ENHANCING THE SAFETY OF EPOXY FLOORING MATERIALS IN WET WORKING CONDITION

Khamaj A.[1], AMM Ibrahim [2*], Samy A. M.[2], Ameer A. K.[2]

[1]Dept. of Industrial Engineering, College of Engineering, Jazan University, jazan, Saudi Arabia

[2]Dept. of Production Engineering & Mechanical Design, Faculty of Engineering, Mini University, Egypt

Abstract. When a person walks across a floor, static electricity is generated purely by the contact and separation of the soles of the individual's shoes from the floor. In many industrial processes, electrostatic charges are fully common. They can cause breakdowns, damage, fires, and explosions. On the other side, without enough friction between shoes and flooring materials during walking, a slip is most probable to occur. There is an increasing demand to increase the coefficient of friction between shoes and flooring materials to eliminate slipping and prevent accidents. The present work aims to improve the frictional and electrostatic properties of epoxy as flooring materials for different applications. We proposed the iron machining chip wastes to use as filling materials for epoxy flooring to increase friction coefficient and decrease the electrostatic charge generated from the friction of shoes against flooring materials. The experimental results revealed that a remarkable reduction in static charge was noticed in wet sliding conditions. This behavior is referred to that the water helps for disposal static charge away from the contact surfaces. In presence of shoes "A" with hardness 65 shore A, the maximum values of friction coefficient values observed at epoxy floor containing 1% and 2% iron powder in wet condition. Meanwhile, 4 % iron powder was the optimum condition for reducing electrostatic charge. For shoes "B" with hardness 63 shore A, the maximum values of friction coefficient values were observed at 2% iron powder content. -In presence of shoes "C" with hardness 67 shore A, the maximum values of friction coefficient values were observed at 2% iron powder content.

Keywords: Epoxy, friction coefficient, electrostatic charge, water, iron powder.

1. INTRODUCTION

The static charge includes potentially dangerous electrical shocks that can cause fires and explosions. It can also reason intense damage to susceptible electronic components. Triboelectric charging is the conveyance of electrons which occurs when two materials are in contact and are then separated. One material gains an overflowing of negative ions and the other an overflowing of positive ions. The charge produced can be more than 25,000 volts. It is well familiar that when two various materials contact each other, they may bring charged. This tribocharging phenomenon is also famous as triboelectrification when materials rubbing against each other, [1-3]. The mechanism of charge transfer in tribocharging can be explained by three mechanisms: ion transfer, electron transfer, and material convey [4 – 6]. The metal-to-metal contact electrification is successfully explained by the electron conveys mechanism. When two distinct materials come to contact, electrons convey happens until their Fermi level equals. Diversity in work functions between those is the main leading force, [7]. As for insulators, the electron conveys only occur on the surfaces of insulators, where electrons get about from the loaded surface of one insulator to the vacuous surface of the other insulator, [8–10]. Few investigators have dragged up triboelectric series to foresee the polarity of the charge that is conveyed from one surface to the latest, [11]. When two kinds of materials contact each other, the upper one in the triboelectric series will bring positively charged

* Corresponding author: Abdelhalim196@hotmail.com

and the other one will be negatively charged. It is attractive increasingly obvious that more than one of these mechanisms may occur together, [12].

Safe walking on the floor was estimated by the static coefficient of friction. Few investigators paying attention to the electric static charge produced during walking on the surface of the floor. It is well familiar that walking and crawling on flooring can produce an electric static charge of consistency depend on the material of flooring. The materials of the floors as well as footwear can influence the produced charge. The electric static charge and coefficient of friction of unclothed foot and foot onerous socks sliding against various types of flooring materials were scrupulous under dry sliding conditions, [13]. The tested flooring materials were marble, ceramic, moquette, rubber, and parquet. It was found that rubber flooring materials showed the highest produced voltage between the tested floorings. The highest voltage values were displayed by polyester hosiery, while cotton hosiery showed the lowest one. This monitoring can assure the emergency of carefully chosen flooring materials. Parquet flooring materials showed the lowest voltage between all tested flooring. Charge produced from rubbing amidst shoes and carpet were discussed, [14-15]. The impact of humidity was explained on the basis that water jot on the surfaces transfers charges in the form of ions to promote charge repose, [16-18]. The effect of the static charge generation on the ambiance is affected by the electrical accessibility of the sliding surfaces.

