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EFFECT OF DISPERSING LITHIUM GREASE BY CLAY PARTICLES

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ABSTRACT
The present work aims to enhance the lubricating properties of lithium grease by the addition of clay particles as well as paraffin oil. Bearing steel ball loaded and slid on aluminum (Al) sheet was used to test the friction and wear when the contact surfaces was greased by lithium grease dispersed by clay of 30 – 50 µm particles size.

Based on the present experiments, it was revealed that dispersing grease by clay particles and blending by paraffin oil decreased friction coefficient. Clay particles decreased the number of the contacting asperities of the two sliding surfaces and consequently friction coefficient decreased. Presence of oil decreased the agglomeration of clay particles, facilitated the rolling of the particles and retarded the sticking of the particles in one of the sliding surfaces. This behavior is attributed to the increased grease fluidity and decreased metallic contact of the sliding surfaces, where the particles were enabled to roll between the two sliding surfaces.

Enhancement of wear may be from the ability of particles to work as ball bearing that decreased the formation of the transferred layer form aluminum sheet and separated the two contact surfaces. Clay particles formed protective thin layer on the contact area and provided high carrying capacity and extreme pressure properties. Grease dispersed by 10 wt. % clay content and blended by 10 wt. % oil gave the best wear values.

KEYWORDS
Lithium grease, clay particles, paraffin oil.

INTRODUCTION
There is increasing demand to develop lubricating greases to enhance the efficiency of greases in different application. It was proved that when grease was dispersed by carbon nanotubes (CNT), friction coefficient displayed the highest values followed by aluminium oxide (Al_2O_3), while CNT/Al_2O_3 showed the lowest values, [1]. Minimum values of friction and wear were observed at 0.4 – 0.6 wt. % of nanomaterial content. Friction coefficient displayed by the grease dispersed by multiwall carbon nanotubes (MWCNT) and carbon nanotubes (CNT) gave lower values than that dispersed by silica (SiO_2) nanoparticles, [2,

3]. Wear resistance provided by silica nanoparticles was enhanced compared to that observed for MWCNT.

Friction and wear of carbon steel in presence of calcium-based grease dispersed by polyethylene (PE), polytetrafluoroethylene (PTFE) and polymethyl methacrylate (PMMA) were discussed, [4], where PMMA significantly reduced friction coefficient and wear. It was proposed to disperse grease by polymeric particles, [5 - 9]. Their mechanism of action is to adhere into the sliding surfaces. Harder polymeric particles roll between the two sliding surfaces reducing friction, while relatively softer polymers adhere to the surfaces. In metal forming process, the sliding of the tools on the work piece is accompanied by severe friction that influences the surface quality. Developing the lubricants can reduce the drawbacks of the friction, [10 - 13]. Friction can be evaluated by contact pressure, [14, 15]. PTFE was dispersing grease to increase load carrying capacity of journal bearing and work as extreme pressure (EP) additives.

The present work investigates the influence of dispersing lithium grease by clay particles on friction coefficient and wear.

EXPERIMENTAL

Experiments were carried out by sliding a bearing steel ball on an aluminum sheet in 10 passes under load values of 2, 4, 6, 8 and 10 N vertically applied, Fig. 1. The lithium grease was dispersed by clay of 30 – 50 μm particle size in concentration of 2, 4, 6, 8 and 10 wt. %. The grease was blended by 5 and 10 wt. % paraffin oil. Wear scar width was measured by means of optical microscope of ± 0.01 mm accuracy. The experiments were performed manually. The stroke was 20 mm and repeated 10 times. Friction coefficient was measured by load cell attached to the ball holder and connected to Arduino circuit and amplifier to detect the values of friction force. The details of the test rig was discussed, [3].

