

PAPER • OPEN ACCESS

Evaluation of RBD palm stearin as alternative lubricant for cold forward extrusion process

To cite this article: A N Farhanah *et al* 2017 *J. Phys.: Conf. Ser.* **908** 012062

View the [article online](#) for updates and enhancements.

You may also like

- [Accurate Evaluation on the Interactions of SARS-CoV-2 with Its Receptor ACE2 and Antibodies CR3022/CB6](#)
Hong-ming Ding, , Yue-wen Yin et al.
- [MODEL OF THE FIELD LINE RANDOM WALK EVOLUTION AND APPROACH TO ASYMPTOTIC DIFFUSION IN MAGNETIC TURBULENCE](#)
A. P. Snodin, D. Ruffolo and W. H. Matthaeus
- [Study of adsorption of the SARS-CoV-2 virus spike protein by vibrational spectroscopy using terahertz metamaterials](#)
M.R. Konnikova, O.P. Cherkasova, T.A. Geints et al.



The advertisement features a dark teal background. On the left, the ECS logo is displayed above the text 'The Electrochemical Society Advancing solid state & electrochemical science & technology'. Below this, the event details are listed: '242nd ECS Meeting', 'Oct 9 – 13, 2022 • Atlanta, GA, US', and 'Presenting more than 2,400 technical abstracts in 50 symposia'. In the center, there is a portrait of M. Stanley Whittingham next to a Nobel Prize medal. To the right of the portrait, the text reads: 'ECS Plenary Lecture featuring M. Stanley Whittingham, Binghamton University Nobel Laureate – 2019 Nobel Prize in Chemistry'. In the top right corner, there is a circular icon with a checkmark and the text 'Register now!'. The bottom right corner of the advertisement shows a photograph of a person in a lab coat interacting with a futuristic interface of glowing icons.

Evaluation of RBD palm stearin as alternative lubricant for cold forward extrusion process

A N Farhanah, S Syahrullail, M A Ajruddin

Faculty of Mechanical Engineering, Universiti Teknologi Malaysia, 81310 UTM
Skudai, Johor

nurulfarhanahazman@gmail.com

Abstract. A rapid growth in awareness level over environmental problems have brought researchers to find a substitute lubricant to reduce the use of mineral based lubricants. In this paper, the lubrication performance of RBD palm stearin was evaluated in order to be utilized as alternative lubricant for metal forming lubricant. Commercial paraffinic mineral oil VG460 and VG95 were used for comparison purposes. The experiment was conducted using cold work extrusion apparatus that consists of taper die (made of tool steel SKD11) and a pair of billet (made of pure aluminium A1100). The results obtained from these experiments showed that RBD palm stearin can reduce extrusion load, produce a lower surface roughness value and have smooth surface profile compared to commercial paraffinic mineral oils. It is demonstrated that RBD palm stearin have promising lubrication performance and can be considered as alternative lubricant in metal forming process.

1. Introduction

In the metal forming process, lubrication is greatly important to reduce friction and wear at tool/workpiece interface, prevent adhesion, scratching, galling and material transfer [1] in order to ease metal flow, increase tool life, energy consumption, heat evolution and improve product quality of the finished product [2]–[4]. The lubricant's effectiveness in metal forming process relies on parameters such as die-punch system, tool/workpiece materials, contact pressure, sliding velocity, surface temperature and surface finish [5], [6].

Traditionally, commercial mineral based lubricant has been used as metal forming lubricant. However, the world are facing environmental crisis and create the awareness among researchers to find an alternative lubricant to replace the mineral based lubricant. Vegetable based lubricant was the most suitable candidate to replace mineral based lubricant due to their biodegradability, non-toxicity and environmental friendly [7]–[9]. Moreover, vegetable oils have excellent boundary lubrication, high viscosity index, high flash point and low volatility due to their polar ester structure [10], [11].

In response to this issues, this research was conducted to evaluate the palm oil based lubricant as an alternative lubricant for metal forming lubricant. Refined, bleached and deodorized (RBD) palm stearin was selected as tested lubricant and commercial paraffinic mineral oil VG460 and VG95 were used for comparison purposes. The lubrication performance of the tested lubricants were evaluated using a cold work forward extrusion process. The evaluations of the lubrication performance will be in term of extrusion load, surface roughness, surface profile and flow angle.