The influence of the type of flooring materials on the obstetrics of electric static charge and coefficient of friction was examined, [19]. It was spotted that voltage produced from sliding against ceramic flooring lightly. The metrical voltage values showed considerable squander as well known for the produced electric static charge, wherever the minimum and maximum values reached 360 and 850 volts. It is prospective that an electrical field will be created due to the electric charge created on the floor surfaces and footwear. Marble flooring displayed higher values than that spotted for ceramic flooring. As the load increased, the voltage increased. Based on the previous discussion, it can be suggested to choose flooring materials according to their impedance to produce electric static charge. The voltage produced from sliding of footwear against parquet ceramic flooring surface was lower than marble and higher than that produced from smooth ceramic. It seems that the surface topography of the parquet ceramic was accountable for that behavior. Voltage approaching a considerable increase when footwear sliding against porcelain flooring, where the maximum value reached 5995 volts. This behavior can be a hurdle in using porcelain as a flooring material, while flag flooring showed the lowest produced voltage, essentially at low loads.

Experimental results show that, rubber particles remarkably increased the coefficient of friction. This attitude concerning to the deformation of rubber through scratching. The minimum value of the coefficient of friction spotted for 100% epoxy was 1.5 at 4 N of applied loads, while the maximum value was 2.5 showed by epoxy filling by 10 wt. % rubber of 0.5 - 1.0 mm particle size, [20]. The examined material is polyester filled with various contents of recycled rubber 5, 10, 15, 20, and 25 % with various particle sizes. Experimental results show that, raise rubber content shows a considerable increase in the coefficient of friction for polyester composite. The maximum value of the coefficient of friction was (1.75) for polyester composite recorded for specimens filled by 25 % rubber. While the minimum friction value (0.18) was spotted at 100% polyester specimens. Increasing particle size of rubber shows a remarkable increase in wear of polyester composite, [21].

The present work discusses the friction coefficient displayed by footwear soles sliding against epoxy flooring materials. The electro static charge performance was investigated for avoiding the several problems caused by static charge. Measurement of friction coefficient is, therefore, of critical importance in assessing the proper friction properties of flooring materials and their suitability to be used in application to enhance the safety of the persons. The friction coefficient and static charge displayed by rubber footwear soles sliding against epoxy flooring materials filled by the powder of iron chip in water-lubricated conditions is discussed.

2. EXPERIMENTAL WORK

The (Ultra Stable Surface Voltmeter) was used to measure the electric static charge (electric static field) after contact and separation of the specimens against rubber to measure the generated charge under applied loads, as shown in Fig. 1. It measures down to 1/10 volt on a surface, and up to 20 000 volts (20 kV). Readings (Volts) are normally done with the sensor 25 mm from the surface being tested.

Fig. 1 Electric static charge (voltage) measuring device.

Friction tests were carried out using a test rig designed and manufactured to measure the friction coefficient between the rubber test specimens and the tested flooring tiles by measuring the friction and normal forces. The tested flooring tiles are placed in a base supported by two load cells, the first measures the horizontal force (friction force), and the second measures the vertical force (normal load). The friction coefficient is determined by the ratio between the friction and the normal forces. The arrangement of the test rig is shown in Fig. 2 . Test specimens in a form of a layer of 150 × 150 mm^2 molded on a wooden block. The tested materials were epoxy filled by different contents of iron powder with 5-micron particle size, was added to epoxy with different content 1, 2, 3, 4 and 5 %. The Friction test was carried out at different values of normal load. The sliding behavior measure by use the rubber shoes with 63, 65 and 67 shore" A" hardness. The friction force measure from load cell and the normal load measure by variable weight. The rubber shoes used in experimental was shown in Fig. 3.

