Simulation Study of Effect of Extrusion Ratio in Forward Extrusion using AFDEX Software

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Abstract— The aim of this paper is to study the effect of Extrusion Ratio in forward extrusion process and to analyze the material behavior, predict and eliminate the defect in product. Parameters considered for the process are Die Angle, Co-efficient of friction, Ram velocity. Initial billet temperature (495), and die angle (30º) will be kept constant. Extrusion ratio, Co-efficient of friction and Ram velocity will be varied in this project. Total 27 iterations will be carried out in order to get optimized values. Design will be carried out using SOLID EDGE V19 and the simulation and analysis will be carried out in AFDEX software.

Keywords: Solid Edge, AFDEX, Extrusion Ratio

I. INTRODUCTION

Extrusion is one of the major metal forming processes used in transforming the size and shape of the materials from the casts structure of an ingot to a useful product. Extrusion is a flexible manufacturing process,as a single extrusion press may be used for multiple materials and can produce infinite number of shapes by simply changing the die and the tooling associated with it. Aluminum is the most widely used material for extrusion process because of its considerable strength and also easily deformable properties. At present, the extrusion process parameters are selected on the basis of experience and the trial runs. Extrusion is a very complicated process which requires proper process parameters to be used to get optimum settings to produce a quality product. Therefore, most of the researchers are inclined towards the selection of optimum parameters which gives the best quality product.

Extrusion can be broadly classified into two categories:

1) Forward extrusion: In this type of extrusion process the direction of metal flow is same as that of ram traverse.
2) Backward extrusion: In backward extrusion process the direction of metal flow is opposite to the ram traverse.

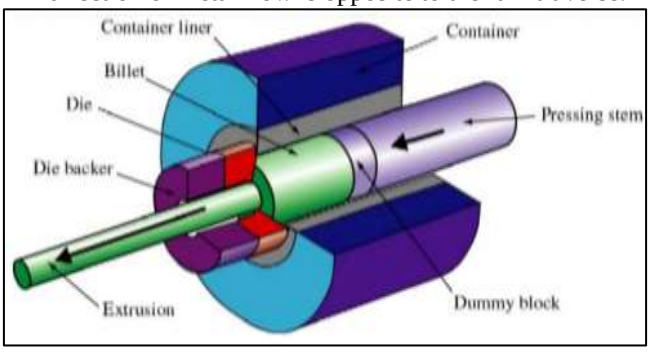


Fig. 1: Forward Extrusion Process

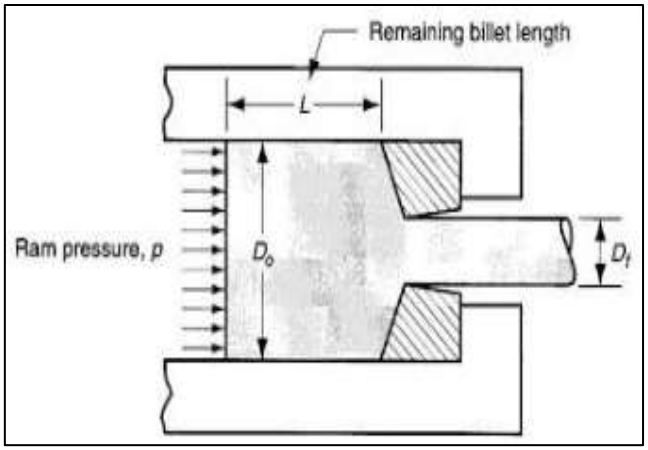


Fig. 2: Extrusion ratio component

Factors Effecting Extrusion Process

1) Co-efficient of friction
2) Die angle
3) Punch velocity
4) Die Land Length
5) Die corner radius
6) Extrusion Ratio
7) Billet Temperature

A. Extrusion Ratio

The extrusion ratio is defined as the starting cross-sectional area divided by the cross-sectional area of the final extrusion. One of the main advantages of the extrusion process is that this ratio can be very large while still producing quality parts.