2. Methodology

2.1 Experimental apparatus and procedure

A plain strain extrusion apparatus was designed and the experimental setup was shown in Figure 1. It consisted mainly of three components: container wall, taper die and workpiece (billet). Tapper die used in this research is fabricated from alloy tool steel SKD11 which had a chemical composition of C (1.55wt%), Si (0.30wt%), Mn (0.35wt%), Cr (11.75wt%), Mo (0.75wt%), V (0.95wt%), S (0.005wt%) and P (0.020wt%) [12]. The tapper dies were subjected to necessary heat treatment process before each experiment. This tool steel are high carbon and high chromium alloy tool steel. The taper die has to be sufficiently hard to sustain the force implied to the billet that is in contact with taper die during the extrusion process. The taper die has an edge 45 degree at die half angle (figure 2(a)). Before each experiment, the surface of the tapper dies which is in contact with billet (see figure 2(b)) should be polished to prevent the debris or any impurities that adheres on the surface of the tapper dies. The optimum value of arithmetic surface roughness, Ra should be 0.15 μm .

The billet used in this research was made of pure aluminium A1100 which had a chemical composition of Si (0.08wt%), Fe (0.33wt%), Mg (0.0016wt%), Cu (0.054wt%), Ti (0.013wt%), Zn (0.013wt%) and Al (99.00wt% min) [12]. The billets, with 4.5 mm thickness, 15 mm width and 80 mm length, were formed by using NC wire cut electric discharge machining device. The billets were subjected to an annealing treatment at elevated temperature of 320°C to give the best condition for cold forming [4] and to relieve the residual stresses present in the billets prior to cutting and surface milling process [13]. A pair of billet were stacked together at which one side of the billet were marked with square gridline (see figure 2(c)) using marking machine as the observation plane for plastic flow angle analysis.

The components (container wall, taper die and billet) were assembled together and the stacked paired billets are put in the rig to be placed on the load cell afterward for load extrusion (y-axis) during each run. The displacement for ram stroke (x-axis) is recorded using the displacement sensor that is attached to the holder of hydraulic extrusion machine. Once the displacement reached at 40 mm piston stroke, the extrusion stopped. This range of ram stroke for displacement is expected to reach the steady state condition. Finally, the billets are taken out of the plane strain extrusion apparatus and then separated for surface roughness and flow angle measurement.

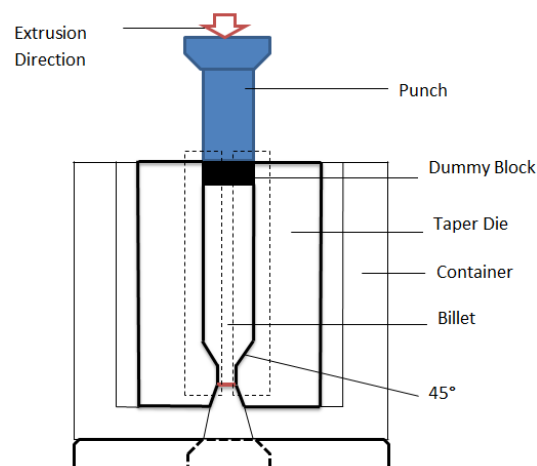


Figure 1. Schematic plane of plain strain extrusion apparatus.

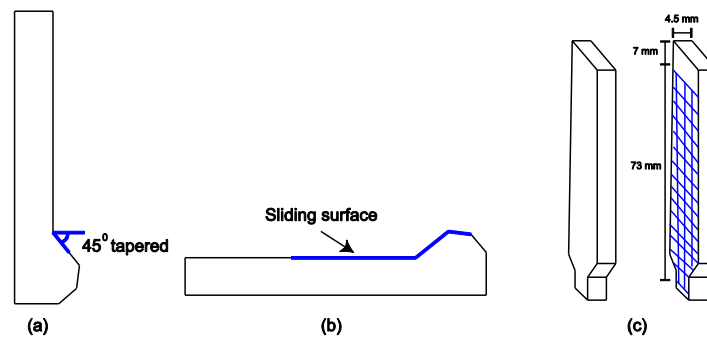


Figure 2. (a) Tapper die angle; (b) Surface area of tapper die to be polished; (c) Schematic drawing of billet.

