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# Relevance of Castor oil and Neem Oil as Renewable Energy Bio-Based Lubricating Fluids in Extrusion of Aluminium Billet

[1]Muhammad Mamuda and [2]Ado Musa
*[1]Sokoto Energy Research Centre, UsmanuDanfodiyo University,Sokoto, Nigeria*
*[2]Department of Physics, Aminu Saleh College of Education, Azare, Bauchi State, Nigeria*
*Corresponding Author: Muhammad Mamuda*

***Abstract:*** *This paper investigated the relevance of Castor oil and Neem oil as renewable energy bio-based lubricating fluids in extrusion of aluminium billet. The two oils were formulated with 0.5 and 0.75 percentage weight of antimony dialkyldithio-carbamate (ADDC) additive using the ASTM D2783-3 standard test method for measurement of anti-wear and extreme pressure (EP) properties of the lubricating oils by Four-Ball Method. Extrusion dies with semi die angles of $30^0$ and $45^0$ were constructed and case-hardened. A hardness value of 613HV was obtained using the Vickers hardness testing machine. Results obtained from this work shows that the renewable energy bio-based oils used are suitable and can serve as substitute to conventional lubricating fluids in the extrusion of aluminium billet because of the good surface finish achieved.*

***Keywords: ADDC Additive, Aluminium billet, Castor oil, Extrusion die, Neem oil.***

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## I. Introduction

Most of the lubricants which are available in the market for metal working processes are mineral oils derived from petroleum which poses alot of danger to the environment because of their toxicity and non-biodegradability (Salih*et al*., 2011).

Aluminium is the most commonly extruded material and can be hot or cold extruded. For hot extrusion, it is heated to 575 to 1100 °F (300 to 600 °C). Some of the aluminium products include profiles for tracks, frames, rails, mullions, and heat sinks(Suliga, 2014).

For some decades, vegetable oils have been identified as environmentally friendly lubricants (Quinchia*et al.,* 2014).These oils have some attractive lubricating properties in addition to their non-toxicity, biodegradability and renewability (Baumgart et al., 2010; Salih*et al*., 2013). One such advantageous property is high lubricity, due to the number of atoms of oxygen present in the ester molecules, causing the molecules to form a monolayer over the metal surfaces (Silva *et al.,* 2013). The attachments are so strong that they are not easily eroded by water, or mechanical/ thermal stresses (Pujari, 2013).

Vegetable oils are highly desired as alternative lubricant for metal working operations. It has been proved that the biodegradability levels of vegetable oils are higher than those of petroleum-based lubricants (Syahrullail *et al.*,2011). Vegetable oils are lipid materials derived from plants. Physically, oils are liquids at room temperature; they are extracted primarily from seeds.

Castor oil is a vegetable oil obtained from the castor plant seed. It consists almost entirely of triglycerides ricinoleic acid. It is a colourless to very pale yellow liquid with mild or no odour or taste. Its boiling point is 313 $^oC$ and its density is 961kg/$m^3$. There are many uses for castor oil and its derivatives. Some of these include manufacture of plastics, cosmetics and hair oils, adhesives, synthetic resins, soap, grease and lubricants, and drying oils(Al-Sabag*et al.* 2012).

Neem oil is a vegetable oil pressed from the fruit and seed of neem (Azadirachta Indica), an evergreen tree. It is perhaps the most important of the commercially available products of neem for organic farming and medicine. Neem oil is generally red as blood and has a rather strong odour that is said to combine the odour of peanut and garlic. It comprises mainly of triglycerides and large amounts of triterpenoid compounds which are responsible for the bitter taste. It is hydrophobic in nature and, in order to emulsify it in water for application purposes, it is formulated with surfactants (Hassan *et al*., 2011).

## II. Extrusion process

Extrusion is a metal forming process by which a block of metal either in the solid state or semi molten state is converted into the same metal which is of different surface orientation of a different cross sectional area of continuous length (Tang and Reynolds, 2010). It involves plastic deformation process in which a work piece is reduced by the application of compressive forces to the material, causing it to flow through a hole in a shaped die (Ibhadode, 1997). The reduced section thus acquires the shape of the die orifice. The process may be carried out hot or cold. In order to maintain maximum production at minimum extrusions, turning, drilling, wire drawing and other forming operations are carried out with lubricants, which are directed onto the working piece and die.

