between the two contact surfaces. In addition to that, the friction increase may be from the increase of ESC generated from triboelectrification, where an electric field is generated across the two contact surfaces. The reinforcing materials are responsible for the generation of the magnetic field.

KEYWORDS

Electrostatic charge, friction coefficient, polyethylene, polyurethane, and polypropylene.

INTRODUCTION

Working gloves keep the hands of the operators safe and enhance their ability to handle materials. This ability can be developed by controlling the friction property of the gloves. Electrostatic charges (ESC) generated from friction of the gloves affect the tactile property of surfaces that control the safety of materials handling. The influence of pre-triboelectrification on friction coefficient displayed by polymeric materials by sliding of polyethylene (PE) on polyurethane (PU) at dry sliding, was investigated, [1]. PU in form of 0.5 mm coating was adhered into polypropylene (PP) as well as copper substrates.

The experiments showed that the intensity of ESC generated on the sliding surfaces depends on their ranking of material in the triboelectric series. It was concluded that adhesion depends on ESC. In addition to that, it was found that metallic substrate of polymeric coatings leak some of the ESC outside the sliding surface causing drastic decrease in friction coefficient. Finally, pre-triboelectrification of surfaces before sliding by rubbing each other reduces the values of friction coefficient.

The influence of pre-triboelectrification on friction coefficient displayed by polymeric materials by sliding of polypropylene (PP) on polyester (PET) at dry sliding was investigated, [2]. The experiments showed that PET provided by thin steel sheets displayed the highest friction values followed by steel textiles, CF, copper textiles, steel fibers and aluminium film. The highest values of ESC were recorded by inserting steel fibers in the back of PET sheet followed by copper textile and steel sheet, while Al film under PET sheet showed no effect on ESC generated on the two sliding surfaces. The same trend was observed for ESC generated from PP and PET when CF and steel textiles were inserted behind PET.

The dependency of friction coefficient on electrostatic charge (ESC) generated from sliding of polyethylene (PA) on polytetrafluoroethylene (PTFE) was investigated, [3]. It was found that ESC generated on PA and PTFE reinforced by CF and friction coefficient increase as CF content increases. This observation strengthens the dependency of friction coefficient on ESC. Therefore, specific information about the value of ESC can be useful in controlling friction coefficient. This behavior can be explained on the bases that increasing ESC can increase the adhesion between the two contact surface and consequently friction coefficient increases. Besides, ESC can be controlled by applying magnetic or electric field. This behavior can be used in controlling friction coefficient of polymeric material when they are contacting each other.

Tactile behaviour is one of the critical properties that control the safety of materials handling. The tested materials based on their friction coefficient in order to increase the safety of glass handling were screened, [4]. Friction measurements were carried out to eight different materials by sliding against glass sheet at dry, water wet and oily conditions. Sensors that can reveal tactile were developed in order to equip robot hands with such a sense, [5, 6]. Development of the materials used in robots is a critical factor for increased safety and efficiency. Gripping forces may be reduced using high-friction surfaces, [7]. Thus, we selected foamy polymers as a suitable type of friction-enhancing material for grippers of the climbing robot. Friction coefficient of the contacting surfaces can control the safety of material handling through increasing the gripping force. The friction coefficient of the tactile sensor was tested, [8].Variety of materials such as foamy polymers and sandwich-like microstructures were tested as shoe soles for potential robot, [9, 10]. The friction coefficient displayed by hands sliding against the surface of the steering wheel covers was discussed, [11]. Measurement of friction coefficient is of critical importance in assessing the proper friction properties of steering wheel covers and their suitability to be used in application to enhance the safety and stability of the steering process during car driving.

It is well established that there is an increasing rate in car accidents. An acceptable value of friction should be obtained to prevent slip between the hands of the driver and the surface of the steering wheel. The knowledge of steering-wheel grip force

characteristics of the drivers may benefit the automobile designers and manufacturers to improve the quality of their products in terms of comfort and driving performance. The steering-wheel grip force of male and female drivers driving an automobile was studied, [12, 13]. Results indicated that the vehicle speed and the road condition did not significantly affect these response variables.

Gloves designed for football goalkeepers provide them with high efficient catching and holding the ball. They enable the goalkeeper to catch and punch a ball away. Gloves have also come into widespread use in sports such as football. Quantitative measurements of the friction coefficient displayed by the sliding of the ball on glove surface were carried, [14]. It was concluded that neoprene coated glove recorded relatively higher friction coefficient values up to 1.13. The high friction values highlight the importance of proper choice of the glove materials. Besides, the materials tested as surface coatings for the gloves of the football goalkeepers can be ranked based on friction coefficient displayed by sliding against football. The high friction difference at low and high loads confirms the importance of proper choice of glove materials of consistent friction trend with increasing the applied load.