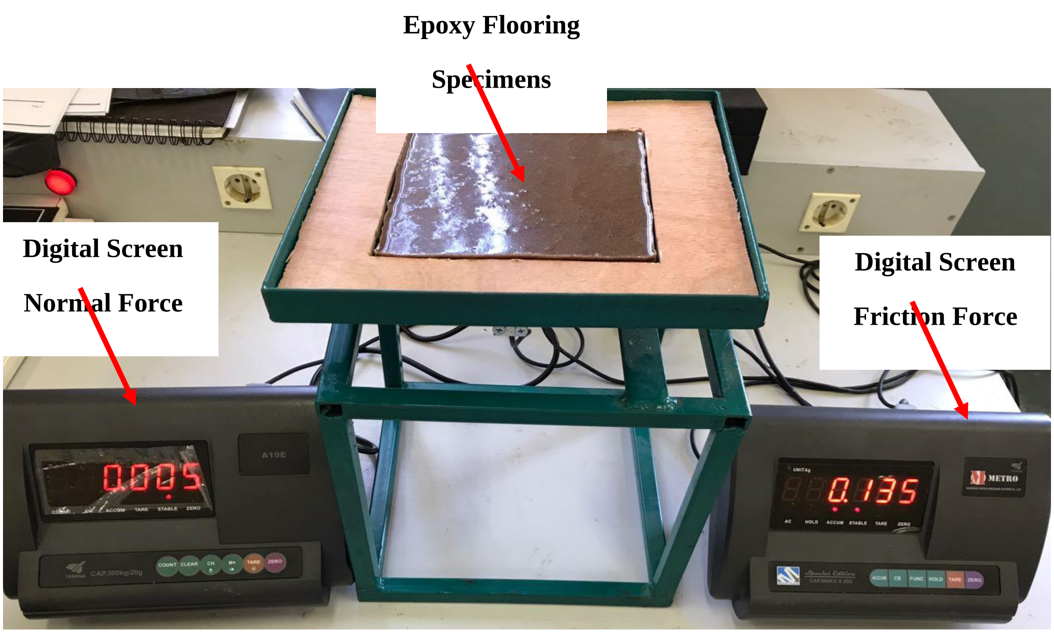

Fig. 2 Friction tester

Fig. 3. Tested Rubber shoes.

3. RESULTS AND DISCUSSION

The friction coefficient of water epoxy flooring material filled by the powder of iron chip is shown in Fig. 4 A. The friction coefficient decreases with increasing the normal load. Increase iron powder content show a significant effect in increasing friction coefficient. However, the increase in the hardness of rubber shoes shows decreasing in friction value. The minimum values of friction coefficient were observed for 100% epoxy specimens. Meanwhile, increasing iron powder content up to 3% show more influence in increasing friction coefficient. Figure 4, B. shows the relation between friction coefficient and normal load, for water epoxy test specimens filled by the powder of iron powder. It can be noticed that the friction coefficient decrease with increasing normal load. Increase the hardness of shoes in the presence of water can lessen the friction coefficient values. This behavior is referred to intrepid the water in the contact area. The minimum values of friction coefficient are displayed by pure epoxy test specimens

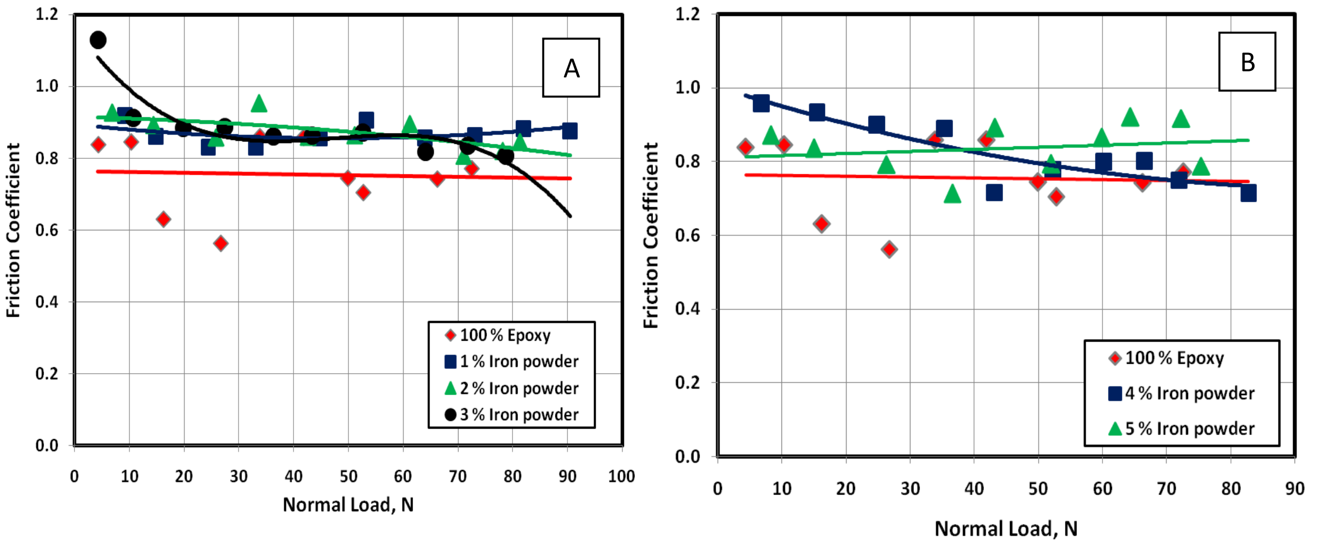

Fig. 4 Friction coefficient of rubber shoes with Hardness 63 shore A sliding against wet epoxy floor filled by iron powder.

