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Behaviour of Aluminium Undergoing Cold Extrusion: A Review

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Abstract. Aluminium is widely used metal. Aluminium alloy is used in mechanical industries for bolts, nuts, rivets and many other things. Aluminium is cold extruded because of its benefits like very less oxidation, high strength because of working in cold temperatures, very closer tolerances, surface finish is good, and higher speeds of extrusion when specimen is intended to hot shortness. The main objective of this research is to perform cold extrusion on aluminium rods by considering different parameters, to obtain a superior product. Different parameters like the die angle, oils and ram speeds are considered for performing this experiment. The extruded products are compared and various tests like tensile, hardness, surface roughness are performed on the extruded products and the results are compared to decide better parameters for obtaining superior product. This paper is a summary of scholarly sources on cold extrusion and aluminium alloys. This research provides a clear view of the present knowledge and helps identify relevant*theories, methods, and gaps in existing research. It also describes the results of the research, and the conclusions are drawn from them.

1 Introduction

Cold Extrusion is performed by pushing the metal through a die which has an entry and exit point, when the metal is penetrated with force its physical size is altered. Cold Extrusion improves the extruded metal mechanical properties. Generally, extrusion is performed as shown in Fig. 1 on the rods to reduce the diameter and produce products like rivets, screws and many other things. In order to perform cold extrusion we need to design a die based on our requirements, lubricants should be selected depending on the product we are extruding which is selected if the production is commercial or a small production In the year 2017 cold working influence of mechanical behavior is studied along with the ductile nature of aluminium alloy, axial displacement was monitored and through the use of SEM fractographs, it was determined that the alloy exhibited ductile dimples that displayed the typical micro void coalescence process of ductile fracture.. It concludes that the cold working effects both plastic deformation and ductile nature [1]. In the year 2017 cold working influence of mechanical behavior is studied along with the ductile nature of aluminium alloy, axial displacement was monitored and using SEM fractographs, it was determined that the

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alloy exhibited ductile dimples that displayed the typical micro void coalescence process of ductile fracture. It concludes that the cold working effects both plastic deformation and ductile nature [1].

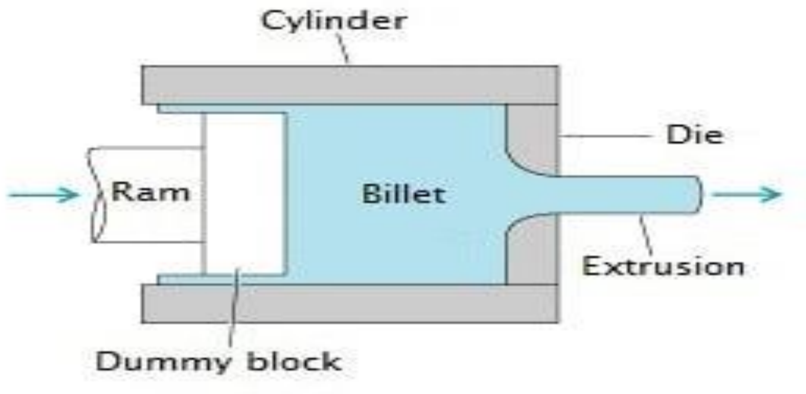

Fig. 1. Set up for performing cold extrusion [2]

2 Experiment Procedure

2.1 Die Angles

The geometry of the die and the speed of the extrusion affect cold extrusion, The hardness of the extruded aluminium product towards the injection is more in die reduced area. It is due to increase of dislocation due to more strains at high reductions, the dimensionless values for both the specific maximum and the specific core extrusion pressure depend mostly on the die angle, load factor, and area reduction and complexity. The smaller the area of the tool, the larger the radius of curvature [3]. Tensile behaviour of Al-Mg alloy varies at hot and cold temperatures and "Uniaxial tensile elongation diminishes with rising strain rates and rises with temperatures," according to research. Improvements in strain hardening and strain rate sensitivity, respectively, are the main causes of improved elongation at cold and warm temperatures. This substance can be formed more easily at cold and warm temperatures than at room temperature [4]. The interchangeable elements in die cause change in extrusion and flexibility, High-resolution history plots were used to extract maximum extrusion force values from the finite element simulation. The software's post analysis module was designed with this feature. [2]. Aluminium alloys can be used to manufacture tools of complex geometries due to its good formidability in cold conditions [5].Feed rate influences the surface roughness quality[6].Extrusion is used in structural work, aluminium extrusion is used in making doors, windows, etc. Extrusion is also in the automotive industry, to form the desired material using brittle materials.