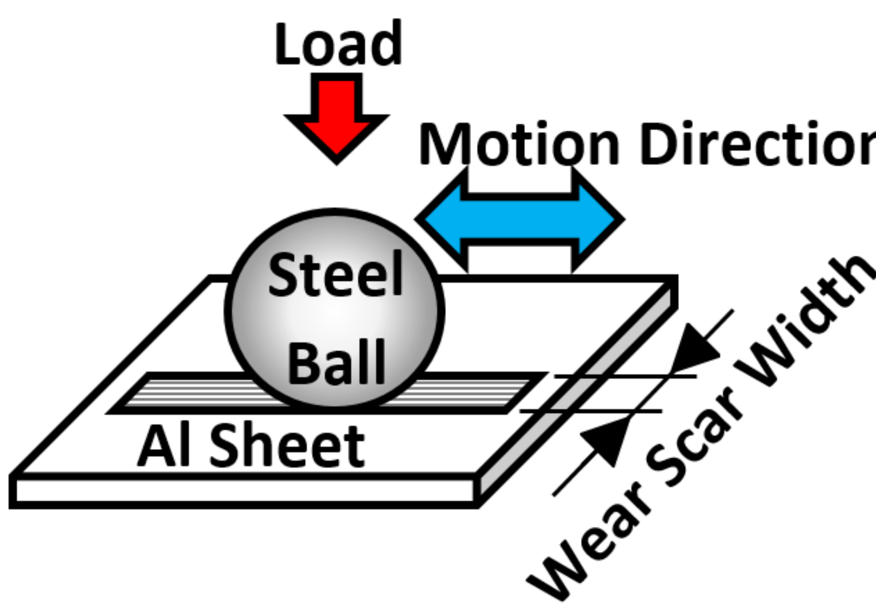

Fig. 1 Procedure of the test.

RESULTS AND DISCUSSION

The effect of clay particles dispersed in the grease showed that friction coefficient slightly decreased down to minimum then increased with increasing clay particles content, Fig. 2. The lowest friction values were observed at 4.0 – 6.0 wt. % of clay content, then they slightly increased with further increase of clay content due to the agglomeration of clay particles and consequently shear stress increased. When grease was tested without clay particles, metallic contact could occur due to the contact of the surface asperities resulting in the friction increase. The clay particles have the possibility to roll or to slide on one of the sliding surfaces. When the clay particles stick to one of the surfaces, they abrade the other one. During the abrasion caused by the clay particles in the aluminium surface, the displaced materials forms frontal and lateral ridges as well as the wear track. The tendency of the clay particle to roll or to be partially embedded in the aluminium sheet depend on the concentration of the particles in the grease, Fig. 4. The presence of clay particles decreased the number of the contacting asperities and consequently friction coefficient decreased. When the clay content increased, the possibility of the particle to roll decreased due to the friction among the particles. Besides, the number of embedded particles in aluminum sheet increased, Fig. 5. On the other side, the particles could stick in the relatively hard surface of the steel ball and could abrade the aluminum sheet.