It is necessary for the goalkeeper to wear gloves to enable him to catch the ball. The material of the gloves should provide grip properties, protect the hands, act as a shock damper and improve ball retention properties, [15, 16]. The gloves should be designed to prevent bending backwards of the fingers when saving, [17], and allow the fingers to flex forwards to catch the ball. In football, goalkeeper needs gloves to keep his hand safe and enhance his ability to catch the ball. Quantitative measurements of the electrostatic charge generated from the sliding of the ball against the glove surface were carried out, [18]. It was found that the gripping ability of the glove is one of the main factors to evaluate its quality. It should provide an adequate grip and tactile response under a wide range of conditions. The other factor is the health of goalkeepers which is of great concern. The materials of the ball as well as the gloves of goalkeepers should be selected on the basis of generation of low ESC. The experiments showed that ESC generated on the glove surface could be controlled by proper selection of the materials of appropriate surface qualities for practical use. ESC values generated from the sliding of the ball on the gloves of the goalkeeper can be doubled and accumulated so that they affect his physical condition during the match.

Little attention was considered for the generation of ESC of the sliding of the ball on the gloves of the goalkeeper. It is necessary to study the electrification of polymeric materials. It is well known that when two different materials contact each other, they may get charged, [19]. This tribocharging phenomenon is also known as triboelectrification when materials rub each other. Triboelectric static charges built up on human skin and or clothes in direct contact with human body are very harmful and can create serious health problems, [20]. Based on the experiments carried out, it was found that, at dry sliding, iron nanoparticles addition into epoxy matrix increased friction coefficient with increasing iron content. Voltage drastically decreased with increasing iron content. Voltage showed the maximum values for epoxy free of iron. The electrical charges have been taken into account on friction between the two insulating materials. The change, in friction and electric charge of alumina sliding against polytetrafluoroethylene (PTFE) under boundary lubrication conditions, was measured, [21]. Specific information about the value of the electrical charge can be useful in controlling friction coefficient.

The aim of the present experiments is to investigate the effect of reinforcing latex by each of iron particles, CFs and carbon nanoparticles on friction coefficient displayed by sliding of latex on PU and ABS coatings.

EXPERIMENTAL

Experiments have been designed to test the friction coefficient displayed by latex sliding on polyurethane. Latex has been reinforced by CF and filled by iron particle as well as carbon nanoparticles to investigate the effect of magnetic field on friction coefficient. Latex sheets of 0.25 mm thickness have covered soft paper of 50 × 50 mm^2 and 20 mm thickness. Two types of counterfaces were used. The first was polyurethane (PU) coating adhered to copper sheet, while the second was Acrylonitrile Butadiene Styrene (ABS). Latex surface has pressed and slid against PU surface, Fig. 1. Latex was reinforced by paper sheets of 0.25 mm thickness, where iron particles (30 – 50 µm particle size) as well as carbon nanoparticles (20 – 30 nm particle size) were adhered on their surfaces. Besides, sheets of polyamide (PA), polymethyl methacrylate (PMMA) and polytetrafluoroethylene (PTFE) of 0.25 mm thickness were used as reinforcement.

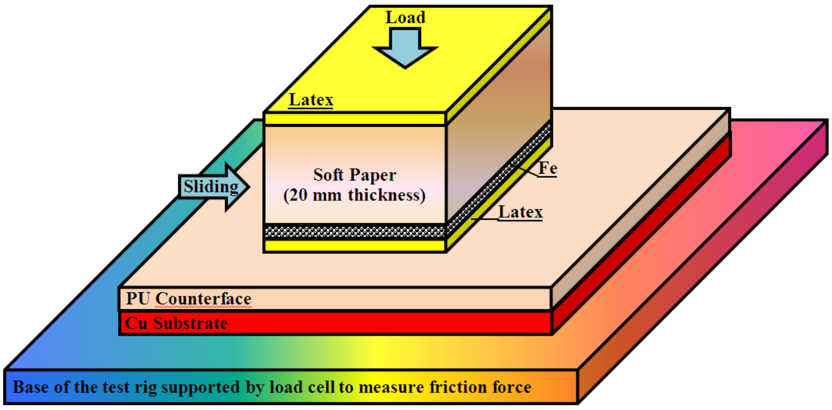

Fig. 1 Arrangement of the tested materials.

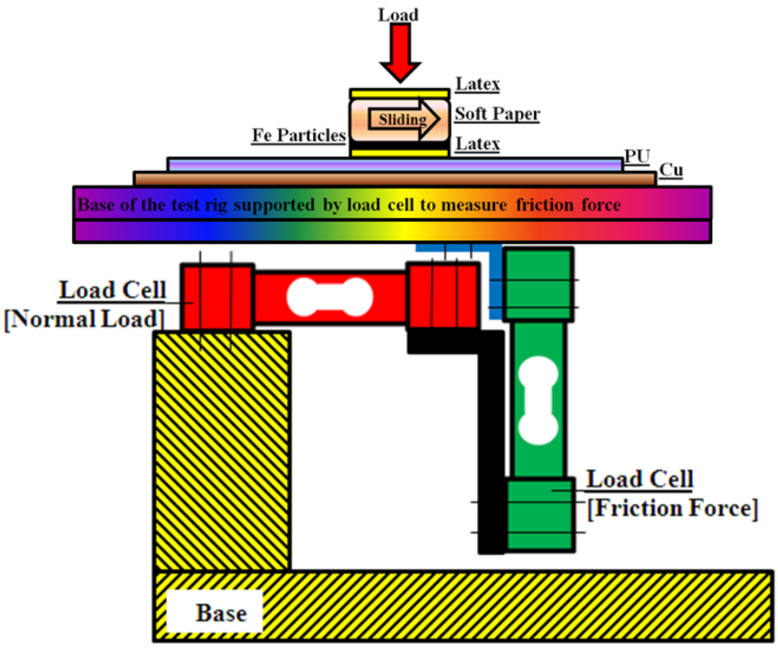

Fig. 2 Arrangement of the friction measurement.