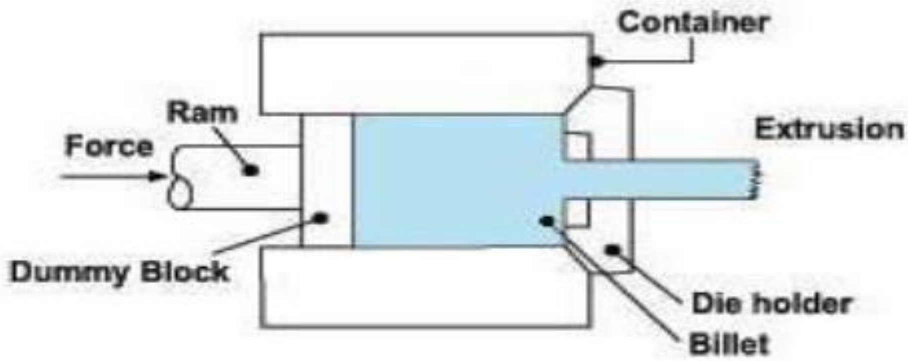


**Figure 3.1 Schematic of Extrusion Process**

## III. Materials and methods

The materials needed to carry out the extrusion include the press, die, container, die holder, punch, aluminium billets and mild steel. In this work, 500 kN universal testing machine located at MATERIAL STRENGTH LABORATORY, Ahmadu Bello University, Zaria, Nigeria, was used in place of the press. The die and other materials were designed and constructed in the production workshop of the same university. Mild steel was sourced from Albabello Trading Company, Zaria, and was used for the construction of the tools (dies, punch, and containers).

The billets oflength 50 mm were 32 in number (6 round, 6 square, 6 rectangles and 6 triangles), and were extruded through the round die, square die, rectangular die and triangular die respectively. Extrusion ratios were chosen to withstand pressure and temperatures normally associated with laboratory facilities. The billets were degreased in methanol for about 10 minutes to remove all the oil grease from the machining operation and cleaned with industrial tissue. They were then extruded through the various die geometries with a crosshead speed of 3 cm/min with the lubricants being directed over the working surface to acts as coolants. The punch travel was measured by means of a rotating dial gauge. A stop watch was used for timing. The approximate period for the extrusion was recorded.

Varying die angle which was employed in the design of the dies good surface finish and hardness of extruded billets were produced which is in agreement with the investigation carried out. The findings agree with those of Moveh and Gambo (2016) on the effects of vegetable oil-based lubricants in the extrusion of aluminium.

**Table 3.1 Physico-chemicalcal Properties of Neem and Castor oils**

| S/ NO | PROPERTIES | NEEM OIL | CASTOROIL |
|---|---|---|---|
| 1 | Viscosity @ $40^0$C | 185 | 230 |
| 2 | Viscosity @ $100^0$C | 70 | 136 |
| 3 | Viscosity Index | 395 | 420 |
| 4 | Refractive Index | 1.47 | 1.50 |
| 5 | Sulphated Ash | 0.015 | 0.40 |
| 6 | Acid Value/Total Base | 1.5 | 3.5 |
| 7 | Pour Point ($^0$C) | 1.3 | 0.2 |
| 8 | Density Kg/m$^3$) | 1.40 | 140 |
| 9 | Colour | Light Brown | Colourless |
| 10 | Flash Point ($^0$C) | 260 | 275 |

**Table 3.2: Extrusion Parameters and Surface Finish of Extruded Billets**

| Oils | Billets | Extrusion Load (kN) | Extrusion Time (sec) | Surface Roughness Ra(μ) |
|---|---|---|---|---|
| Castor | Round | 40 | 120 | 0.5 |
| | Square | 150 | 240 | 3.0 |
| | Rectangle | 250 | 300 | 3.0 |
| | Triangle | 100 | 200 | 1.5 |
| Neem | Round | 50 | 140 | 1.5 |
| | Square | 150 | 200 | 3.1 |
| | Rectangle | 220 | 220 | 3.1 |
| | Triangle | 100 | 150 | 1.5 |

**Figure 3.2 Extrusion Die Punch on Universal Testing Machine**

## IV. Results and Discussions

TABLE 3.1 shows the physicochemical analysis of the two oil samples. Neem seed oil had a viscosity of 190 cp at $40^0$C and 110 cp at $100^0$C while Castor oil had a viscosity of 230 cp at $40^0$C and 136 cp at $100^0$C.

TABLE3.2showsthat using castor oil as lubricant during the extrusion process ensured that tougher materials and the demand for closer control of better surface finish was achieved. This signifies that castor oil gave a better surface finish quality for both round and triangular billets. Also for neem oil lubricants, round and triangular billets had the good surface finish. Surface cracking is generally recognized as one of the main defects occurring.

The research findings indicated that the surface quality is good even though the temperature may be high during extrusion. Also, all the geometries of aluminium extruded came out curved except for the round billet. This shows that for extrusion of different geometrical shapes, guiding elements should be provided in order to make the extruded metal straight. This is also confirmed by the findings of Hafis, *et al.,* (2011).

This paper signifies that good surface finish products can be achieved by using the vegetable oils as lubricants. Also as result of varying die angle which was employed in the design of the dies good surface finish and hardness of extruded billets were produced which is in agreement with the investigation carried out by Chaudhari et al, (2012) on the effect of die angle on the quality of extruded products.

## V. Conclusion

This paper testifies that renewable energy bio-based oils are suitable and can serve as substitute to conventional lubricating fluids in the extrusion of aluminium billet because of the good surface finish achieved. Extrusion process was carried out and the oils were used as lubricants in the extrusion of aluminium billets and compared with other works done in the use of vegetable oil as lubricants during extrusion processes and were found to be suitable because of their heat reduction abilities. Based on previous experiments carried out on the extrusion of aluminium, surface cracking were major defects caused by the rise in temperature as the process proceeds.

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