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Simulation Study of Effect of Billet Temperature in Forward Extrusion

Mallikarjun Shivappa[1], Prof Bharat S Kodli[2]

[1]*PG Student of Production Engineering, PDA College Of Engineering, Kalaburagi.*
[2]*Department of Mechanical Engineering, PDA College of Engineering, Kalaburagi*

Abstract— The main objective of this project is to study the effect of billet temperature in forward extrusion and to determine the parameters influencing on forward extrusion process. The analysis is done by varying the billet temperature and die angle in order to optimise the load by keeping the parameters such as Ram velocity and co efficient of friction are constant. In this CAD technique, the simulation process of modelling using UNIGARPHICS and process of simulation by AFDEX software. The material used for this process is Aluminium Alloy 7075. The parameters are chosen as different temperature (such as 300,350,400,450,500) and also varying Die-Angle (30, 45, and 60). The optimise load has occurred at temperature 500 and Die angle 60 and Extrusion force as 6.625 E-1

Key words: Die, Billet Temperature, Ram Velocity, Coefficient of Friction, Die Angle, AFDEX, UNIGRAPHICS.

I. Introduction

Extrusion is the process of forcing a billet to flow through a shaped die opening. In extrusion, a ram applies pressure to the billet, causing the work-metal to flow in the required direction. The relative motion between ram and die is obtained by attaching die to the stationary bed and the ram to a reciprocating arm. The axis of the machine can be horizontal or vertical. The pressure can be applied rapidly as a sharp blow, as in crank press, or more slowly by a squeezing action, as in hydraulic press. In hot extrusion, the temperature at which extrusion is performed depends on the material being extruded.

A. *Direct Extrusion*

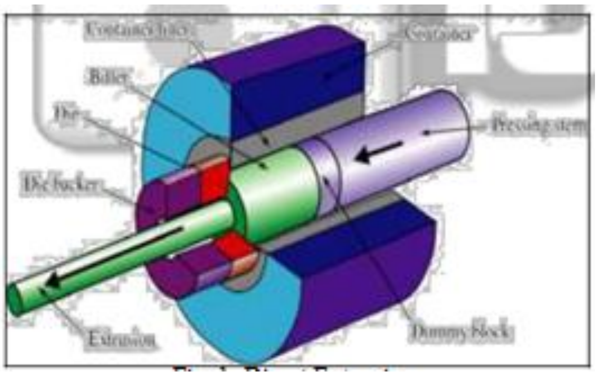

Fig. 1: Direct Extrusion

Direct extrusion is a type of extrusion in which the material flows out of the die in the direction of ram movement

Table 1:

Material	Billet Temperature °C
Lead Alloys	90– 260
Magnesium Alloys	340 – 430
Aluminium Alloys	340 – 510
Copper Alloys	650 – 1100
Titanium Alloys	870 – 1040
Nickel Alloys	1100 – 1260

The main objective of this Project work is to design and simulate the extrusion of hexagonal bar from round billet and to study the effect of billet temperature on extrusion process optimize the process parameter which minimize the load applied in forward extrusion. The die, billet and ram were modelled in UNIGRAPHICS and the simulations were performed by using AFDEX.

B. ***Literature survey***

Govindraj Karalgikar & Bharat S Kodli [1] **Simulation Study of Material Behaviour and Optimization of Die Land Length in Forward Extrusion using AFDEX Software.** The paper deals with analysis of metal extrusion process. The primary objective of this paper is to study the material behaviour , predict and eliminate the defect in the product. A combination of Unigraphics is used with AFDEX 2014 simulation software package to accomplish the purpose. The present case is aimed at combining the considerations on die design and process parameters to bring in optimization. Optimization is of great importance when it comes to extrusion process.

S. Chahare, & K. H. Inamdar [2]. **Optimization of Aluminium Extrusion Process using Taguchi Method.** Direct hot extrusion of Al 6063 aluminium alloy was considered in this study to obtain the optimum process parameters for feature angularity of a two track top profile used in commercial window assembly. Taguchi design of experiments was used to analyze the experimental results and obtain the optimum process parameters using s/n ratio analysis. Three factors (billet pre-heating temperature, container temperature and ram speed) with three levels each were used for performing the experiments to determine the response variable (feature angularity). Through analysis the optimum level of process parameters for feature angularity was obtained with billet pre-heating temperature of 500 0C, container temperature of 400 0C and ram speed of 6.0 mm/sec. Analysis of variance was used to investigate the impact of process parameters on the feature angularity. It was found that ram speed has the maximum contribution with 59.83% followed by container temperature and billet pre-heating temperature.