The applied force was ranging from 3 to 18 N. The sliding distance was 200 mm. After sliding, ESC generated on the two sliding surfaces was measured. The friction force was measured by the deflection of the load cell of the test rig, [20]. The ratio of the friction force to the normal load was considered as friction coefficient. The load was applied by weights. The test speed was nearly controlled to be 2 mm/s. All measurements were performed at 30 ± 2^{o} C and 50 ± 10 % humidity.

RESULTS AND DISCUSSION

Friction coefficient displayed by latex filled by iron particles sliding on ABS, Fig. 2, slightly decreased with increasing normal load. Slight increase in friction was observed in the presence of iron particles. It seems that presence of iron particles generated magnetic field that increased the adhesion force between latex and ABS. The values of friction coefficient were ranging between 1.06 and 0.85. Sliding of latex on PU displayed relatively higher friction than that observed for sliding against ABS, Fig. 3. The effect of iron particles on friction was more pronounced where the values displayed in the presence of iron particles were 1.15 and 0.88 at 3 and 18 N respectively. In the absence of iron particles the friction values were 1.03 and 0.68 at 3 and 18 N respectively. Reinforcing latex by CFs was more effective than iron particles when sliding on PU, Fig. 4. The highest friction values were observed when the reinforcement surface was covered by 60 % CFs.

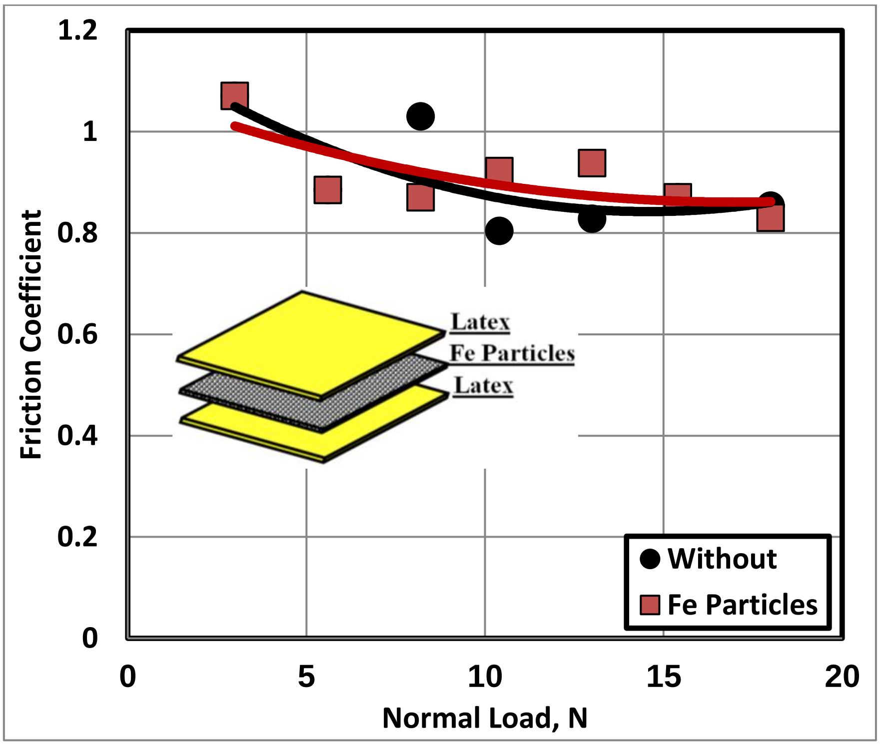

Fig. 2 Friction coefficient displayed by latex sliding on ABS.

Friction coefficient displayed by latex filled by carbon nanoparticles sliding on PU is shown in Fig. 5. Latex free of carbon nanoparticles showed higher friction than carbon filled latex. Then latex was reinforced by polymeric sheets like PA, PMMA and PTFE showed lower friction values than latex without reinforcement, Fig. 6.