2.2 Lubricants

In this research, the alternative extrusion lubricant assessed was refined, bleached and deodorized (RBD) palm stearin. While the conventional extrusion lubricants, paraffinic mineral oil VG95 and VG460, were used for comparison purposes. The physical properties of the tested lubricants were given in table 1. Before each experiment, 15 mg of the tested lubricant (equivalent to one drop of lubricant) was applied on the experimental surface of the taper die.

Table 1. Physical properties of the tested lubricants.

Lubricants	Density (g/cm ³)	Viscosity index (VI)	Kinematic viscosity (mm ² /s)		
			27°C	40°C	100°C
RBD PS	870	171	48.29	38.01	8.56
PMO VG95	850	192	249.95	71.75	13.4
PMO VG460	850	95	1374.6	411.25	28.1

3. Results and discussion

3.1 Extrusion load

Figure 3 shows the curved of extrusion load that is required to extrude billet lubricated by RBD PS, VG95 and VG 460. This figure shows that the extrusion load has reached the steady state load at point of 18 mm of piston stroke until 40 mm. It is noticed that the steady state only reached by billet extruded by lubricating oil of RBD PS and VG460. The extruded billet of VG95 on the other hands gradually increases at piston stroke from 18 mm to 30 mm, then decreases gradually to 36 mm of piston stroke and starts to maintain until 40 mm. The maximum extrusion load were plotted in a bar graph (figure 4) where the values for RBD PS, VG460 and VG95 are 60.78 kN, 57.20 kN and 71.37 kN respectively. The results showed that the value of the maximum extrusion load of RBD PS only has a slight different with VG460, and much lower than VG95.

The comparative results of VG460 shows a lesser extrusion load than VG95 due to its viscosity. Since VG460 has higher viscosity than that of VG95, a thick lubricant film will be formed to minimize metal-to-metal contact between billet and taper die which contributed to the lesser friction and reduction of the extrusion load. However, although RBD PS has lower viscosity than that of VG95 it produce lesser extrusion load. This phenomenon is attributed to the fatty acid in RBD PS that plays a significant role in maintaining the lubricant film to protect the contact surfaces [14]. From this findings, it is recommended that RBD PS is possible to be used as alternative lubricant for extrusion process which in line with statement made by Wang et al. [15], any lubricant that able to minimize the load to a small range as mineral lubricant and works to the same lubricating performance is good to be considered as substitute mineral lubricant.

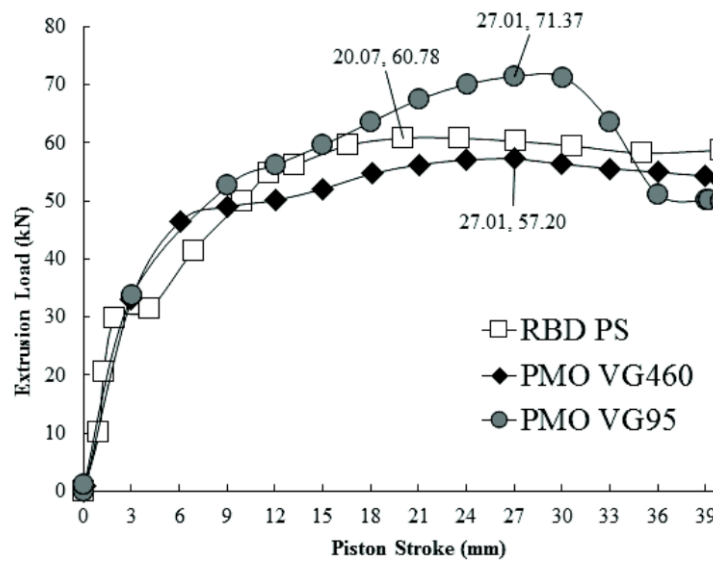


Figure 3. Extrusion load versus piston stroke curve.