Extrusion ratio, R, is the ratio of the initial cross-sectional area , A_o, of the billet to the final cross-sectional area , A_f, after extrusion.

$$R = \frac{A_o}{A_f}$$

- Fractional reduction in area, r

$$r = 1 - \frac{A_f}{A_o}$$

- Rewrite the extrusion ratio R

$$R = \frac{1}{(1-r)}$$

II. LITERATURE SURVEY

Ahmed Moizuddin Nadeem, Bharat S Kodli [1] Simulation Study of Material Behaviour and Optimization of Die Corner Radius in Forward Extrusion using AFDEX Software. The purpose of this paper is to analyze metal extrusion process. The main objective behind this paper is to study the material behaviour, predict and eliminate the defect in the product. A combination of Solid Edge V19 and

AFDEX_V16 simulation software is used to achieve the goal. The present study deals with die design and process parameters to bring in optimization.

GovindrajKaralgikar, Bharat S Kodli [2] Simulation study of material behavior and optimization of die land length in forward extrusion using AFDEX software. This paper deals with analysis of metal extrusion process. The primary objective of this paper is to study the material behavior, 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.

AntoniosLontos, FilipposSoukatzidis [3] Effects of extrusion parameters and die geometry on the produced billet quality using finite element method. The aim of this paper is to study the effect of extrusion parameters (extrusion speed and temperature) and die geometry, i.e. extrusion radius, on the extruded billet quality (Equivalent stress and strain) using F.E.M. technique. For this purpose the general F.E.A. software Deform-2D has been used to set up the finite element model of the warm aluminium extrusion in two dimensions (2D). 6061 Aluminium was used as billet material, with 40mm diameter and 50mm length. The extrusion process was modeled as isothermal, which means that the billet material was preheated at a specific temperature and then it was pressured into the circular die, with extrusion ratio 3.3. The extrusion speed was varied from 1 to 3 mm/s, the extrusion temperature varied from 400ºC to 500ºC and the extrusion die radius was varied from 1 to 4 mm.

Bhargava C Nadig, Bharat S Kodli [4] Simulation study of material behavior in forward extrusion. The purpose of this paper is to study the material behavior, prediction and elimination of defect, to increase the product life in forward extrusion. The task is to simulate the extrusion process using AFDEX software. To achieve this objective, CAD technology is combined with this process simulation tools to enable modeling of the component, die, billet and ram. The models were constructed using UNIGRAPHICS and then simulation was performed using AFDEX.

DurmusKarayel[5] Simulation of direct extrusion process and optimal design of technological parameters using FEM and Artificial Neural Network(ANN). This study aims the modeling and simulation of the direct extrusion process and determination of optimal process parameters using Finite Element Method and Artificial Neural Network cooperatively. The die set has been designed for direct extrusion of an Aluminium rod and its numerical simulation has been prepared by mean of ABAQUS. ANN model of the process has been developed under MATLAB.

A. S. Chahare, K. H. Inamdar [6] 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.

III. SIMULATION

In this project, Solid Edge V19 is used to create the CAD models and AFDEX_V16 is used to simulate the forward extrusion process. AFDEX_V16 is general purpose metal forming simulation software that can be applied to conventional bulk metal forming processes and also to new creative bulk metal forming processes. Theoretically AFDEX is based on rigid-thermoviscoplastic finite element method.

IV. METHODOLOGY

Parameters considered for the project are Die Angle, Co-efficient of friction, Ram velocity. Initial billet temperature (495),and die angle(30º) will be kept constant.
Extrusion ratio (3,3.5,4), Co-efficient of friction and Ram velocity will be varied in this project. Total 27 iterations will be carried out in order to get optimized values.
Appropriate forging parameters used for the simulation are enlisted in below Tables and these parameters are provided to the AFDEX database.

Type of Extrusion	Hot Extrusion
Work Piece Material	AA7075
Press Type	Tabular Motion
Friction Type	Manual
Temperature Range	400 - 600
Extrusion Ratio	3, 3.5, 4

Table 1: Simulation Parameters

Component	Round Bar (Solid)
Material Used	AA7075 T6
Extrusion Type	Hot
Extrusion Ratio	4
Die Type	Conical
Initial Billet Temperature	495

Table 2: Details of the Component

Sl. No.	Extrusion Ratio	Co-efficient of friction (μ)	Ram Velocity (mm/s)
1	3	0.1	1
2			1.5
3			2
4		0.15	1
5			1.5
6			2
7		0.2	1
8			1.5
9			2

10	3.5	0.1	1
11			1.5
12			2
13		0.15	1
14			1.5
15			2
16		0.2	1
17			1.5
18			2
19	4	0.1	1
20			1.5
21			2
22		0.15	1
23			1.5
24			2
25		0.2	1
26			1.5
27			2

Table 3: Parameters considered for extrusion simulation

After completion of basic 27 iterations with fixed temperature, find the iteration with least load value and consider that parameters as OPTIMISED values.