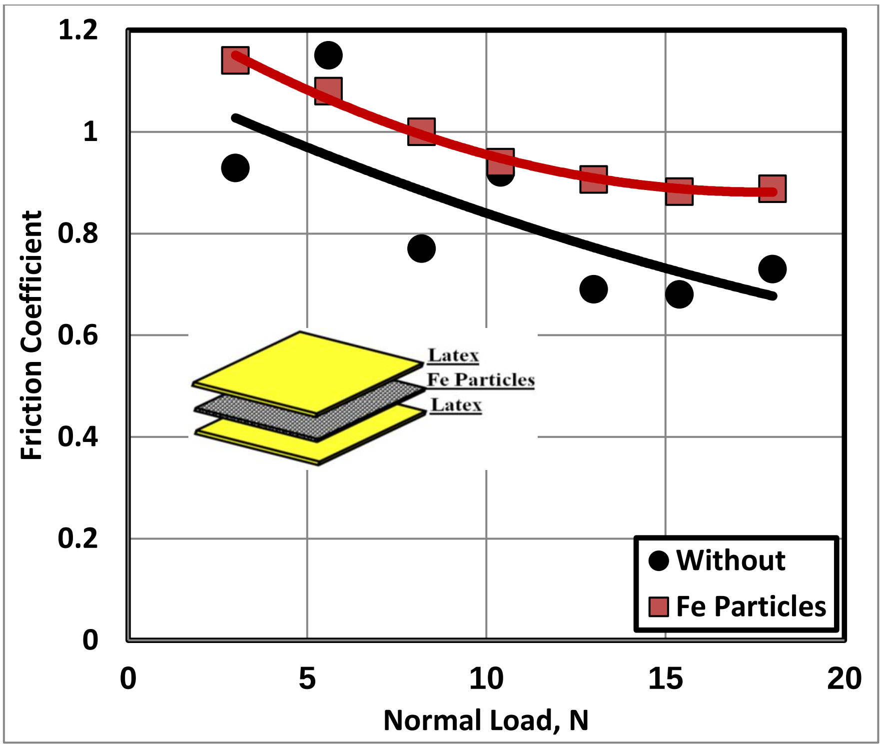

Fig. 3 Friction coefficient displayed by latex sliding on PU.

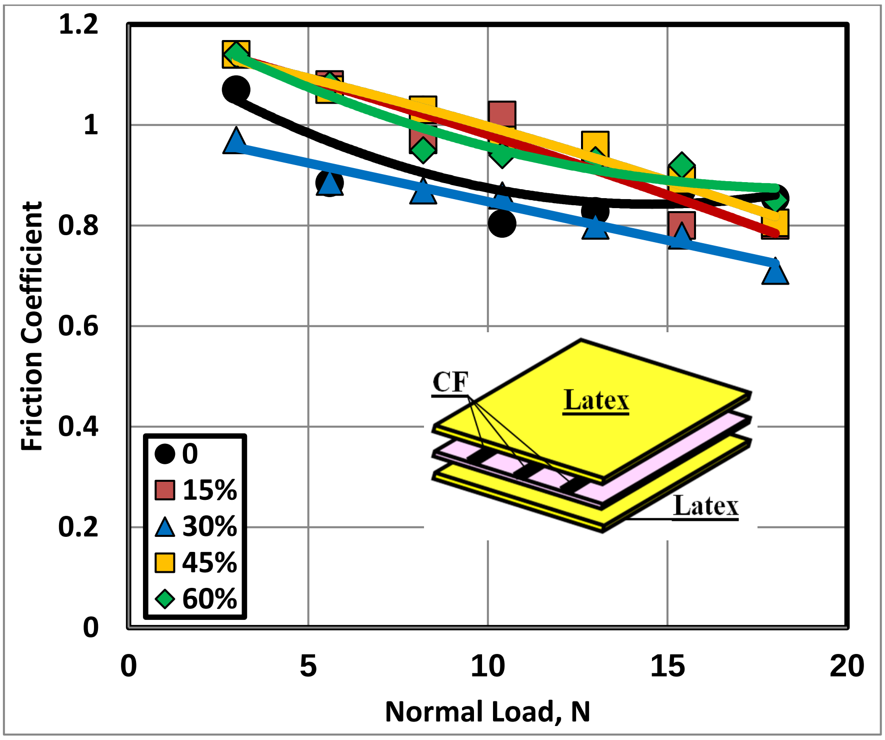

Fig. 4 Friction coefficient displayed by latex reinforced by CF sliding on PU.