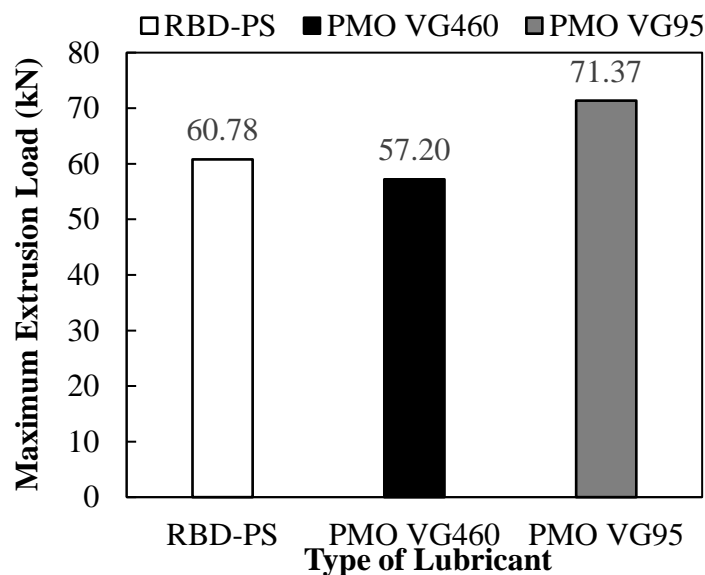


Figure 4. Maximum extrusion load.

3.2 Surface roughness

Figure 5 showed the arithmetic surface roughness, Ra of the billet at product area taken at 0 mm, -2 mm and -4 mm point coordinate of surface area. The surface roughness of the billet was measured perpendicular to the direction of extrusion. From this figure, it's clearly shows that surface roughness of the billet lubricated with RBD PS was smoother than the other conventional mineral lubricants, VG460 and VG95. The presence of polar fatty acid structure in RBD PS was able to create effective boundary lubrication that allows strong interaction with metallic surfaces [16], thus provide better performance than the conventional mineral lubricants.

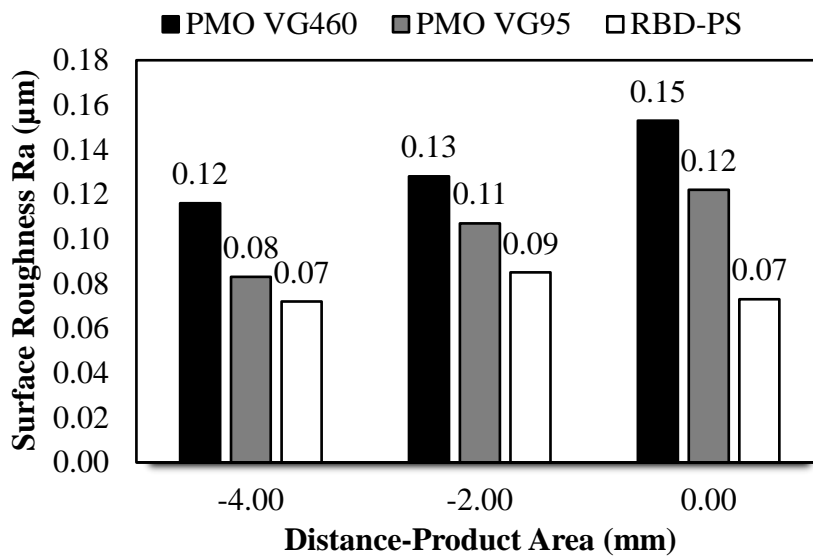


Figure 5. Surface roughness of the billet at product area.

3.3 Surface profile

Figure 6 represents the surface profile of the billet at three point area: product area (0 mm), deform area (8 mm) and undeform area (14 mm). From the observation, the surface profile of billet lubricated with RBD PS have smooth surface compared to surface profile lubricated with VG460 and VG95. While, it was observed that there is parallel groove along the other surface profile of the billet which more parallel groove were found on the billet’s surface lubricated with VG460. It was also found that there is no severe wear occur on the surface product area. Deform area is the transition of normal surface to extruded surface and has mixed topography between undeform area and product area. There is an obvious change in topography at deform area lubricated by VG460 and VG95, while when lubricated with RBD PS the change of topography is insignificant. This findings was in line with the surface roughness values along the span of product area to deform area are constant (0.07 µm to 0.08 µm). At undeform area, the surface area lubricated with different tested lubricants was the same since no extrusion effect took place.