Akshay Gupta, G.V Shriyak Reddy, V. Krupa Sagar, V.Amruth Sagar, Sirajuddin Elyas Khany [3] **An Experimental Study of The Effect of Process Parameters on The Extrusion Pressure and its Impact on The Die Life.** In this work an experimental study of the effect of process parameters on the extrusion pressure and its impact on the life of a hollow die having a bearing shape of roman section/Channel was carried out. The aluminium used here was of a grade 6061-O and the die material of high density steel. Upon extrusion of aluminium from the die- variable factors (Temperature, pressure, lubrication, die angle) affecting the life of the die were noted down and a brief analysis was carried out. A relationship was determined between the experimental and the theoretical data. The practical analysis is carried out with the aid of live readings obtained while performing extrusion. The indicative values obtained here are ideal pressure/fluid pressure, which is the pressure exerted on the ram, Billet temperature is in the range of 4200C – 6000C and coefficient of friction(μ) could be obtained from the graph for relative temperatures accordingly .The die angle and the reduction ratio are constant. From the observed data, we can conclude that Extrusion process could be carried out at a temperature between 520°C and 560°C for a minimum extrusion pressure.

- At 560°C the pressure of extrusion is lowest.
- Life of the Die can be improved by maintaining a constant pressure (obtained from the data) and by applying Boron Nitride aerosol as a Lubricant.
- The temperatures suggested here are for a specific bearing area. However this range is suitable for extruding large varieties of hollow channels.
- The usage of boron nitride decreases the smoke emission which helps in reduction of air pollution.

Mohammed Y. Abdellah, Mahmoud Moustafa, Ashraf T. Mohamed [4] **Hot Extrusion of Reinforced Aluminium Powder Compacts.** Metal working Process was carried out to enhance the strength and density of green powder compacts. Extrusion process is performed on aluminium powder compacts reinforced with copper wires, 1, 2, 3 and 4 wires. The temperatures selected for extrusion process are below recrystallization temperature 350°C and over 450°C. Graphite lubricate is used as it is good lubricate when works in elevated temperatures. The process gives observable enhancement in both density and strength. The extrusion at elevated temperatures is found applicable and produces good products. The green product relative density is enhanced to reach nearly 98% of actual one. The compressive strength of the aluminium powder compact is enhanced well compared to green ones. The metal working process at elevated temperature above the recrystallization temperature is the more suitable to produced nearly full consolidated powder compacts.

S. N. Ab Rahim, M. A. Lajis, S. Ariffin [5] **Effect of extrusion speed and temperature on hot Extrusion process of 6061 aluminium alloy chip.** This study concentrated on improving the understanding of the behaviour and the formation mechanism distribution with the aim of predicting the best on parameter process hot extrusion of 6061 aluminium alloy chip by using Deform 3D simulation without lubricant. The influence of extrusion process parameters, namely ram speed (Vr), preheat temperature (Tph), preheat time (tph) and extrusion die angle on the responses flow stress and heat distribution was investigated. Result shown the temperature 500°C on the cross-section of extrudate becomes more Inhomogeneous at a higher ram speed. The temperature always rises occurred at the beginning stage and the Temperature tends to be stable as the ram travels further. Simulation models can be used as a tool in the prediction of extrusion forces and surface quality.

II. SIMULATION

In this Project, Unigraphics software is used to design and AFDEX – 2014 are used to simulate the extrusion process. AFDEX is a general purpose metal forming simulator which can be applied not only to conventional bulk metal forming processes including forging, rolling, extrusion and deep-drawing, but also, to new creative bulk metal forming processes. AFDEX is theoretically based on rigid-thermovisco plastic finite element method.

III. METHODOLOGY

The parameters considered for the execution of the project work are listed in the table below.

Table II

Material Properties

Component	Hexagonal Bar (Solid)
Material Used	AA7075
Extrusion Type	Hot
Die Type	Conical
Initial Temperature Of Billet	260ºC

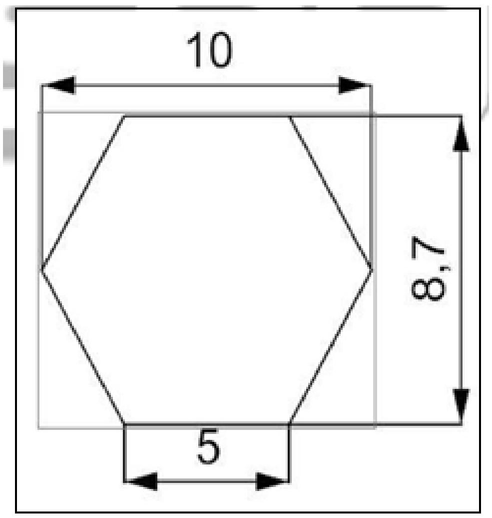

Fig. 2 Hexagonal Design

A. Parameters Considered

Table III
Parameters

Sl No	Die Angle	Friction Co-efficient	Ram Velocity
1.	30	0.1	1.0
2.	45	0.1	1.0
3.	60	0.1	1.0