2.2 Lubricants

Extrusion die geometry, frictional conditions at the die-billet interface, and temperature gradients inside the billet have all been demonstrated to significantly affect metal flow in cold extrusion [7,3]. Numerous researchers have tried to investigate how various lubricants affect the die-billet interaction. [8,9]. In order to avoid the friction in between surfaces of die and the part we use lubricants. The angle between the die wall and the drawing centreline is the angle of die. Die angle performs important role in the finishing of final product. Previous research shown that as the length of the die land grows, so does the force needed for extrusion. Improving the appropriate die angle aids in the extrusion of superior products. When extruding, lubricants are used to minimise friction. They come in solid, liquid, and semi-solid forms. Studies were done to compare the viability of palm oil with RBD palm stearin, additive-free paraffinic mineral oil, paraffin VG460, and VG95 when used as a lubricant in cold operations, such as the forward plane strain extrusion process. [10] It is discovered that the billet's product area, which was extruded with RBD palm stearin, has less surface roughness than billets that were extruded with paraffinic mineral oils VG95 and VG460. The forward micro-extrusion of a work piece has been successfully simulated in this study using input parameters like description of material and frictional behaviour, outlining the differences between simulated and experimental processes while also identifying the impactful stress-strain and material flow properties following the extrusion as well as the higher punch reaction of the formed material [11]. This study examined four commercial lubricants: a mineral oil with addition of grease for high pressures and three semi-synthetic important oils in which chlorine is not present in a variety of dynamic viscosities. They are already applied to zinc phosphate coated billets during metal forming procedures [12]. The castor oil of graphite lubricant formulation with very low pressure of extrusion has a castor oil graphite ratio of 85:15%. It is advised to use castor oil of graphite lubricant with 15% graphite while cold extruding aluminium alloy (EC grade). It is crucial to investigate the results of castor oil graphite lubricant performance tests for cold extrusion of various alloys of aluminium [13].

2.3 Hardness

In the experiments conducted by Fuertes and Murillo on mechanical properties of Al-Mg alloy (2015), the microhardness of HV was found to increase by 21% compared to a connecting the rod which is forged with the material without prior deformation of ECAP. Mechanical properties of isothermally forged connecting rod are studied. The qualities acquired during the SPD process must be taken into consideration while performing isothermal forging on the material [14]. However, stress relief occurs in the material if the process is run at a lower temperature and at a quick enough pace (without the dynamic re - crystallization time), allowing the needed component to be forged but at the expense of the good mechanical qualities previously attained in the ECAP process. It is observed that the microhardness values of HV rod produced after two passes are 21% higher compared to rod forged under calm heat conditions. Furthermore, The zones with the greatest cumulative plastic strain values from finite volume simulation were found to match with the zones with the greatest microhardness values observed empirically[15].

2.4 Microstructure

The evolution of the microstructure and mechanical properties of the AA5754 and Ti6Al4V dissimilar laser welds are being examined in relation to the effects of after-welding heat treatments (PWHT) done at 350 C and 450 C. On the titanium side of the welded fuse zone, the microstructure was more like martensitic, while on the aluminium side, it was fine structure of dendrite. For the weld that was treated using a higher energy line, there was greater density for intermetallic parts. The titanium underwent a post-weld heat treatment that resulted in the dissolution of the retained b phase(represented in Fig. 2), the tempering of the martensite, and the precipitation of the TiAl3 combination. Microhardness increased. Tensile characteristics demonstrated that HT 450 had a detrimental impact on the welds. The increase in grain size put a strain on the yield.[16].

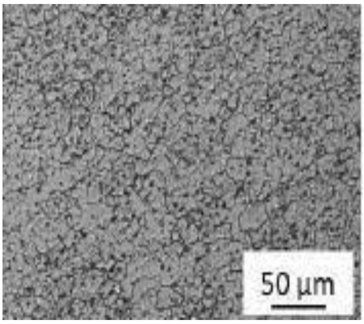

Fig. 2. Representation of the microstructure for the 5754 H111 aluminium alloy of Friction stir welded region [16].