Component	Weight %
Manganese	0.3
Silicon	0.4
Chromium	0.18-0.3
Copper	1.2-2
Iron	0.5
Zinc	5.1-6.1
Aluminum	87.1-91.4
Magnesium	2.1-2.9
Titanium	0.2
Others	0.005-0.15

Table 4: AA 7075 T6 Composition

Density	2.81 gm/cc
Tensile Yield Strength	503 MPa
Ultimate Tensile Strength	572 Mpa
Modulus of Elasticity	71.7 Gpa
Hardness – Vickers	175
Poisson's Ratio	0.33

Table 5: AA 7075 T6 Properties

A. Die Sketches

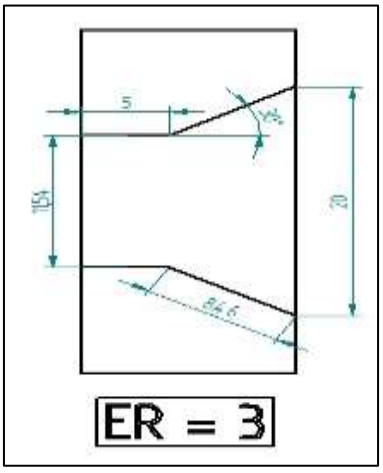


Fig. 3: Extrusion ratio 3

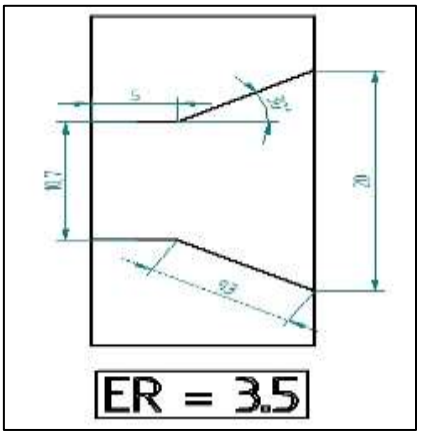


Fig. 4: Extrusion ratio 3.5

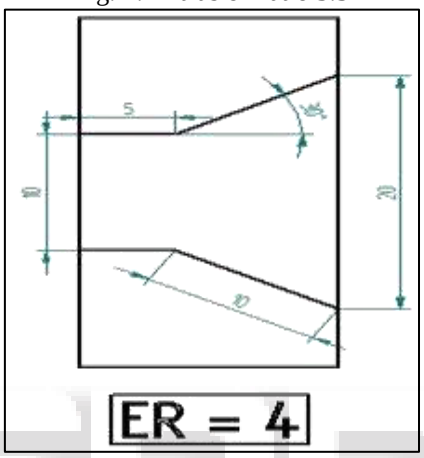
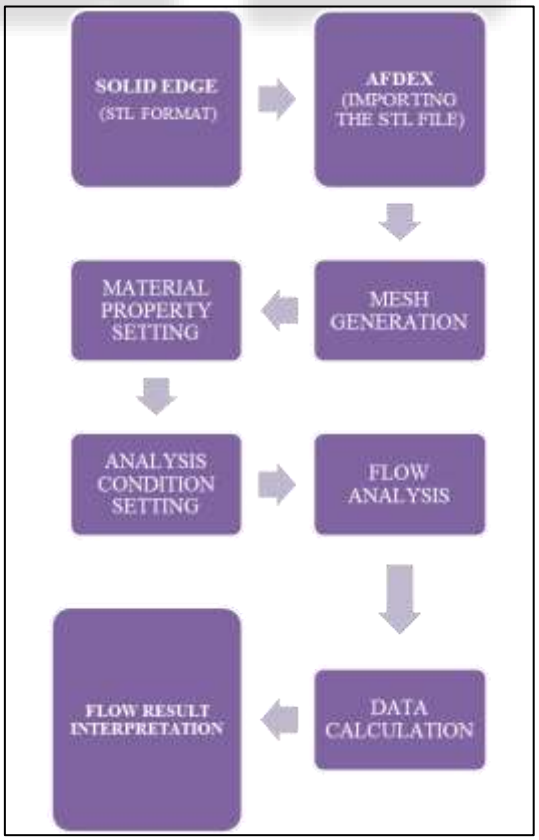