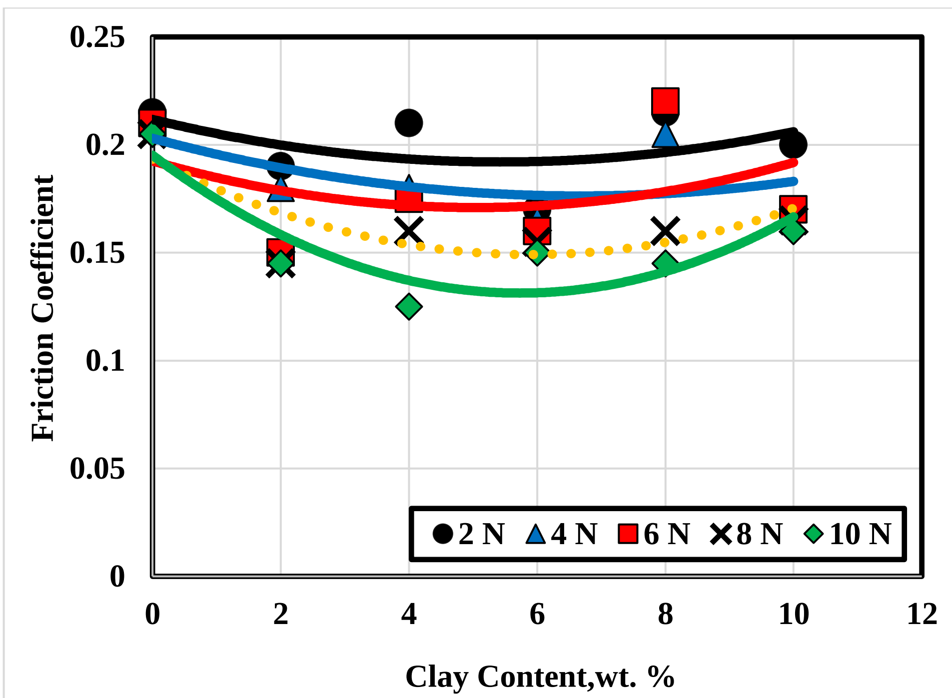

Fig. 2 Effect of clay particles dispersed in the grease on friction coefficient.

Blending the grease by paraffin oil of 5.0 wt. % content was accompanied by slight friction decrease, Fig. 6. This behavior was noticed at 10 wt. % clay content. It seems that presence of oil homogeneously distributed the clay particles, enabled the particles to roll and decreased their sticking in one of the sliding surfaces.

The reduction of friction coefficient was obviously noticed when the grease was blended by 10 wt. % oil, Fig. 7. Friction values showed drastic decrease with increasing clay content. The clay particles acted as tiny balls and rollers separating the two sliding surface, Fig. 8. Oil blending grease enhanced the distribution of the clay particles inside the grease, provided thicker lubricant film due to the increased fluidity of the lubricant and enabled the particles to roll between the two sliding surfaces.

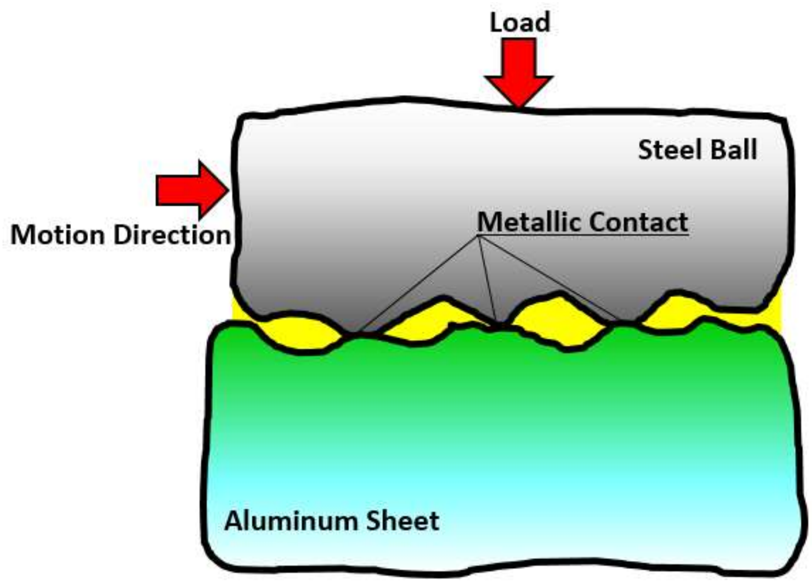

Fig. 3 Metallic contact of the sliding surfaces in the presence of grease free of clay particles.