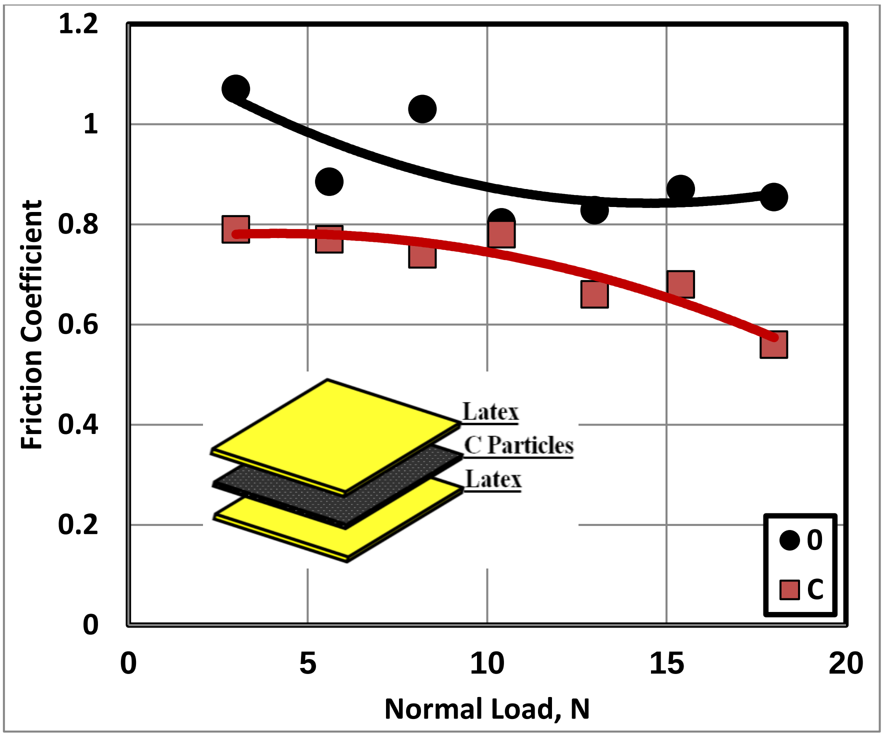

Fig. 5 Friction coefficient displayed by latex filled by carbon nanoparticles sliding on PU.

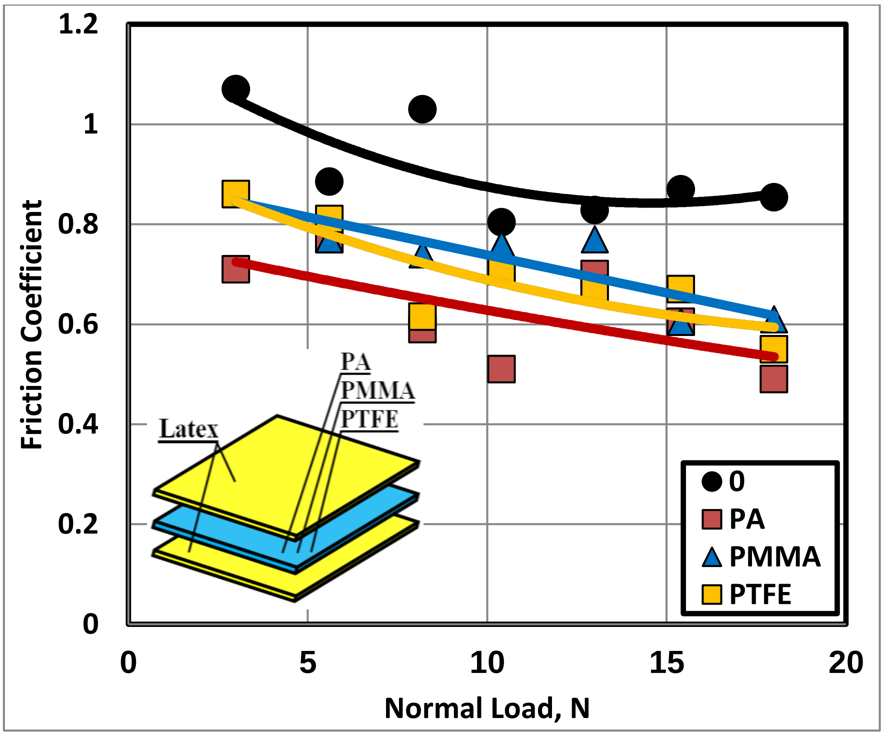

Fig. 6 Friction coefficient displayed by Latex reinforced by polymeric sheets sliding on PU.

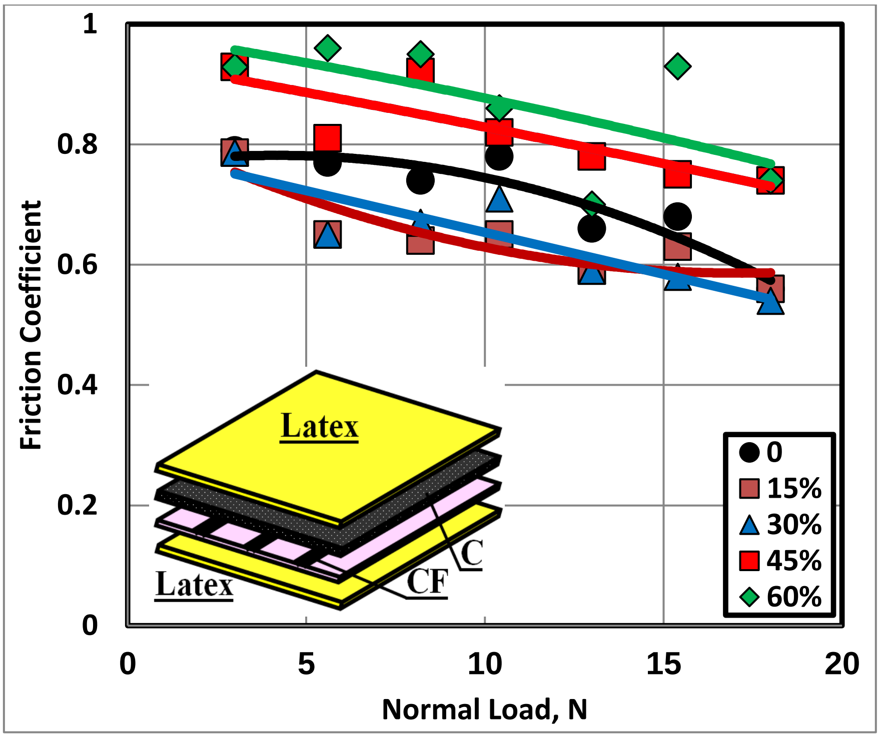

Fig. 7 Friction coefficient displayed by latex filled by carbon nanoparticles, reinforced by CFs that sliding on ABS.