Figure 5, A shows the relation between friction coefficient and normal load, for rubber shoes sliding against water epoxy floor filled by the powder of iron chip powder. It can be noticed that the friction coefficient increase with increasing iron powder content. This behavior may be related to increasing the ability of the floor to prevent sliding. Friction coefficient decrease with increasing normal load, this behavior is associated with the shoes type where the rubber shoes and all polymeric material friction coefficient decreases with increasing normal load. The minimum friction coefficient was observed at 100 % epoxy flooring. The maximum friction coefficient was observed at 2 % iron powder. Increase powder of iron powder content in epoxy flooring is shown in Fig. 5, B. The friction coefficient shows an increase with increasing iron powder content. On the other hand, the Friction coefficient decreases with increasing normal load. This behavior is related to the presence of water in the contact area between shoes and the floor. Nonetheless, iron powder plays important role in increase friction coefficient, in which the iron particles permit the water to pass over iron powder and leakage out off contact area. Minimum values of friction coefficient were observed for 100% epoxy flooring.

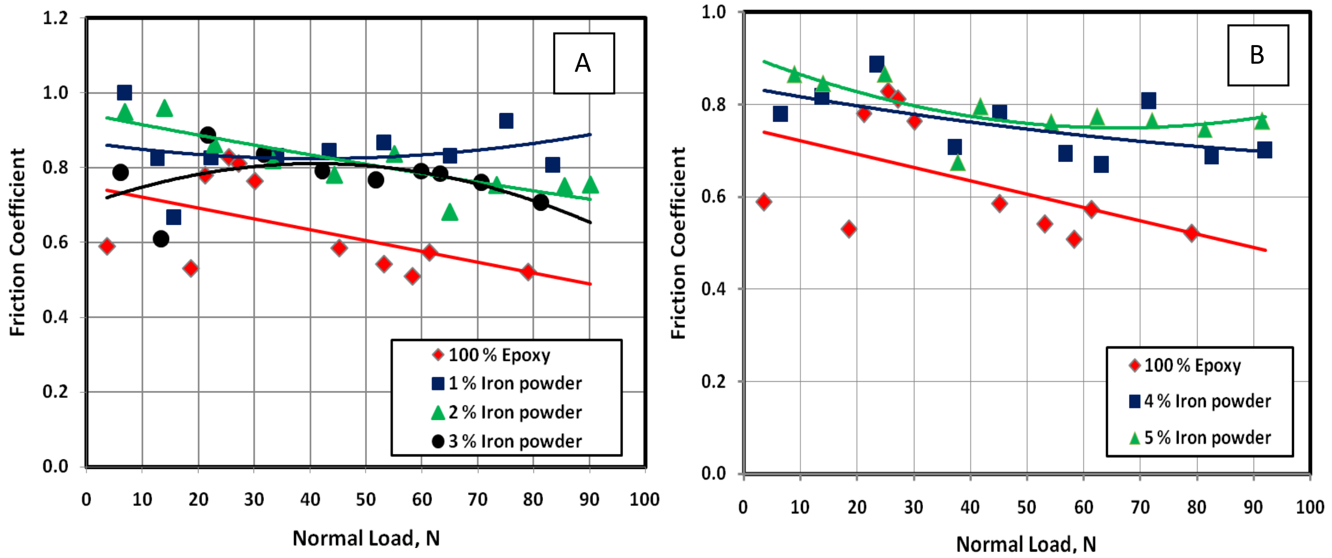

Fig. 5 Friction coefficient of rubber shoes with Hardness 65 shore A sliding against wet epoxy floor filled by iron powder**.**

The friction coefficient of rubber shoes sliding against water epoxy test specimens filled by the powder of iron chip is shown in Fig. 6, A. Friction coefficient increases with increasing powder of iron chip content. This behavior may be related to the easy escape of water from the contact area. The maximum value of friction coefficient was observed at specimens of epoxy filled by 2 % iron powder. Nevertheless, the minimum value of friction coefficient was observed at 100% epoxy flooring material. Figure 6, B. show the relation between friction coefficient and normal load, for epoxy test specimens at 4% and 5% iron powder. It can be noticed that the friction coefficient increase with increasing iron powder content. This behavior related to the escape of water from contact area and increase bonding between shoes and floor.

The electrostatic charge of wet epoxy flooring material filled by the powder of iron chip is shown in Fig. 7, A. Interestingly, the electrostatic charge decreases with increasing iron powder content. Increase hardness of shoes exhibited slight increase in electrostatic charge. This behavior is related to the decrease deformation of shoes and the gap between floor and shoes this gap allows electrostatic charge generated. The minimum values of electrostatic charge were observed at 3% iron powder. Figure 7, B. show the relation between electrostatic charge and friction coefficient, for wet epoxy test specimens filled by powder of iron chip. It can be noticed that the electrostatic charge decreases with increasing iron powder. Increasing iron powder to 4% show significant effect on reduction of electrostatic charge. In presence of water on sliding surface electrostatic charge increased for 100% epoxy floor. This behavior related to the epoxy is non-conduct and save this charge on surface of specimens, the iron help for disposal electrostatic charge to ground.