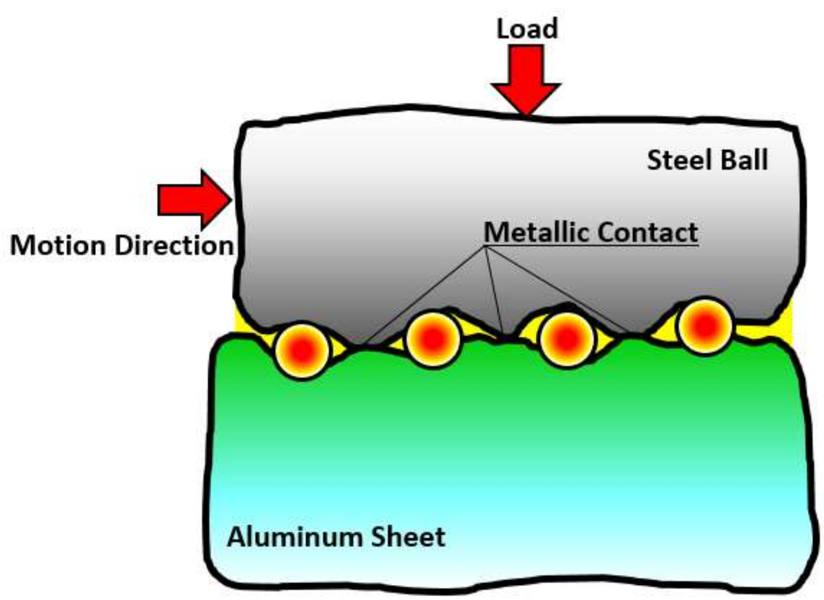

Fig. 4 Illustration of contact in presence of grease dispersed by clay particles.

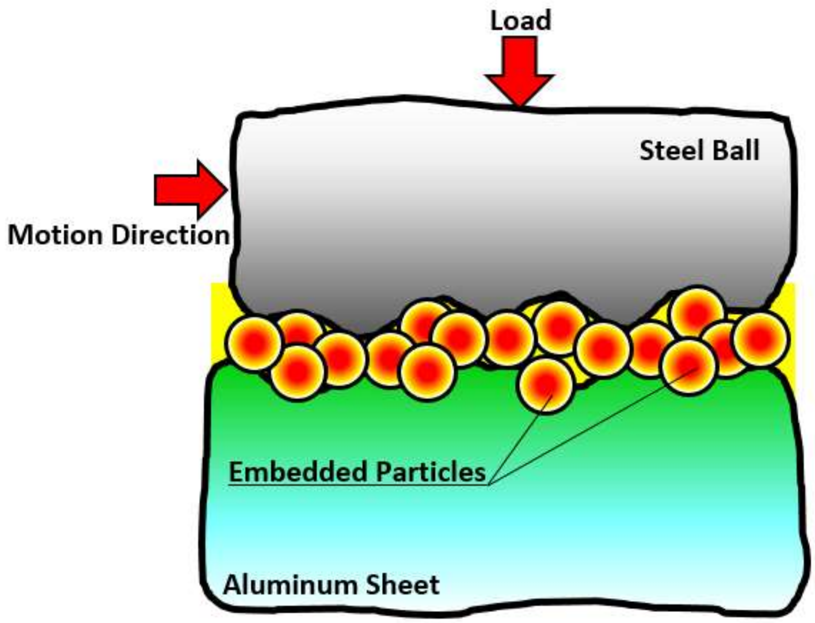

Fig. 5 Illustration of the contact in presence of grease dispersed by relatively higher clay content.