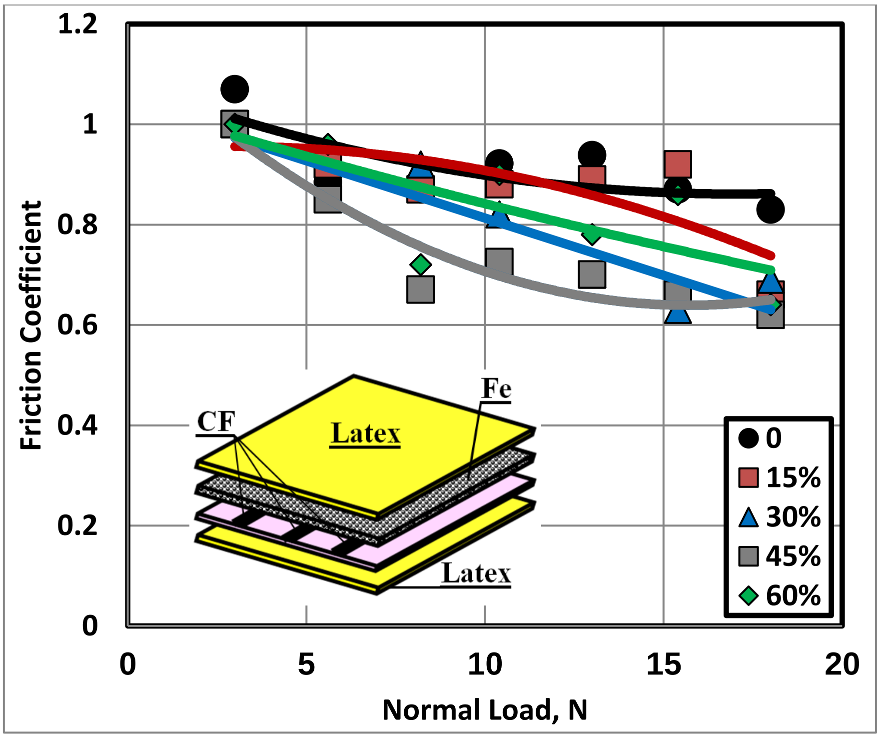

Fig. 8 Friction coefficient displayed by latex filled by iron particles and reinforced by CF that sliding on ABS.

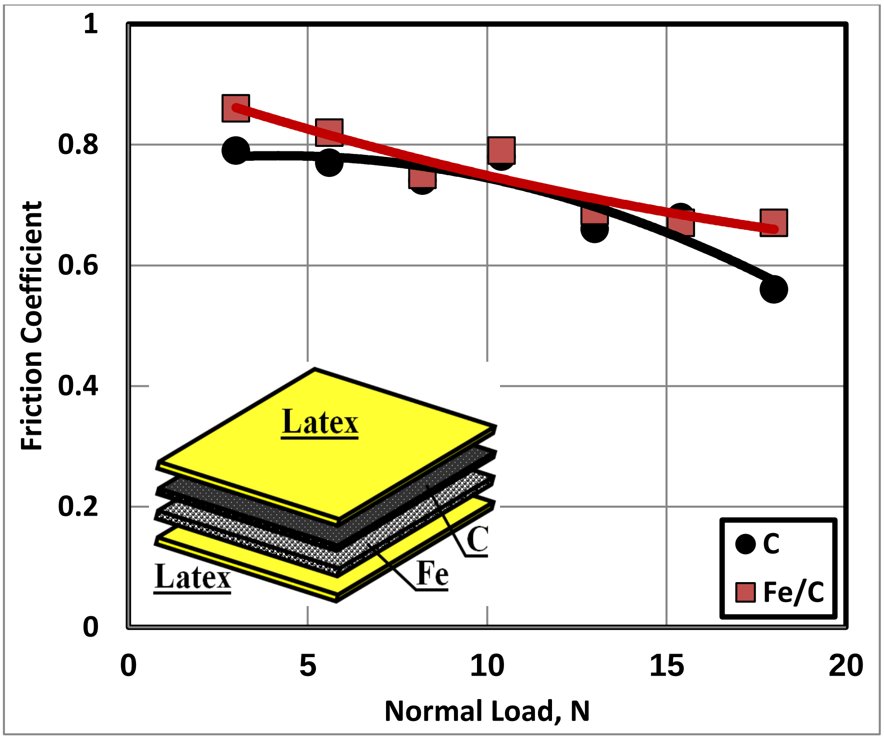

Fig. 9 Friction coefficient displayed by latex filled by carbon nanoparticles and iron particles that sliding on ABS.