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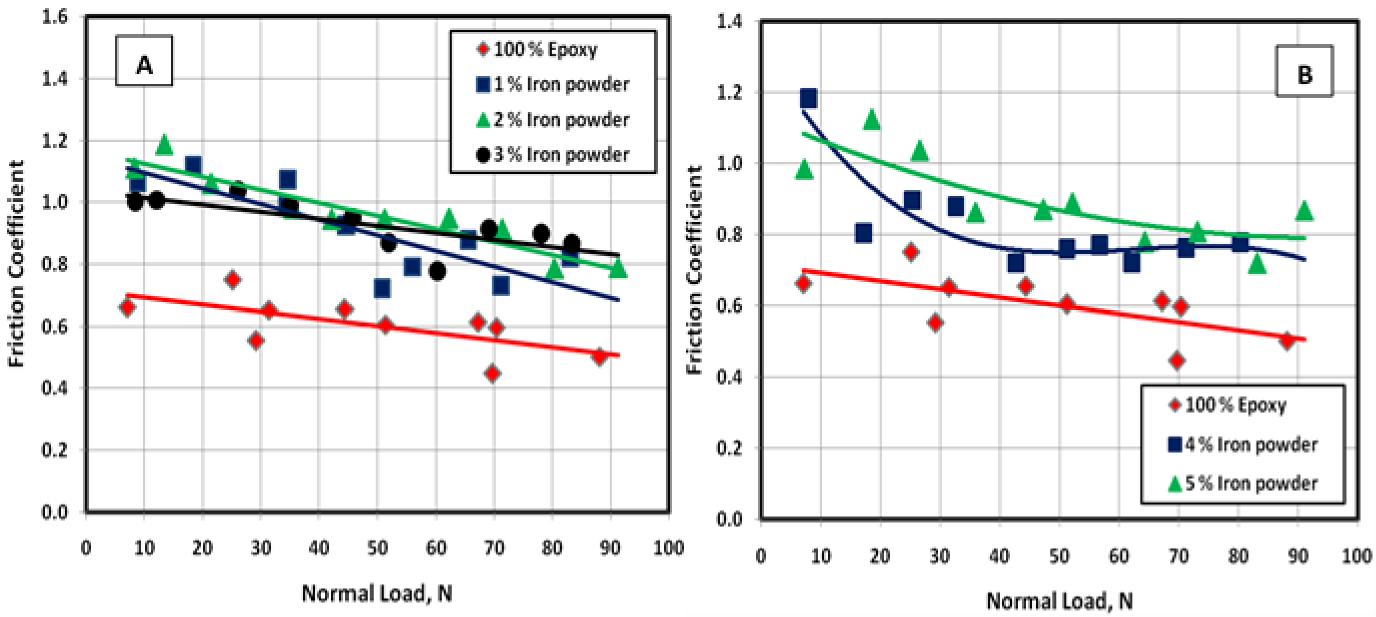

Fig. 6 Friction coefficient of rubber shoes with Hardness 67 shore A sliding against wet epoxy floor filled by iron powder.

