Effects Of Vegetable Based Oils Lubricants In The Extrusion Of Aluminium

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Abstract: Four vegetable based oils were used as trial lubricants in the extrusion of aluminium billet through four different die geometries. The oils used were Castor oil, Neem oil, Jatropha oil and Cotton oil respectively. Results obtained from this work as compared with other works done in the area shows that these oils were found to be suitable as lubricants in the extrusion of aluminium because of the good surface finish that was achieved. Extrusion dies with semi die angles of 30^0, 45^0 and 60^0 were constructed and case hardened and a hardness value of 612HV was obtained using the Vickers hardness testing machine, which is in accordance with the minimum standard of 600HV. Precise surface roughness measurements were made quantitatively with the profilometer for all the geometries of billet extruded, where round and triangular billets gave good surface finish for all the oils except for castor oil which gave the best surface finish. 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. This research experiments indicated that the surface quality is good even though the temperature may be high during extrusion process

Keywords: Extrusion, Billet, Die, Hardness, Aluminium, Vegetable, Oil, Lubricants.

1 INTRODUCTION

Metal forming includes a large group of manufacturing processes in which plastic deformation is used to change the shape of metal work pieces. Deformation results from the use of a tool, usually a die in metal forming, which applies stresses that exceed the yield strength of the metal. The metal therefore deforms to take a shape determined by the geometry of the die. Extrusion process is used to describe the 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. The extrusion process is an attractive production method in industry because of its ability to achieve energy and material savings, quality improvement and development of homogeneous properties throughout the component (Raj et al 2000). This process involves plastic deformation process in which a work piece is reduced by the application of compressive forces to it, 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 cost in the face of increasingly different design tolerance, engineers have been making extensive researches to ensure that tougher materials and the demand for closer control of surface finish is achieved. Extrusion, turning and drilling and other forming operations are carried out with lubricants, which is directed onto the working piece and die. The functions of lubricants cannot be neglected for the role they perform in forming operations, as these operations cannot be carried out efficiently without the appropriate lubricants.

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Lubricants are generally found in the liquid or gaseous state and are applied to the working surface to facilitate smooth extrusion of the billet and to remove the possibility of folding which usually results in deposit in the dead region of the container. These benefits extrusion in many ways, especially as they act as a heat remover. They also help to remove defects such as internal piping of the thin billet skin that is extruded into the extruded rod. Conventional lubricating fluids are usually petroleum based, and since they are not bio-degradable they pollute and contaminate water and soil when discharged as waste to the ground thereby having detrimental effect on health and environment. In order to alleviate the health risk associated with the petroleum based lubricants and the need to make the extrusion process more ecologically friendly, there is the need to develop an alternative safe and environmentally friendly lubricant. Vegetable oils among other options could be investigated in developing a new lubricating fluid where high performance in forming operations with good environmental capabilities could be achieved. The most important characteristics of vegetable oil are their safety and biodegradability (Obi, 1998). Compared to petroleum based oil (mineral oil), Vegetable oil has been shown to replace mineral oil as lubricants in previous researches carried out (Syahrullail et al 2011),. Also it has higher flash point and natural viscosity than mineral oil, thus improving the surface finish and extending tool life. It also does not contribute to health hazard via toxic mist and skin cancer and does not pollute the environment.

2 MATERIALS AND METHODS

In order to carry out extrusion, the main components needed include the main power supply unit which is the press, die, container, die holder, punch, mild steel and aluminium (billets). In this work however the universal testing machine was used in place of the press. All these except the universal testing machine were designed and produced in the workshop using available materials (mild steel). Mild steel was sourced from Samaru market, Zaria and was used for the construction of the tools (dies, punch, containers); hence a case hardening process was applied to the dies and the punch.

2.1. Aluminium: Aluminium (Al), is the most abundant metallic element in Earth's crust. With atomic number of 13; the element is in group 13 (IIIa) of the periodic table. Aluminium is a lightweight, silvery metal with atomic weight of 26.9815; it melts at 660°C, boils at 2519°C and has a specific gravity of 2.7. Aluminium is a strongly electropositive metal and extremely reactive. In contact with air, aluminium rapidly becomes covered with a tough, transparent layer of aluminium oxide that resists further corrosive action. For this reason, materials made of aluminium do not tarnish or rust. Aluminium weighs less than one-third as much as the same volume of steel. The only lighter metals are lithium, beryllium, and magnesium. Its high strength-to-weight ratio makes aluminium useful in the construction of aircraft, railroad cars, and automobiles, and for other applications in which mobility and energy conservation are important. Because of its high heat conductivity, aluminium is used in cooking utensils and the pistons of internal combustion engines.

2.2. LOCAL LUBRICANTS

Vegetable oils are highly desired as alternative lubricant for metal working operations. However, vegetable oils have limited ability to be utilised in the metal working application because it is mostly utilised in food industries. It was proved that the biode- gradability levels of vegetable oils are better compared to petro- leum-based lubricants (Syahrullail et al 2011). Vegetable oils are lipid materials derived from plants. Physically, oils are liquids at room temperature; oils are extracted primarily from seeds. The vegetable oil may or may not be edible and examples of the inedible oils are castor oil and Jathropher oil. Examples of the edible oils are soya, palm oil, etc.