Fig. 5: Extrusion ratio 4

The following flowchart shows the sequence of steps involved in executing the simulations in the present study



V. RESULTS

Sl. No.	Extrusion Ratio	Co-efficient of friction (μ)	Ram Velocity (mm/s)	Load Values (ton)
1	3	0.1	1	5.424946E-01
2			1.5	6.838338E-01
3			2	6.148777E-01
4		0.15	1	6.013635E-01
5			1.5	6.404051E-01
6			2	6.557261E-01
7		0.2	1	7.860612E-01
8			1.5	8.657975E-01
9			2	1.010229
10	3.5	0.1	1	5.925682E-01
11			1.5	6.491181E-01
12			2	6.688762E-01
13		0.15	1	1.072094
14			1.5	7.151207E-01
15			2	7.476274E-01
16		0.2	1	9.795924E-01
17			1.5	9.864735E-01
18			2	1.011247
19	4	0.1	1	6.526553E-01
20			1.5	6.972991E-01
21			2	7.277153E-01
22		0.15	1	7.242875E-01
23			1.5	8.145124E-01
24			2	8.487255E-01
25		0.2	1	1.186389
26			1.5	1.159476
27			2	1.117143

Table 6: Load values for various Extrusion Ratio

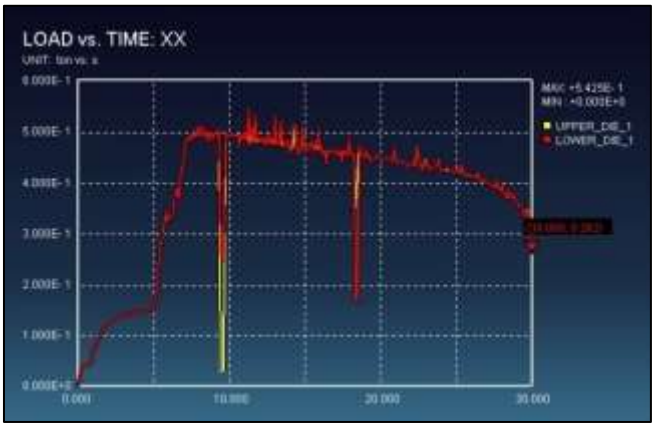


Fig. 6: Graph1 Extrusion ratio-3, Ram velocity-1.0mm/s, co-efficient of friction - 0.1

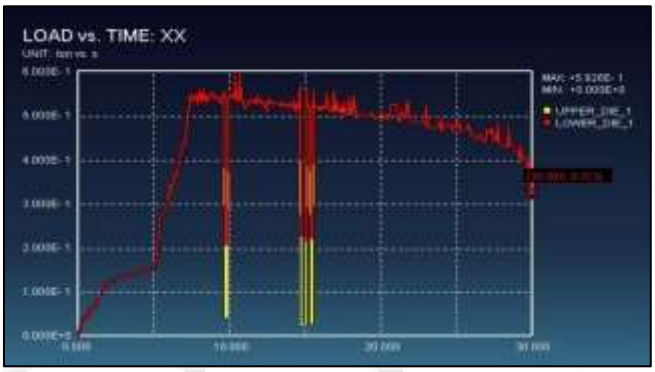


Fig. 7: Graph2 Extrusion ratio-3.5, Ram velocity-1.0mm/s, co-efficient of friction - 0.1

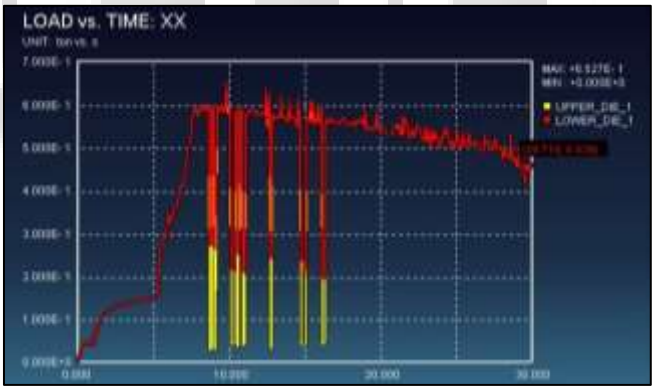


Fig. 8: Graph3 Extrusion ratio-4, Ram velocity-1.0mm/s, co-efficient of friction - 0.1