2.5 Metal Flow

Here the material used is aluminium alloy of grade 6031. Three different dies are used with different profile complexity. The size of the DMZ(Dead Metal Zone) and distortion in flow of the metal do not consistently increase with the complexity of the profile but rather follow an increasing-decreasing trend. This goes against the predicted behaviour of more irregular flow of metal and greater the DMZ more complicated are the shapes. These changes in profile symmetry and extrusion ratio, as well as the uneven and inadequate complexity definitions, may contribute to this unanticipated and chaotic behaviour as shown in Fig. 3. This emphasises the need for a new definition of difficulty index that is more consistent [17].

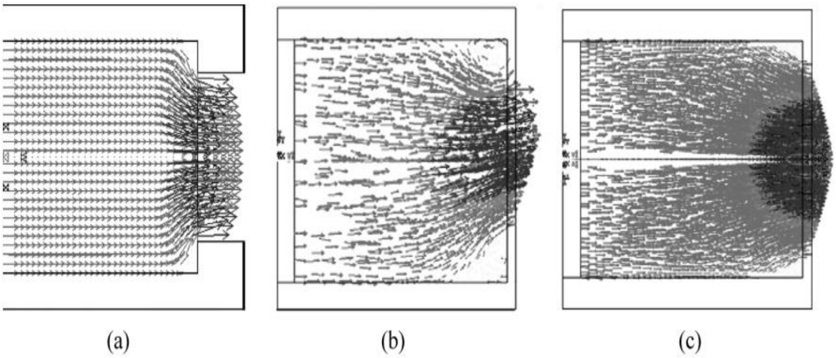

Fig. 3. Figure showing Velocity of three different complexity profiles.[18].

3 Results and Discussions

In the Fig. 4 four different lubricants taken into consideration. Those are Vg460, palm stearin, palm kernel and commercial extrusion oil. After performing cold extrusion on aluminium alloy the samples obtained are tested for surface roughness. From the obtained results it clearly shown that palm stearin has best surface finish followed by commercial extrusion oil and that followed by Vg460. The last one is palm kernel oil.

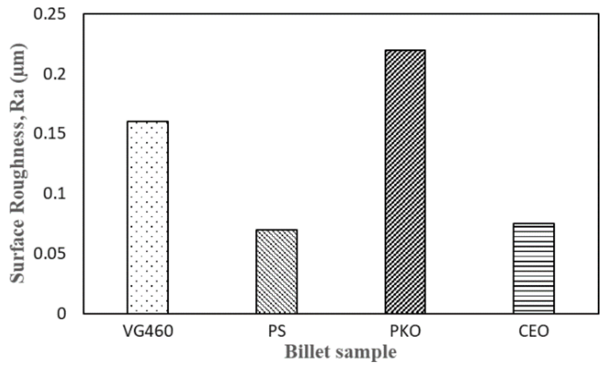

Fig. 4. Figure deciping surface roughness values of cold extruded aluminium alloy with different lubricants.[7].

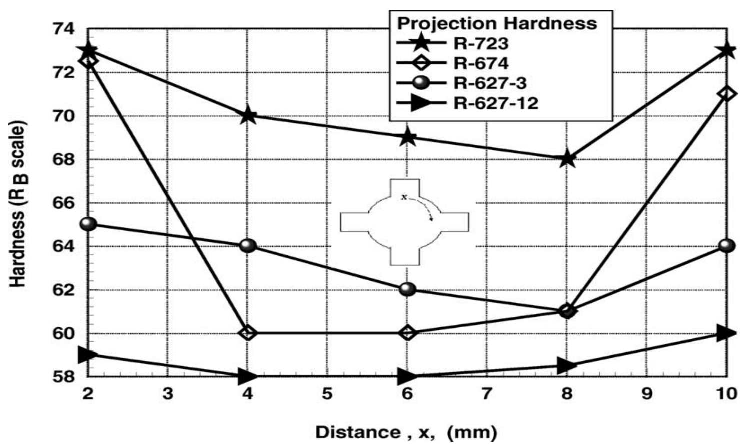

Fig. 5. The above figure explaining Hardness values of Aluminium from surface to core [1].