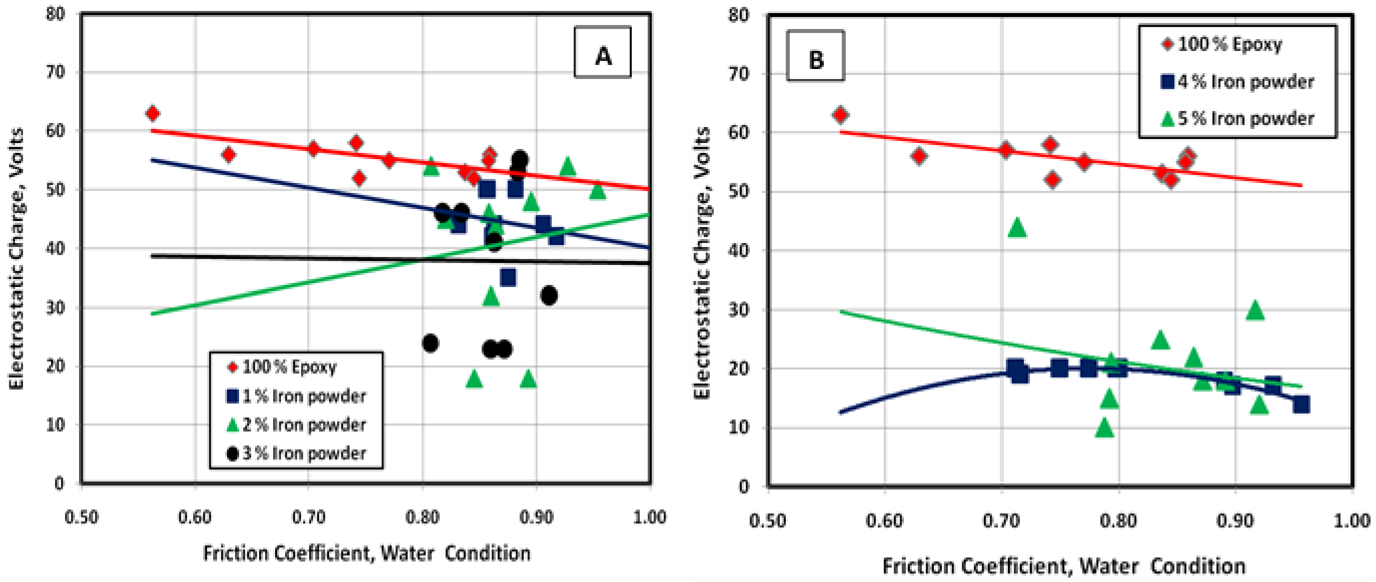

Fig. 7 Friction coefficient of rubber shoes with Hardness 63 shore A sliding against wet epoxy floor filled by iron powder.

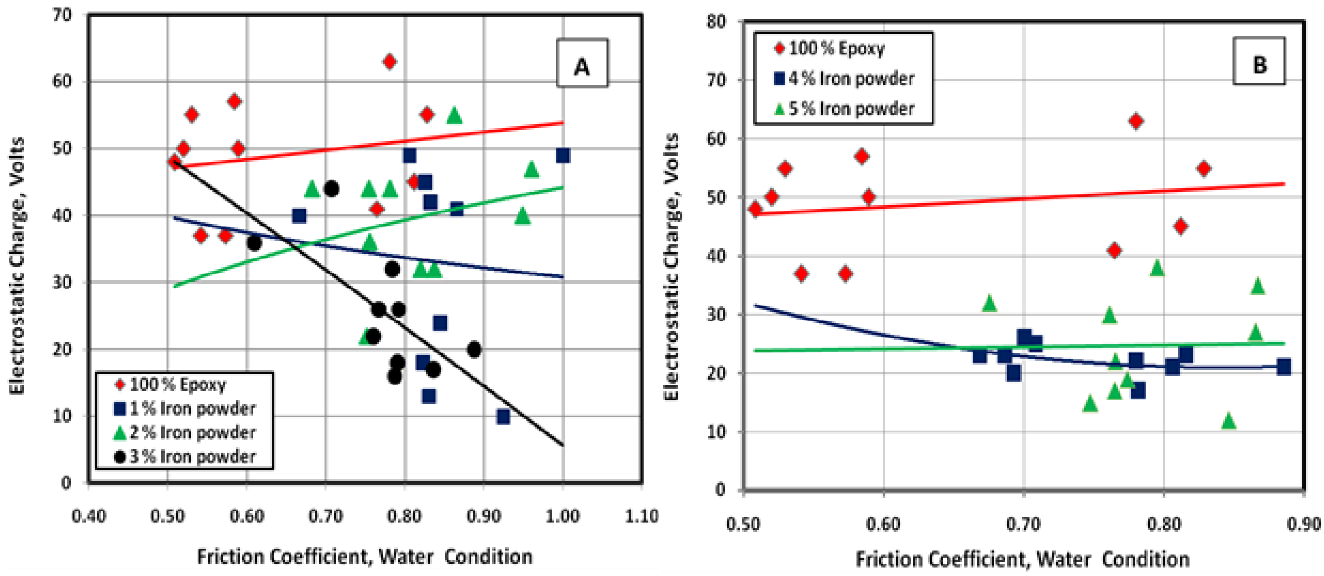

Fig. 8 Electrostatic charge of rubber shoes with Hardness 65 shore A

sliding against wet epoxy floor filled by iron powder.

Figure 8, A. shows the relation between electrostatic charge and friction coefficient, for epoxy filled by the powder of iron chip, under water as a sliding condition. It can be noticed that the electrostatic charge decrease with increasing iron powder content. In presence of water, the electrostatic charge decreases to the minimum values at 3% iron powder content. This behavior can be explained as; the water distributes the charge on surface of floor and iron powder disposal from this charge to ground. Meanwhile, the minimum electrostatic charge was observed at 3 % iron powder. The maximum charge was observed at 100 % epoxy flooring. Increase powder of iron chip content in epoxy flooring was shown in Fig. 8, B. Electrostatic charge shows decreasing with increasing iron powder content. The values of electrostatic charge decrease to the minimum value at 4 % iron powder content. This behavior is related to the more effect of iron powder on the disposal of this charge. Maximum values of electrostatic charge were observed at 100 % epoxy floor. The best content for reducing charge was 4% iron powder.