B. Die Sketches

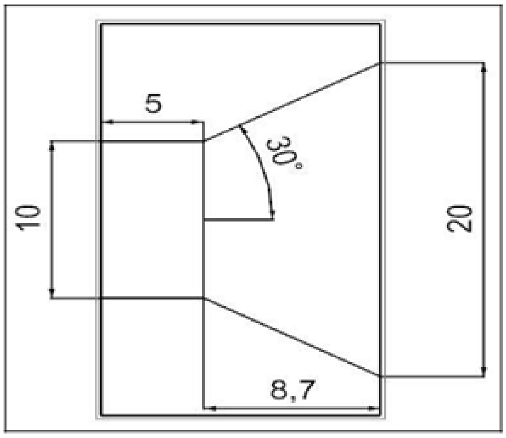

Fig. 3 Semi-cone angle α=30°

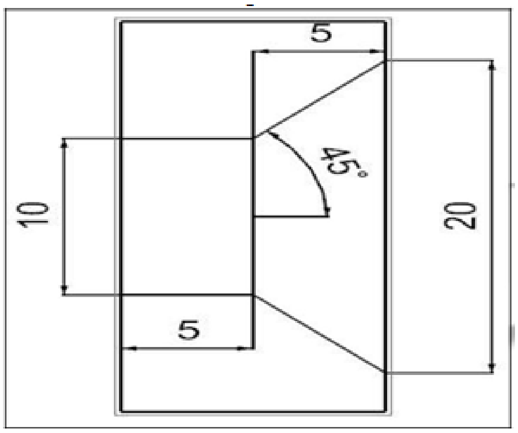

Fig. 4 Semi-cone angle α=45°

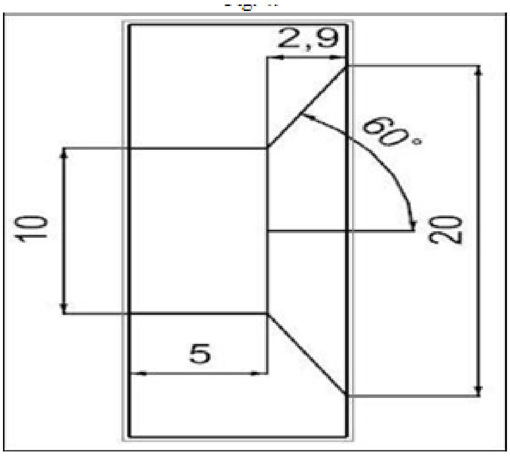

Fig. 5 Semi-cone angle α=60°

In the present work, the flow-chart below shows the steps involved in executing the simulation.

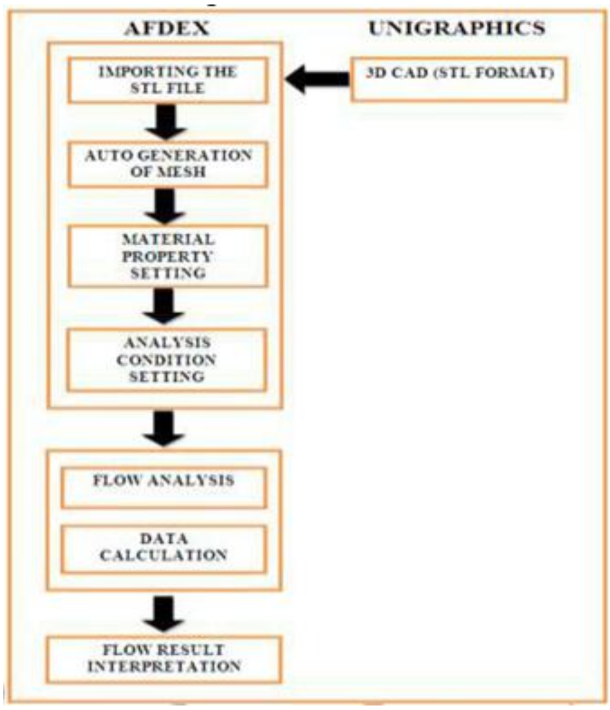

Fig 7 executing the simulation

Table IV:

Material 1 – AA7075 Composition

Component	Weight %
Aluminium	97.36
Magnesium	0.8
Silicon	0.4
Iron	0.7
Copper	0.15
Zinc	0.25
Titanium	0.15
Manganese	0.15
Chromium	0.04

Table V:

AA7075 Properties

Density	2.7g/cc
Tensile Yield Strength	276MPa
Ultimate Tensile Strength	310MPa
Modulus Of Elasticity	68.9GPa
Hardness – Vickers	107
Poisson’s Ratio	0.33

IV. RESULTS

The values and the output after simulation are analysed and tabulated as follows.

1. Initial Analysis.

Table VI:
Initial analysis with round C-sectional shaft.