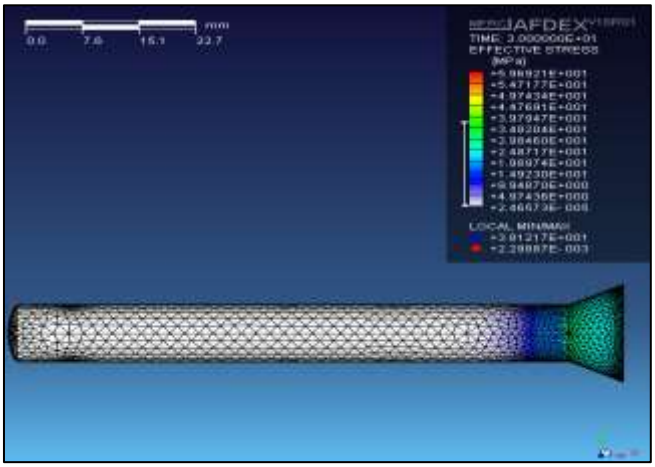


Fig. 9: Component after stimulation (Extrusion ratio- 3)

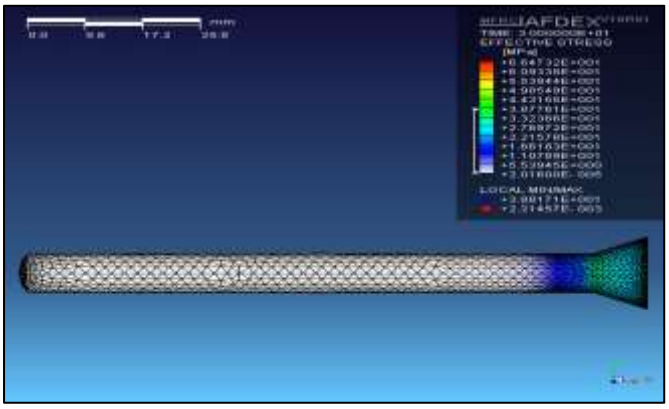


Fig 10: Component after stimulation (Extrusion ratio- 3.5)

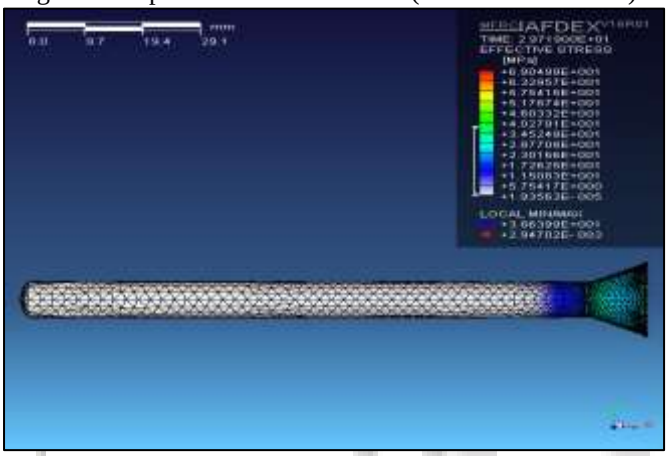


Fig 11: Component after stimulation (Extrusion ratio- 4)

VI. CONCLUSION

Twenty seven iterations were carried out in the AFDEX software and results were obtained by using different values of the parameters which consist of extrusion ratio, co-efficient of friction and ram velocity whereas die angle =30 º was kept constant.

From the above iterations, we can observe the load value obtained is low in the first iteration (Extrusion Ratio = 3).

For the value of extrusion ratio = 3, the corresponding load applied was 5.424946E-01 Ton. And the following parameters were used in the analysis of this iteration,

Die Angle = 30º
Ram Velocity = 1 mm/sec
Friction co-efficient = 0.1

It is clearly evident that load value obtained for the above said parameters is least as compared to other iterations. A change in extrusion ratio also leads to change in load values and hence it can be said that extrusion ratio has an effect on load values. As extrusion ratio increases the load values also increases. It can also be concluded that as ram velocity increases, the load applied also increases.

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