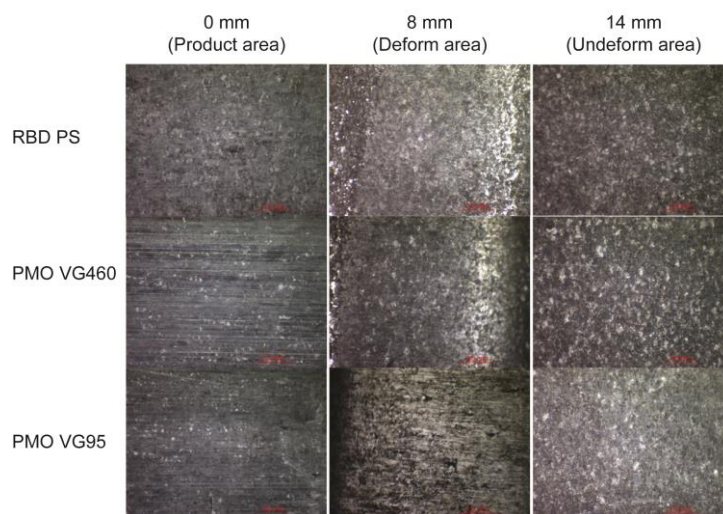


Figure 6. Surface profile of extruded billet (100x magnification).

3.4 Flow angle

The mutual comparison of the flow angle at the deformation area is shown in figure 7. The flow angle is a measurement of angle to indicate how the flow of billet during extrusion. The flow angle of the billet extruded with VG460 was the highest, followed by VG95 and RBD PS. Comparing the angle reduction, the billet extruded with VG460 shows lesser reduction of angle (43.74° of flow angle at 4 mm distance deform area). This means that VG460 can effectively maintain the lubricant film thus reducing the friction. The angle reduction of the billet extruded with RBD PS shows higher reduction of angle (27.38° of flow angle at 4 mm distance deform area) due to its semi solid condition as well as the breaking of lubricant film. According to Ong et al. [17], a semi solid condition of the lubricant will results in high contact pressure and friction. This happen when the billet is being pressed extensively during loading that caused the sudden drop of angle at local point.