Castor oil: this is a vegetable oil obtained from the castor plant seed. Castor oil consists of almost entirely of the triglycerides ricinoleic acid. It is a colourless to very pale yellow liquid with mild or no odour or taste. Its boiling point is 313 C and its density is 961kg/m. There are many uses for castor oil and its derivatives. Some of these include plastics, cosmetics and hair oils, adhesives, synthetic resins, soap, grease and lubricants and drying oils. (www.azom.com/oars.asp)

Cotton seed oil: cotton seed oil is cooking oil extracted from the seed of a cotton plant of various species, mainly Gossypiumhirsutum and Gossypiumherbaceum. Cotton grown for oil extraction is one of the big four genetically modified crop grown around the world next to soy, corn and rapeseed (conola). Its fatty acid profile generally consists of 70 percent unsaturated fatty acid (18% monounsaturated and 52% polyunsaturated) and 26% saturated fat. (Nutrient data for 04502, US Department of Agriculture).

Neem seed oil: neem oil is a vegetable oil pressed from the fruit and seed of a neem (Azadirachtaindica) 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 inorder to emulsify it in water for application purposes; it must be formulated with appropriate surfactants (www.azom.com/oars.asp).

Jathropher oil: Jathropher oil is a vegetable oil produced from the seed of a jathropercurcas, a plant that can grow in marginal land. The oil gotten from a jathropher plant can be further processed into a high quality biodiesel that can be used in a standard diesel car (www.azom.com/oars.asp).

Figure 1: Extrusion die punch assembly on universal testing machine (UTM)

The billets of length 40mm were 32 in number (8round, 8 square, 8 rectangles and 8 triangles) which were extruded through the round die, square die, rectangular die and triangular die respectively. Small extrusion ratios were chosen to withstand pressure and temperatures normally associated with laboratory facilities. The billets were degreased in acetone for about 10mins to remove all the oil grease from the machining operation. The billets were then extruded through the various die geometries with a crosshead speed of 2cm/mins, while the lubricants were directed over the working surface to acts as coolants. The punch travel was measured by direct connection of a rotating dial gauge and by means of a stop watch the approximate time to complete each extrusion was recorded.

Table 1: *Hardness Test Results*

Readings	1	2	3
Horizontal diagonal d1 (mm)	80	0.311	0.327
Vertical diagonal d2 (mm)	0.280	0.314	0.305
Mean diagonal d (mm)	0.280	0.313	0.16
Vickers Hardness HV	710	568	557

Table 2: *Percentage of oil in seed, saponification, iodine, values and the specific gravity of local oil*

Lubricant	***% of oil in seed***		**Saponification value**	**Iodine value**	**Specific gravity**
Castor oil	50		187 OH-160	86	0.965/25^{0}C
Neem oil	40		175	65	0.915/30^{0}C
Jathropa oil	40		191 OH 4-20	82	0.918/15^{0}C
Cotton oil	25		191	103	0.915/15^0

SOURCE: *National research institute for chemical technology, (2012)*

***Table 3:** Fatty acid content of the four vegetable oils*

Fatty acid	Neem oil	Castor oil	Cotton oil	Jathropa oil
Myristic	2.60	-	0.4	1.4
Palmitic	13.6	2.0	20	12.0
Arachidic	3.4	-	-	0.3
Oleic	49	7.0	35	37
Linoleic	2.3	5.0	42	19
Stearic	14.4	1.0	2.0	5.0

***SOURCE:** National research institute for chemical technology, (2012)*

***Table 4:** extrusion parameters and surface finish of extruded products for various vegetable oils*

Oils	Billets	Extrusion Load (KN)	Extrusion Time (Sec)	Surface Roughness Ra (μ)
Castor	Round	44	120	0.8
	Square	180	209	3.2
	Rectangle	270	260	3.2
	Triangle	88	200	1.6
Neem	Round	53	149	1.6
	Square	185	220	3.2
	Rectangle	200	220	3.2
	Triangle	72	184	1.6
Jatropha	Round	58	153	0.8
	Square	120	200	1.6
	Rectangle	280	300	1.6
	Triangle	70	180	0.8
Cotton	Round	47	133	1.6
	Square	183	206	3.2
	Rectangle	260	258	3.2
	Triangle	84	195	1.6

3 DISCUSSION OF RESULTS

The extrusion process is divided into two parts the coining stage, which is the stage when the billet being extruded begins to fill up the die cavity. This stage is also of two parts, the initial container filling part and the on-set of extrusion. The second stage is the steady stage, which is when the extrusion proceeds steadily and it is characterized by a drop in load to the coring point. From table 4 it can be seen that 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. I.e. to say castor oil gave a better surface finish quality for both round and triangular billets. Also for the three other trial lubricants (Neem, Jatropha and cotton) round and triangular billets also had the good surface finish. Surface cracking is generally recognized as one of the main defects occurring during the process of aluminium extrusion, especially in the case of the so called hard aluminium alloys. Previous experiments suggest that this type of defect is caused by the rise in temperature as the process proceeds. This research experiments indicated that the surface quality is good even though the temperature may be high during extrusion Also for some of the geometries of aluminium extruded, they came out curved except for the round billet. Which shows that for extrusion of different geometrical shapes guiding elements should be provided in order to have the extruded metal straight. Based on the result gotten by Hafis, et al (2011) in the investigation of the effect of palm oil as lubricant in cold forward extrusion Therefore, in this research good surface finish products were 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.

4 CONCLUSION

Extrusion process was carried out and the oils were used as trial lubricants in the extrusion of aluminium 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. This research experiments indicated that the surface quality is good even though the temperature may be high during extrusion process because of the cooling effect of the lubricants used.

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