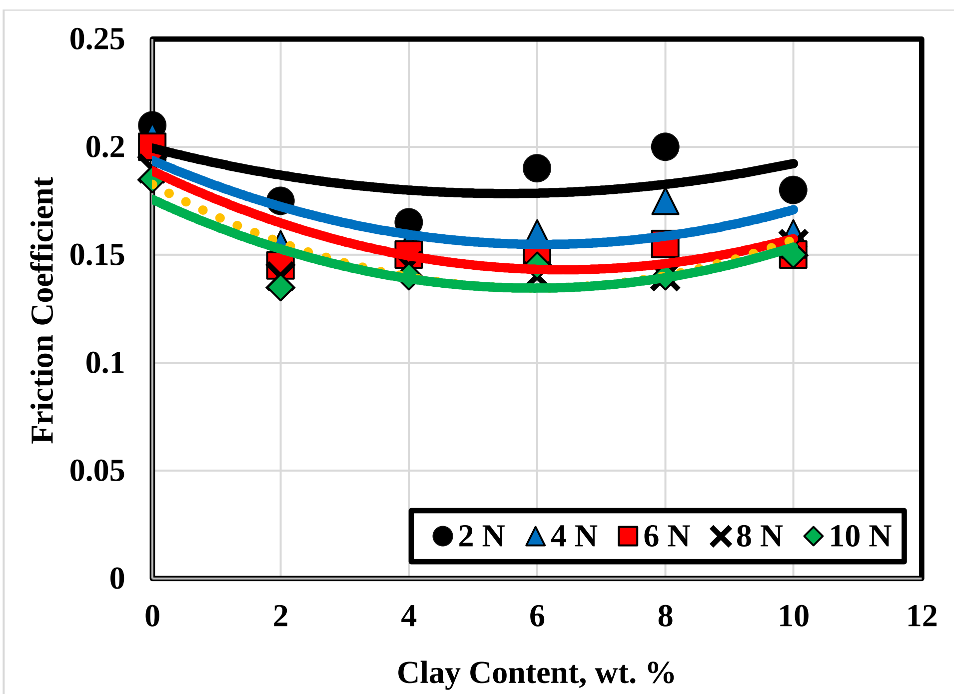

Fig. 6 Effect of clay particles dispersed in the grease blended by 5.0 wt. % oil on friction coefficient.

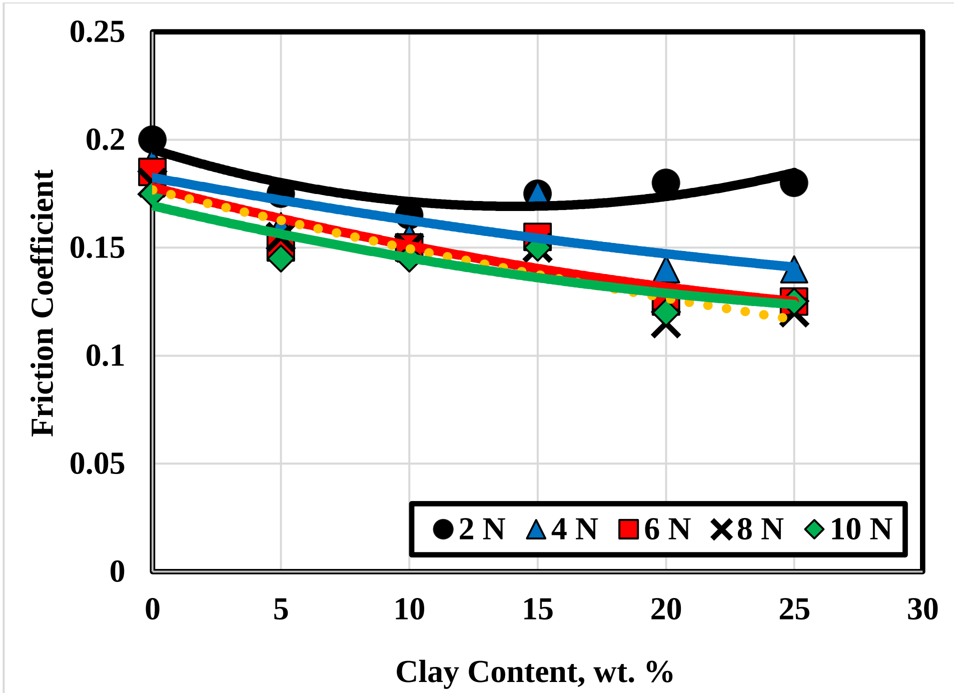

Fig. 7 Effect of clay particles dispersed in the grease blended by 10 wt. % oil on friction coefficient.