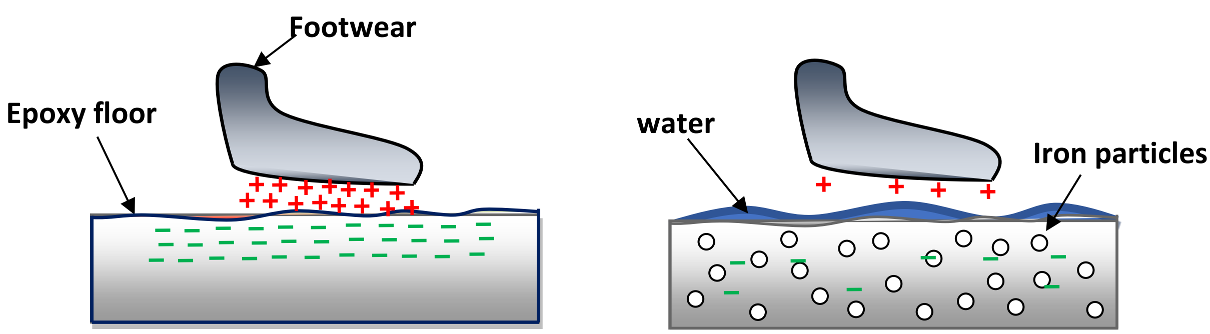

Fig. 9 The effect of water on reduction the electrostatic charge

The effect of iron powder on the reduction of the electrostatic charge generated from friction between shoes and epoxy flooring materials, shown in Fig 9. The iron is good conducting material and helps for the good distribution of the static charge on the contact surface. The water on the contact surface helps for disposal of the static charge from the contact surface.

The electrostatic charge of rubber shoes sliding against water epoxy test specimens filled by the powder of iron chip is shown in Fig. 10, A. Electrostatic charge decrease with increasing friction coefficient. This behavior may be related to increasing deformation of rubber shoes and decreasing the gap between shoes and the floor. Increasing iron powder content shows a significant decrease in electrostatic charge generated from friction. The maximum value of electrostatic charge was observed at 100% epoxy flooring material. Figure 10, B. shows the relation between electrostatic charge and friction coefficient, for epoxy test specimens at 4% and 5% iron powder content. It can be noticed that the electrostatic charge decrease with increasing iron powder content. Increase iron powder content to 5 % show a reduction in charge value. This behavior is related to the more effect of iron powder on the disposal of electrostatic charge to ground. Where found the iron powder in sliding surface help for good distribution this charge and not collect in any zone. This behavior helps the water to disposal of the electrostatic charge. The minimum value of electrostatic charge was observed at 5% epoxy specimens filled by 5% iron powder.