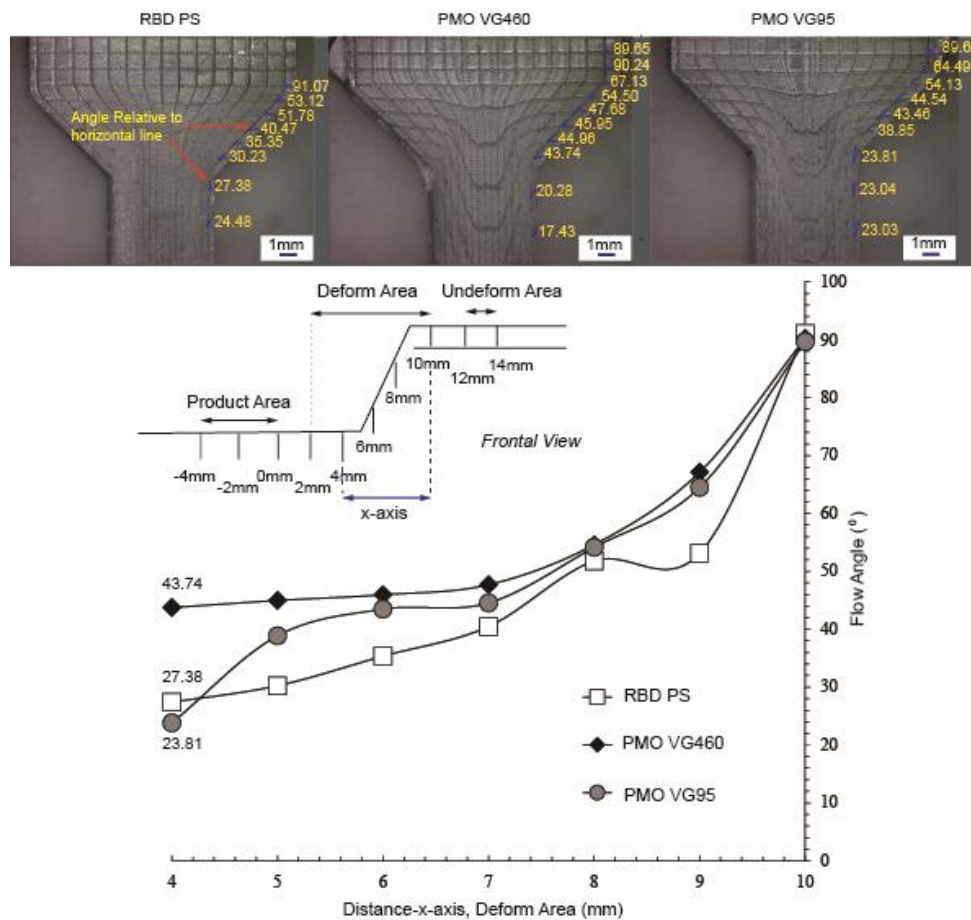


Figure 7. Flow angle at deform area.

4. Conclusion

This research was conducted to evaluate RBD palm stearin as alternative lubricant for metal forming process. Commercial paraffinic mineral oil VG460 and VG95 were used for comparison purposes. The results showed that RBD palm stearin was able to minimize the extrusion load and produce a smooth surface product with a low surface roughness value compared to the commercial mineral lubricants. From the observation of surface profile, the surface profile of billet lubricated with RBD palm stearin was smoother compared to the commercial mineral lubricants and there is no severe wear occur on the surface product area. However, the angle reduction of billet extruded with RBD palm stearin shows a higher reduction. From these findings, it is recommended that RBD palm stearin is possible to be used as an alternative lubricant for metal forming process.

5. Acknowledgments

The authors would like to express their thanks to the Research Management Centre (RMC) of Universiti Teknologi Malaysia for the Research University Grant, GUP (17H96) and Ministry of Education of Malaysia and Ministry of Higher Education for their support.

6. References

- [1] Syahrullail, S, Azwadi, C S N and Ing, TC 2011 *Int. Rev. Mech. Eng.* **5**(1) 21–27.
- [2] Hu Z M and Dean T A 2000 *Int. J. Mach. Tools Manuf.* **40** 1637–1649..
- [3] Abdulquadir B L and Bolaji Adeyemi M 2008 *Ind. Lubr. Tribol.* **60** 242–48.
- [4] Nurul M A, Syahrullail S and Musa M N 2015 *J. Teknol.* **74** 35–43.
- [5] Lazzarotto L, Dubar L, Dubois A, Ravassard P and Oudin J 1998 *J. Mater. Process. Technol.* **80–81** 245–50.
- [6] Jayaseelan V and Kalaichelvan K 2014 *Procedia Eng.* **97** 166–71.
- [7] Golshokouh I, Ani F N, Masjuki H H and Syahrullail S 2013 *Int. Rev. Mech. Eng.* **7**(1) 72–80.
- [8] Golshokouh I, Ani F N, Kianpour E, and Syahrullail S 2013 *Life Sci. J.* **10** 110–119.
- [9] Farhanah A N and Syahrullail S 2016 *J. Tribol.* **10** 1–15.
- [10] Singh A K and Gupta A K 2006 *J. Synth. Lubr.* **23** 167–76.
- [11] Aiman Y and Syahrullail S 2017 *J. Tribol.* **13** 1–20.
- [12] Syahrullail S, Zubil B M, Azwadi C S and Ridzuan MJ 2011 *Int. J. Mech. Sci.* **53** 549–55.
- [13] Tiernan P, Hillery MT, Draganescu B and Gheorghe M 2005 *J. Mater. Process. Technol.* **168** 360–66.
- [14] Fox N J, Tyrer B and Stachowiak G W 2004 *Tribol. Lett.* **16** 275–81.
- [15] Wang L, Zhou J, Duszczuk J and Katgerman L 2012 *Tribol. Int.* **56** 89–98.
- [16] Maleque M A, Masjuki H H and Sapuan S M 2003 *Ind. Lubr. Tribol.* **55** 137–143.
- [17] Ong H C, Mahlia T M, Masjuki H H and Norhasyima R S 2011 *Renew. Sustain. Energy Rev.* **15** 3501–15.