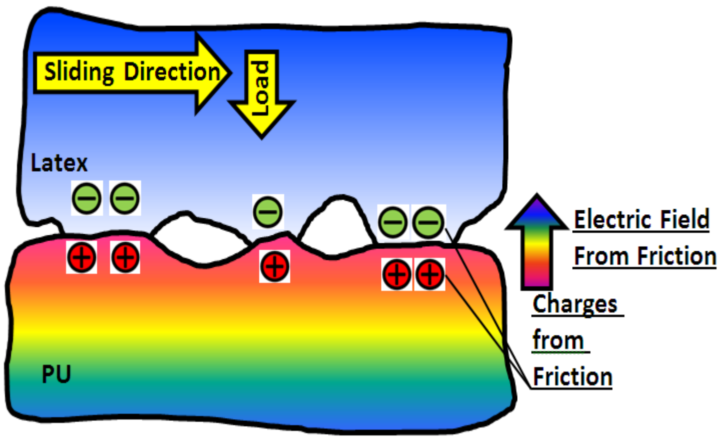

Fig. 10 Generation of ESC on the sliding surface. An electric field will be generated as result of the ESC.

Combining carbon nanoparticles and CFs to reinforce latex sliding on ABS displayed significant friction increase, Fig. 7, where sheets area of covered by fraction of 60 % CFs represented the highest friction values. This observation strengthens that combination to increase friction coefficient. In contradiction to that, combining iron particles and CFs showed drastic friction decrease, Fig. 8, where latex free of reinforcement illustrated the highest friction. Friction coefficient displayed by latex filled by carbon nanoparticles and iron particles sliding on ABS, Fig. 9, showed slight friction increase compared to latex without reinforcement.

In order to explain the enhancement in friction coefficient based on the effect of iron particles, CFs and carbon nanoparticles. It is necessary to discuss the relationship between friction coefficient and ESC generated from friction. During contact and separation as well as sliding, double layer of ESC is generated on the two contact surfaces, Fig. 10, where the intensity of ESC depends on the ranking of the two contact materials in the triboelectric series. As result of that an electric field is generated across the contact surfaces.

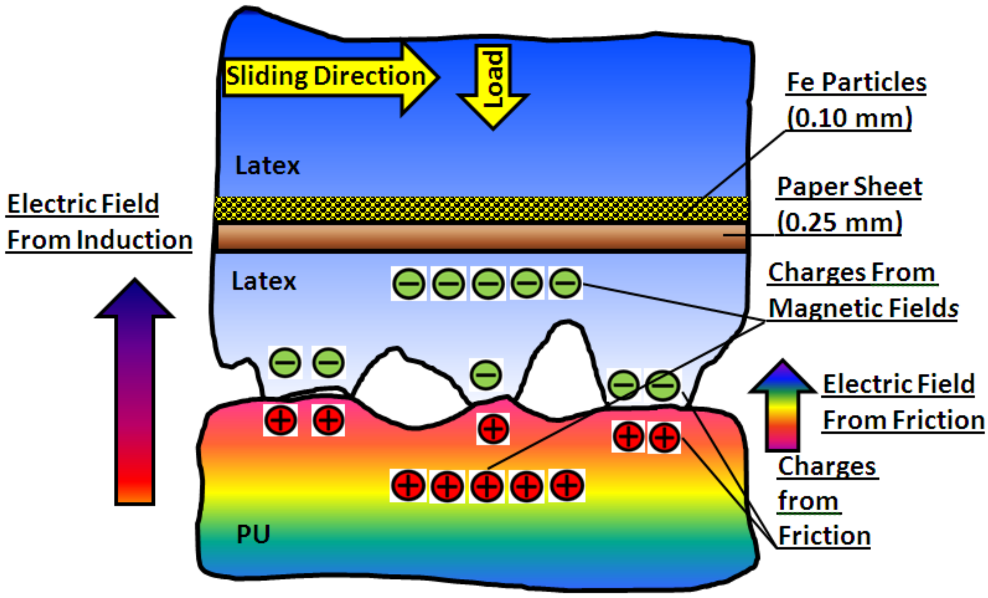

Fig. 1 Electric field generated on latex reinforced by iron particles.