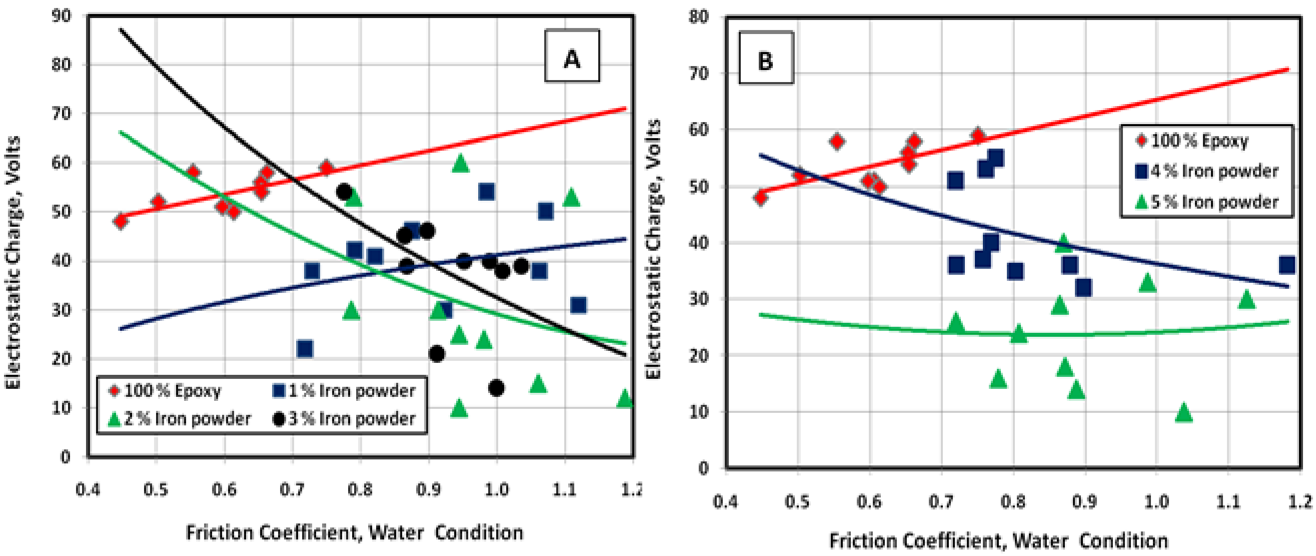

Fig. 10 Electrostatic charges of rubber shoes with Hardness 67 shore A sliding against wet epoxy floor filled by iron powder

4. CONCLUSIONS

1. As water sliding conditions the remarkable reduction in static charge was shown, this behavior related to the water helps for disposal of static charge away contact surfaces.

2. In presence of shoes “A” with hardness 65 shore A, the maximum values of friction coefficient values observed at epoxy floor contain 1% and 2% iron powder in water conditions. And 4 % iron powder for reducing electrostatic charge.

3. For shoes “B” with hardness 63 shore A, the maximum values of friction coefficient values were observed at 2% iron powder content. And 4 % iron powder for reducing electrostatic charge.

4. In presence of shoes “C” with hardness 67 shore A, the maximum values of friction coefficient values were observed at 2% iron powder content. And 4 % and 5% iron powder for reducing electro-static charge.

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تعزيز الأمان للإيبوكسي المستخدم كمواد أرضيات في ظروف العمل الرطبة

عبدالرحمن خمج[1]، احمد محمد محمود[2]، عبدالحليم محمود سامي[2]، أمير علي كامل[2]
[1] قسم الهندسة الصناعية – كلية الهندسة – جامعة جازان- المملكة العربية السعودية

[2] قسم هندسة الانتاج والتصميم الميكانيكي، كلية الهندسة، جامعة المنيا، جمهورية مصر العربية

عندما يمشي شخص ما علي الارضيات ، تتولد الكهرباء الساكنة عن طريق تلامس وفصل نعل الحذاء عن الأرض. في العديد من العمليات الصناعية تكون الشحنات الكهروستاتيكية شائعة التواجد وبالتالي يمكن أن تسبب الأعطال والأضرار والحرائق والانفجارات. بالاضافة الي ذلك بدون احتكاك كافٍ بين الأحذية ومواد الأرضيات أثناء المشي فمن المرجح أن يحدث الانزلاق والسقوط. لذلك هناك طلب متزايد على زيادة معامل الاحتكاك بين الأحذية ومواد الأرضيات لمنع الانزلاق ومنع وقوع الحوادث.

يهدف العمل الحالي إلى تحسين الخواص الاحتكاكية والكهربائية للإيبوكسي كمواد أرضيات لاستخدامها في العديد من التطبيقات. لقد اقترحنا استخدام الرائش الناتج من عملية تصنيع الحديد كمواد تعبئة للأرضيات الإيبوكسي بهدف زيادة معامل الاحتكاك وتقليل الشحنة الكهروستاتيكية الناتجة عن احتكاك الأحذية بمواد الأرضيات. أظهرت النتائج التجريبية انخفاضًا ملحوظًا في الشحنة الساكنة في ظروف الانزلاق الرطب. يرجع هذا الانخفاض الي أن الماء يساعد في التخلص من الشحنات الساكنة بعيدًا عن أسطح التلامس. في حالة الإحذية ذات صلادة ٦٥ مقاسة علي جهاز شورA ، لوحظت القيم القصوى لمعامل الاحتكاك عند أرضية الإيبوكسي التي تحتوي على ١٪ و ٢٪ مسحوق حديد في حالة وجود الماء. وفي الوقت نفسه ، كانت ارضيات الايبوكسي التي تحتوي علي ٤٪ مسحوق الحديد هي النسبة الأمثل لتقليل الشحنة الكهروستاتيكية. بالنسبة للأحذية ذات صلادة ٦٣ مقاسة علي جهاز شور Aو الأحذية ذات صلادة ٦٧ مقاسة علي جهاز شورA ، لوحظت القيم القصوى لمعامل الاحتكاك عند نسبة ٢٪ مسحوق الحديد.

الكلمات الرئيسية: الايبوكسي ، معامل الاحتكاك ، الشحنة الكهروستاتيكية ، الماء ، مسحوق الحديد.