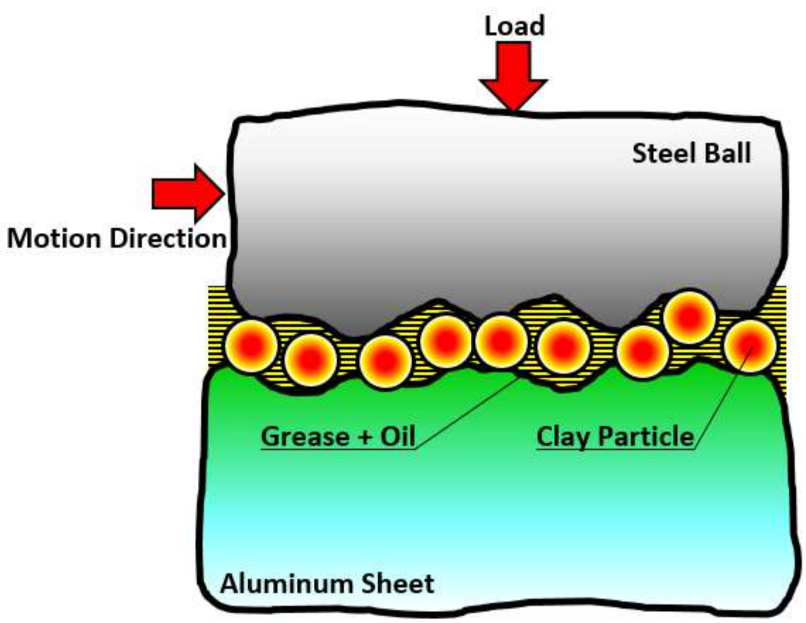

Fig. 8 Illustration of the contact in presence of grease blended by paraffin oil and dispersed by clay content.

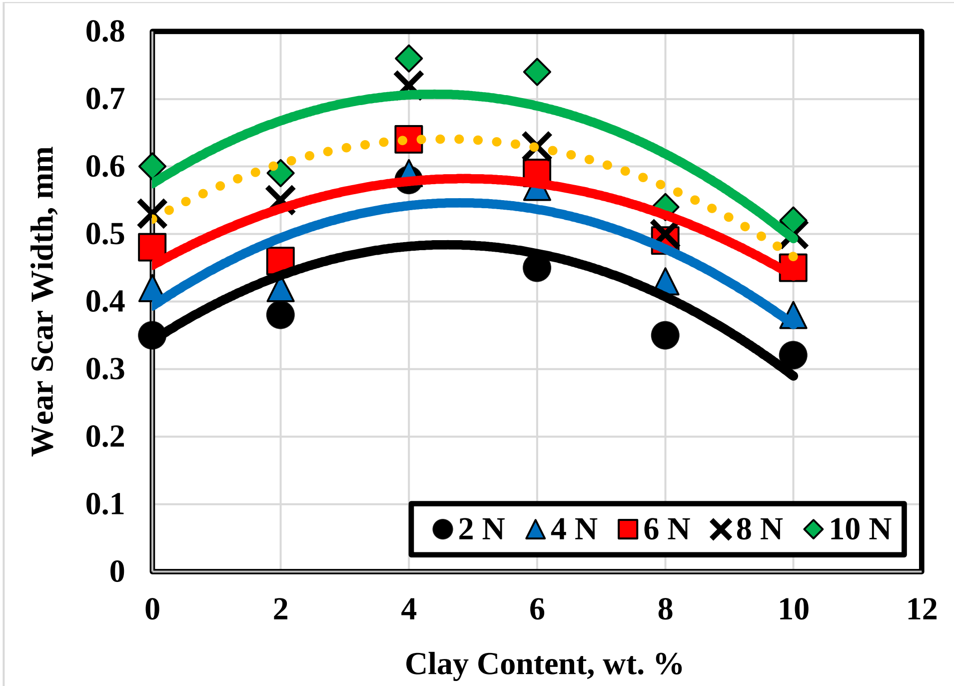

Fig. 9 Effect of clay particles dispersed in the grease on wear.