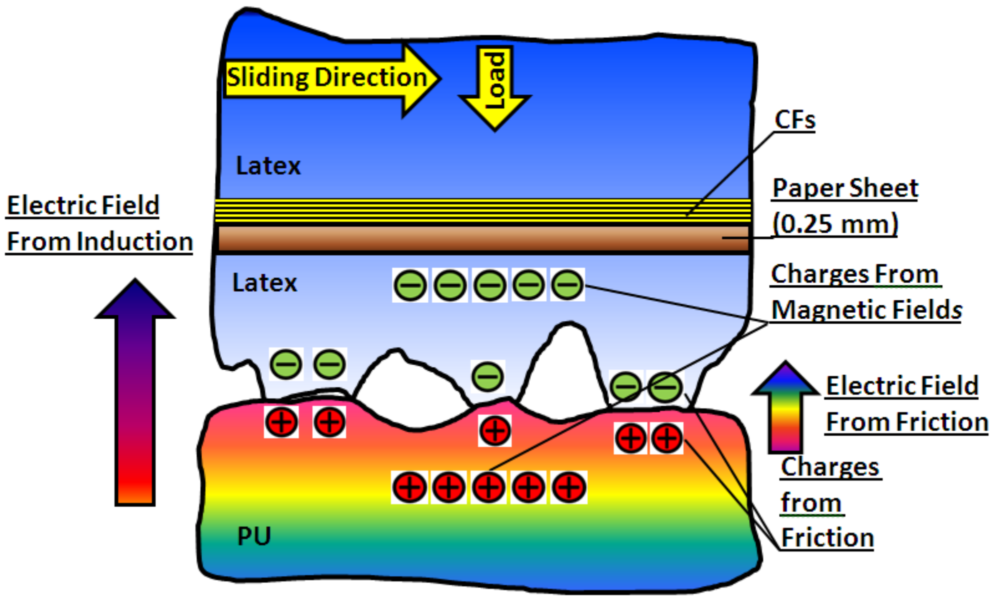

Fig. 12 Electric field generated from friction and induction for latex reinforced by CFs.

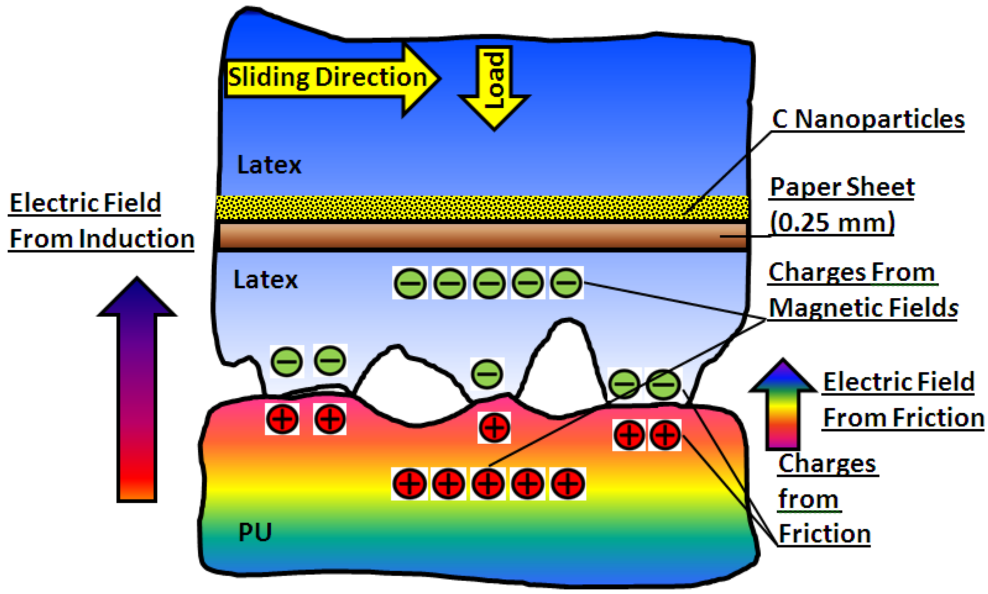

Fig. 13 Electric field generated from friction and induction for latex reinforced by carbon nanoparticles.

The strength of the electric field is proportional to how much charge is generated on the friction surface. The relative motion of one surface relative to the other will change the flux of the electric field over time and induce a current in the conductor (iron particles, CFs and carbon nanoparticles) reinforcing the contacting materials and thus create a source of electromotive force (EMF). The Faraday principle states that if an electric conductor is moved through a magnetic field, or a magnetic field moves through the conductor, electric current will be induced and flow into the conductor. The induced current creates an induced magnetic field. The Magnetic field around a straight conductor is directly proportional to the current value and inversely proportional to the distance from the conductor. Voltage can be induced by the relative motion between a conductor and magnetic lines of force. The significant friction may be from the ESC increase when the contacting materials were reinforced by iron particles, CFs and carbon nanoparticles due to the generation of a magnetic field around the reinforcing materials, Figs. 11, 12 and 13 for iron particles, CFs and carbon nanoparticles respectively.

CONCLUSIONS

1. Friction coefficient displayed by latex filled by iron particles sliding on ABS slightly decreased with increasing normal load. Slight increase in friction was observed in the presence of iron particles.
2. Sliding of latex on PU displayed relatively higher friction than that observed for sliding against ABS. The effect of iron particles on friction was more pronounced.
3. Reinforcing latex by CFs was more effective than iron particles when sliding on PU. The highest friction values were observed when the reinforcement surface was covered by 60 % CFs.
4. Latex free of carbon nanoparticles showed higher friction than carbon filled latex and latex reinforced by polymeric sheets like PA, PMMA and PTFE.

5. Combining carbon nanoparticles and CFs to reinforce latex sliding on ABS displayed significant friction increase, where sheets area of covered by fraction of 60 % CFs represented the highest friction values.

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