# The effect of macro-rivet textures on tribological performances

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**ABSTRACT** – This study examines the tribological effect of macro-rivet textures on a surface. The rivet textures of mild steel plate were produced using milling process with different size and density. The sizes of rivet used in this study are 0.006 m and 0.009 m of diameter and density of rivet are 10%, 20% and 40%. The experiment was performed on a simple tribometer to measure friction at variable speed from 0.146-2.012 m/s. Based on the study, it was found that the plate of with size of 6mm and density of 10% give lowest friction force with 24% reduction to achieve better tribological performances in sliding contact.

## 1. INTRODUCTION

Surface texturing has been proven as an emerging method to improve friction and tribological performances. Numerous analytical and experimental studies have been conducted to discover the fundamental effect of surface texturing at different lubrication regimes that enable to improve the tribological performances.

Rivet texture is believed to improve the aerodynamics and hydrodynamics performances in parallel sliding contact. The study on rivet texturing is come from the natures, i.e. plant leave [1] and animal skin [2]. It is found that macro-rivets surface improves its hemodynamic, that promotes 10% better aerodynamics as compared with dimple, thus it helps the airplanes to reduce fuel consumption [3]. Ibrahim et al. [4] reported that the airplanes winglets with rivet texturing gave better aerodynamics properties as it produces high lift forces and velocity across the surface.

Lubrication performances will be improved by having an optimal shape and size of the textures. The area of constant film thickness increases with the increasing of texture size thus the gap between two textures decreases. Consequently, the lubricants get trapped within this cramped gap so that the pressure build-up leading to decline in friction performances.

Texture density plays important role on tribological performances parameter. The texture density is more critical to reduce the COF compared to texture shape. Syed and Sarangi [5] found that higher number of textures can reduces hydrodynamic lubrication performance in transverse direction. The fluid is trapped within the texture gaps as the number of textures increases.

In the present study, an experimental study is conducted to determine the influence of density and size of rivet textures on tribological performances.

## 2. METHODOLOGY

### 2.1 Sample Preparation

Figure 1 shows the macro-rivet textures were created with varying size and density on rectangular shape of metal plate. The plates were made of mild-steel material with the yield strength of 247 MPa and tensile strength of 500 MPa as it is common material in ship making. The macro-rivet textures were created by using milling and CNC machining process. Then, the plates were polished by using grinder machine to remove excess rim on the contact surface for further process. The parameters of textured plates with different sizes and density as tabulated in Table 1. The size of the rivet of each cell is determined by its diameter and the height. Meanwhile, the density is determined by the surface area of rivet per unit cell.

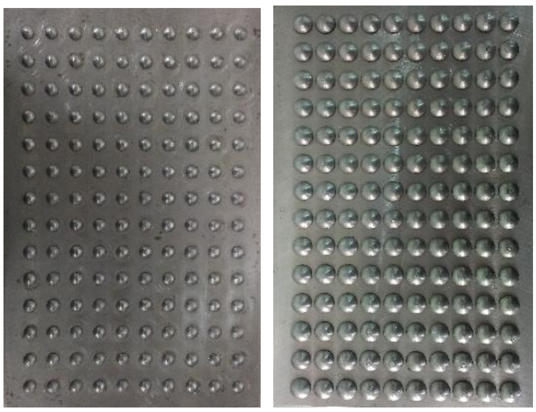

Figure 1 Mild steel plates with macro-rivet textures.

Table 1 Parameters of sample plates.

| Sample | Shape | Macro- rivet size Diameter (m) | Macro- rivet size Height (m) | Cell density (%) |
|---|---|---|---|---|
| 1 | Round | 0.0060 | 0.0020 | 10 |
| 2 | Round | 0.0060 | 0.0020 | 20 |
| 3 | Round | 0.0090 | 0.0035 | 20 |
| 4 | Round | 0.0090 | 0.0035 | 40 |
| 5 | Untextured | - | - | - |

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### 2.2 *Experimental Analysis*

A simple friction belt machine was designed to conduct friction test in one directional sliding as illustrated in Figure 2. The setup of the machine enables to measure the friction force between sample plate and belt using tension meter. The machine that consists of composite polyethylene belt was immersed in distilled water to create a water flow while the plate was put on a direction of belt operation. The load of 0.5 kg was hanged to the rear of plate to fix the contact moment between two planes. The test was carried out under conformal contact conditions of 0.000228 m² of area contact at different speeds.