Sl No	Die Angle	Friction Co-efficient	Ram Velocity	Load Value
01	30	0.1	1.0	1.523E+0
02			2.0	1.628E+0
03			3.0	1.689E+0
04		0.2	1.0	2.035E+0
05			2.0	2.177E+0
06			3.0	2.279E+0
07		0.3	1.0	2.211E+0
08			2.0	2.343E+0
09			3.0	2.447E+0
10	45	0.1	1.0	1.431E+0
11			2.0	1.513E+0
12			3.0	1.578E+0
13		0.2	1.0	2.071E+0
14			2.0	2.156E+0
15			3.0	2.239E+0
16		0.3	1.0	2.210E+0
17			2.0	2.410E+0
18			3.0	2.490E+0
19	60	0.1	1.0	1.369E+0
20			2.0	1.463E+0
21			3.0	1.525E+0
22		0.2	1.0	2.035E+0
23			2.0	2.171E+0
24			3.0	2.272E+0
25		0.3	1.0	2.259E+0
26			2.0	2.437E+0
27			3.0	2.508E+0

2. Final Analysis.

Table VII:
Final analysis with Hexagonal C-sectional shaft and Billet temperatures.

Sl No	Die angle	Billet Temperature	Load Value
01	30	300	1.868E+0
02		350	1.868E+0
03		400	1.868E+0
04		450	1.051E+0
05		500	7.299E-1
06	45	300	1.748E+0
07		350	1.751E+0
08		400	1.739E+0
09		450	1.015E+0
10		500	6.925E-1
11	60	300	1.696E+0
12		350	1.696E+0
13		400	1.703E+0
14		450	9.763E-1
15		500	6.625E-1

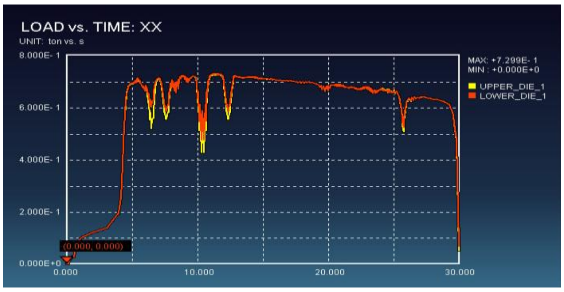

Fig 9.3: Load vs Time Graph

The graph shows load variation during the course of extrusion. The load increases initially, then it is fluctuating and gradually decreases. The lowest load obtained Iteration is 7.299E-1 Tons.

Fig 9.10: Load vs Time Graph

The graph shows load variation during the course of extrusion. The load increases initially, then it is fluctuating and gradually decreases. The lowest load obtained Iteration is 6.925E-1 Tons

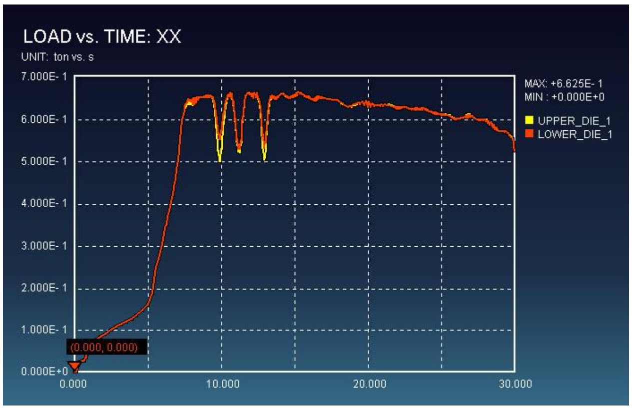

Fig 9.17: Load vs Time Graph

The graph shows load variation during the course of extrusion. The load increases initially, then it is fluctuating and sgradually decreases. The least load obtained Iteration is 6.625E-1 Tons.

V. CONCLUSIONS

Forty two iterations were carried out in the AFDEX software and the discussed results were obtained by using different values parameters which consist of die angle, coefficient of friction and ram velocity.

The maximum stress occurs on the billet surface in the exit region of the die. Extrusion load has reduced with an increase in the die angle. But, it can't be said that this correlation is absolutely correct when the angle is small. Extrusion load has increased when the friction coefficient and the Ram velocity increased hence the minimum extrusion load occurs if Ram velocity and friction coefficient are minimum and die angle is maximum.

The extrusion least load are as follows.

- When the die angle is 30°, μ=0.1 and the ram velocity=1mm/s, it is found that the load is 7.299E-1 ton.
- When the die angle is 45°, μ=0.1 and the ram velocity=1mm/s, it is found that the load is 6.925E-1 ton.
- **When the die angle is 60°, μ=0.1 and the ram velocity=1mm/s, it is found that the load is 6.625E-1ton.**

Then we can clearly conclude that as the billet temperature and die angle increases, here as obtained extrude load decrease which in turn reduces the power usage.

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