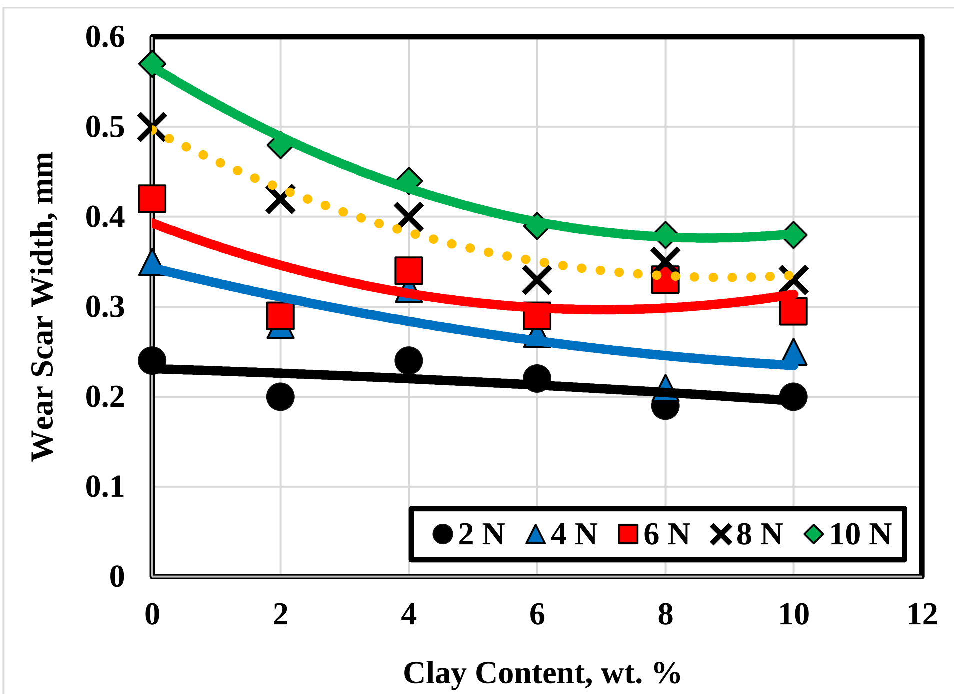

Fig. 10 Effect of clay particles dispersed in the grease blended by 5.0 wt. % oil on wear.