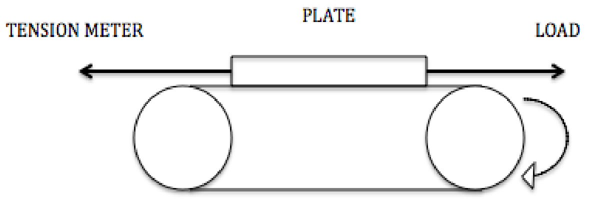


Figure 2 Friction belt machine.

## 3. RESULTS AND DISCUSSION

### 3.1 *Effect of Size*

Figure 3 shows the $F_f$ is slightly decreasing as the sliding speed increases for the tested samples. The macro-rivets with 0.006 m diameter of 10% and 20% density reduce greater $F_f$ with 24% and 16% respectively. Meanwhile, the macro-rivets with 0.009 m diameter of 20% and 40% density reduce lower $F_f$ with 13% and 7% respectively. Under theoretical, the formation of film thickness is increases as the texture size is increases due to the larger area of horizontal contact of rivet and water flow [5]. Thus hydrodynamic lift increases to reduce friction force. In this case, the limitation of viscosity and Reynolds number of the fluid flow causes the formation of hydrodynamic lift to decline thus it reduces the friction performances. The larger size of macro-rivet is more effective with higher viscosity fluid.

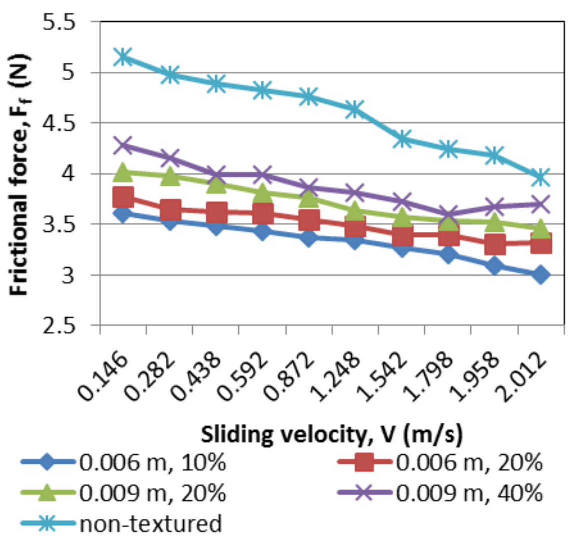


Figure 3 Graph of $F_f$ against sliding speed, V.

### 3.2 *Effect of Density*

Based on Figure 3, the macro-rivets with higher density of 40% reduce less $F_f$ with 7%. And the macro-rivets with lower density of 10% give a higher reduction of $F_f$ with 24%. It shows that the hydrodynamic lubrication performance is decreases as the density of textures increases. This phenomenon is happened due to the fluid get trapped within the rivets texture gaps as the density increases [5]. Then, the flow becomes smooth leads to decline in development of pressure. Thus, less number of textures gives a better tribological performance.

## 4. CONCLUSIONS

The effect of surface texturing on tribological properties was studied by measuring the friction substantially observed their behavior. The comparison of the macro-rivet textured and untextured plate shows the significant reduction of $F_f$. Thus, the analysis shows the rivets textures can be exploited to improve tribological performances. It was found that, macro-rivets textured with 0.006 m diameter and 10% density performs better as it has the lowest $F_f$ with 24% of reduction to achieve better tribological performance in sliding contact.

## 5. ACKNOWLEDGEMENT

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