Along the projection, the extruded aluminium product's hardness values rise(represented in Fig. 5), increasing the die reduction area. It is caused by the dislocations multiplying as a result of high strains in high reduction areas. When forging ECAP-processed products, the microhardness of the aluminium alloys AA-5754 and AA-5083 increased by 12.2% and 10.3%, respectively. The findings of the FEM models and experimental results closely match one another, with the absolute difference between them being just about 5% in average.[19]

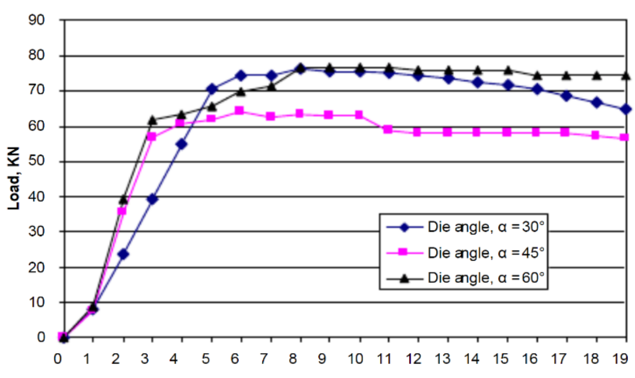

Fig. 6. Figure showing the Load vs displacement graph for three different die angles [3].

From the above Fig. 6 it resulted that for displacements smaller than 5mm the extrusion load is less for 60 degrees die angle. When it passes the displacement of 5mm the extrusion load is higher die having die angle 30 degrees. For die angle 45 degrees it lies in between.

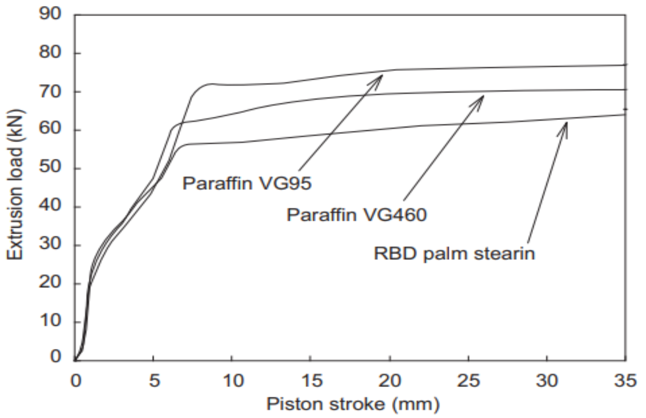

Fig. 7. Figure explaining the graph of Extusion load vs Piston stroke for three different lubricants [8].

The above graph (Fig. 7) explaining us the variation of loads for three different lubricants those are Paraffin Vg95, Paraffin Vg460 and RBD palm stearin. Out of all those lubricants used initially till stroke of the piston before reaching 8mm the extrusion loads are similar but after 8mm Paraffin Vg95 has highest extrusion load followed by Paraffin Vg460. RBD palm stearin has least extrusion load. Overall the palm stearin is best for good efficiency and surface finish but the price of it is very high.

4 Conclusion

This article mainly focused on cold extrusion of aluminium based on different process parameters and their potential key players and current activities were reported. Although the fundamentals of the extrusion are well known, it is primarily the advancements in manufacturing and forging, that have led to the widespread adoption of new parameter improvements

- Because of the absence of oxidation, increased strength from cold working, tighter tolerances, and faster extrusion rates, cold extrusion is favoured to hot extrusion in the event that the material is exposed to heat shortening.
- Dimensional accuracy, Lower energy consumption, and higher rates of production.
- As the die angle increases the hardness value of the extruded billet decreases.
- If the die angle increases then the extrusion load gradually increases.
- There is no great deviation in extrusion loads with different lubricants. However the surface roughness depends on lubricant used.

However, few obstacles are still common. We can further research the optimum values for the process parameters to obtain a much better final product. There is still a lot of scope in cold extrusion which helps us understand it and make it efficient.

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