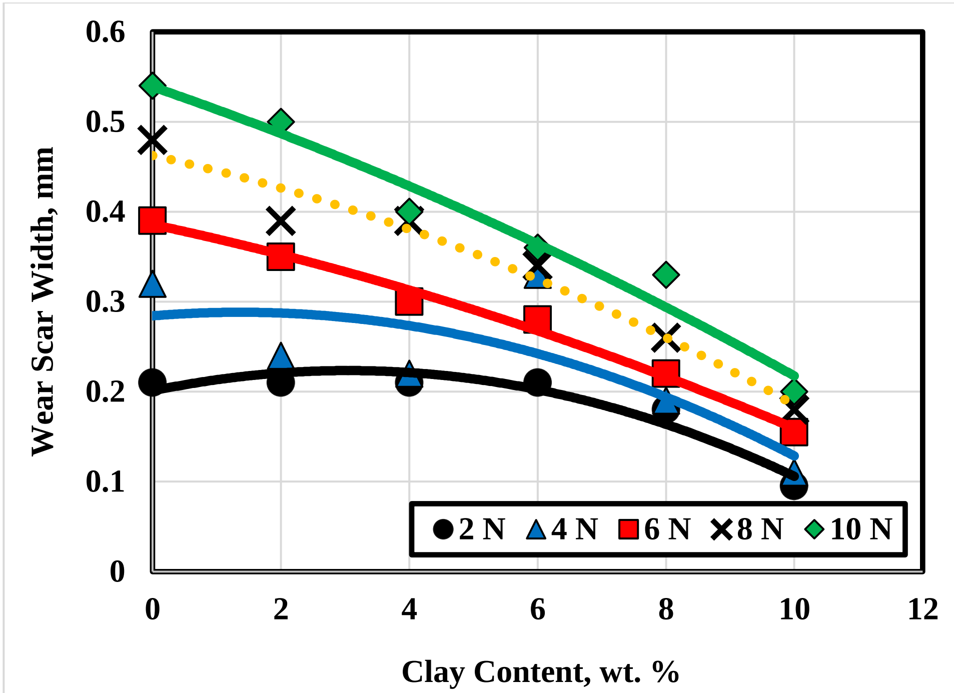

Fig. 11 Effect of clay particles dispersed in the grease blended by 10.0 wt. % oil on wear.

Fig. 12 Photomicrograph of the wear track.

Wear of the aluminum sheet was measured by wear scar width. The effect of clay particles dispersed in the grease on wear showed increasing trend with increasing clay content up to maximum values then decreased, Fig. 9. The highest values were displayed by grease dispersed by clay of 4.0 – 6.0 wt. % content. Further increase in clay content drastically decreased wear. The wear increase may be from the abrading action of the clay particle in the aluminum sheet surface. As the content of clay increased, the particles were able to form layer separating the two sliding surfaces. This behavior is called the mechanism of ball bearing that depends on the particle shape and size as well as the hardness that should be higher than the hardness of the two contacting surfaces, [16 – 20]. Clay particles could act as rolling bearings preventing metal to metal contact. The disadvantage may be from

their fracture higher load where the rolling action is retarded. Based on that observation, clay particles can be recommended in extreme pressure.

As the grease was blended by 5.0 wt. % oil, wear showed drastic decrease with increasing clay content, Fig. 10. This behavior may be explained on the bases that the oil retarded the agglomeration of clay particles and facilitated the movement of the particles. Oil increased the ability of the grease to penetrate and decreased the sticking of the particles in the sliding surfaces. Besides, oil homogeneously distributed the particles on the contact area, where they form thin solid layer in viscous lubricant of high elasticity separating the sliding surfaces. Clay particles may polish the asperities of the contact area and enhance the surface roughness.

Grease blended by 10.0 wt. % oil showed further wear decrease, Fig. 11. It seems that presence of oil increased the fluidity of the grease, enabled the particles to roll on sliding surfaces and decreased the metallic contact of the sliding surfaces. The mechanism of action of the particles worked as ball bearing effect that decreased the formation of the transferred layer form aluminum sheet, [21 - 24]. Clay particles like hard particles provide high carrying capacity and extreme pressure properties due to their ball bearing effect, [25]. The photomicrograph of the wear track is shown in Fig. 12, where the traces is not severe indicating the mechanism of the action of the clay particles. The lowest wear values were observed for grease dispersed by 10 wt. % clay content.

CONCLUSIONS

1. Friction coefficient slightly decreased down to minimum then increased with increasing clay particles content. Minimum values were observed at 4.0 – 6.0 wt. % of clay content.
2. Slight friction decrease was observed for grease blended by paraffin oil of 5.0 wt. % content at 10 wt. % clay content.
3. Further reduction of friction coefficient was noticed for grease blended by 10 wt. % oil.
4. Wear increased with increasing clay content up to maximum values then decreased, where the highest values were displayed by grease dispersed by clay of 4.0 – 6.0 wt. % content.
5. Grease blended by oil showed drastic wear decrease with increasing clay content, where the lowest values were observed for grease blended by 10 wt. % oil.
6. The mechanism of action of the proposed grease may be explained on the bases that the hard clay particles act as ball bearing and provide extreme pressure properties as well as high carrying capacity. The presence of oil decreased the agglomeration of clay particles and facilitated the movement of the particles. Besides, oil decreased the sticking of the particles in the sliding surfaces and distributed the particles homogeneously on the contact area, where they form thin solid layer in viscous lubricant separating the sliding surfaces.

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