Simulation Study of Effect of Optimized Die Angle on Extrusion Process using AFDEX

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Abstract— The main objective of this project is to simulate the study of effect of optimized die angle on extrusion process using AFDEX and to eliminate the defect minimize the amount of scrap generated in an aluminum extrusion process to determine the parameters influencing on extrusion process. The analysis is done by varying die angle and constant billet temperature in order to optimize the load by keeping the parameters such as varying co-efficient friction, ram velocity in this CAD technique .The modeling was done using Solid edge and simulation process by AFDEX -2016 software. The material used for this process is Aluminum Alloy 6061.The parameters are chosen as varying Die-angle (30,45, and 60), constant billet temperature 480°C, constant die land length 5mm .The optimize load has occurred at Die angle 45°C and extrusion force as 4.828533E-01.

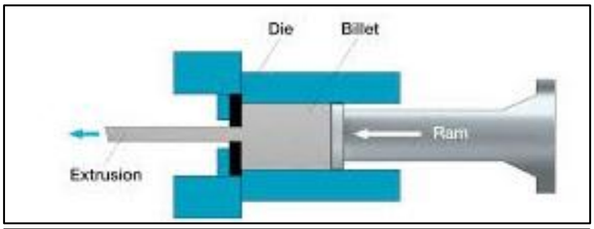
Keywords: Billet Temperature, Die Land Length, Ram Velocity, Die Angle, Co-Efficient of Friction, AFDEX-2016 Software, SOLID EDGE

I. INTRODUCTION

Extrusion is a manufacturing process where a billet of material is pushed and/or drawn through a die to create a shaped rod, rail or pipe. An item formed by the process of extrusion is called extrusion. The two main advantages of this manufacturing process over other manufacturing processes are its ability to create very complex cross section, the work material which are brittle, because the material which encounter shear and compressive stresses. The material part gives the good quality of surface finish.

Extrusion can be classified into two types Direct extrusion and Indirect extrusion. Whereas direct extrusion the direction of the metal flow is same as that of the ram transverse and in Indirect extrusion the direction of metal flow is opposite to ram transverse. The extrusion process can be done with hot material or Cold material.

A. Extrusion Process



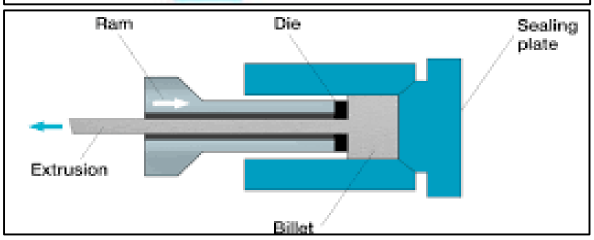


Fig. 1.1: Direct extrusion Fig. 1.2: Indirect extrusion

Typically extruded materials include metals, polymers, ceramics, concrete, play dough, and foodstuffs. The products form by extrusion are generally called as “Extrudates”. Drawing metal is the main way to produce wire, sheet, bar and tube are also often drawn.

Material	Billet temperature
Lead Alloys	90-260
Magnesium Alloys	340-430
Aluminum Alloys	340-510
Copper Alloys	650-1100
Titanium Alloys	870-1040
Nickel Alloys	1100-1260

Table 1:

The main objective of this project is to simulate the study of effect of optimized die angle in an extrusion process. This process is affected by many parameters such as material, work piece, ram velocity, die angle, die land length, extrusion ratio, billet temperature. The model of die angle is created in solid edge and converted into STL file. The simulation and analysis of optimized die angle is performed by AFDEX -2016 Software.

II. LITERATURE SURVEY

Bhargava C .Nadig & Bharat S Kodli [1] Simulation study of Material Behavior Forward Extrusion. Purpose of the paper was to study, predict and eliminate the defect ,to increase the product life in forward extrusion .This study was aimed at analysis of forward extrusion process parameters such as workpiece material ,ram speed ,extrusion ratio and die angle.

Govindraj Karalgikar & Bharat S Kodli [2] Simulation Study of Material Behaviour and optimization of Die Land Length in Forward Extrusion by AFDEX Software. The paper deals with the 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. To achieve this objective, unigraphics is used with AFDEX simulation software. The present case goal is combining the considerations on die design and process parameters to bring in optimization. Optimization is of great importance when it comes to extrusion process.

Vikram G. Oza &Mr. B Gotawala [3] Minimizing the amount of scrap generated in an aluminum extrusion process. In this simulation approach is presented to optimize. The fragment produce during Aluminum Extrusion process. The model applied to real data obtained from an existing extrusion factory. Apply simulation analysis approaches for calculating scrap amount in kg .Results comparison from existing conventional analysis method.

Durmus Karayel [4] This study aimed the modeling and simulation of the direct extrusion process and determination of optimal process parameters using Finite

Element Method (FEM) and Artificial Neural Network (ANN) cooperatively.

Mallikarjun Shivappa and Prof. Bharat S Kodli [5] Simulation Study of Effect of Billet Temperature in Forward Extrusion. 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 in order to optimize the load by keeping the parameters ram velocity and co-efficient friction constant.

III. SIMULATION

In this project SOLID EDGE is used to design the model converted into STL file and AFDEX-2016 is used to simulate the extrusion process. AFDEX (Advisor for Metal Forming Process Design Expert) can be used for the process of simulation. AFDEX simulator is applied not only to conventional metal forming process that includes forging, rolling deep drawing and extrusion but also to new creative bulk metal forming processes. AFDEX is theoretically based on rigid-thermovisco plastic finite element method.

A. Methodology

The main parameters which are taken for the execution of this project are illustrated in below table.

Component	Hexagonal Bar
Material Used	AA6061
Extrusion Type	Hot
Die Type	Conical
Billet Temperature	480°c

Table 2: Material Properties

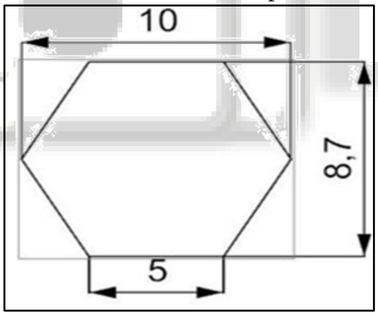


Fig. 1.3: Hexagonal Design

1) Parameters considered

Sl.no	Die angle(deg)	Die land length(mm)constant	Co-efficient friction(μ)	Ram velocity mm/sec
1	30	5	0.1 0.2 0.3	1 2 3
2	45	5	0.1 0.2 0.3	1 2 3
3	60	5	0.1 0.2 0.3	1 2 3

Table 3:

2) Die Sketches

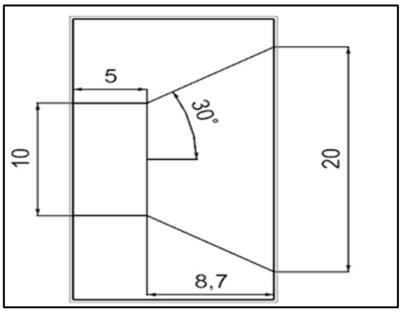


Fig. 1.3: Die angle α=30°

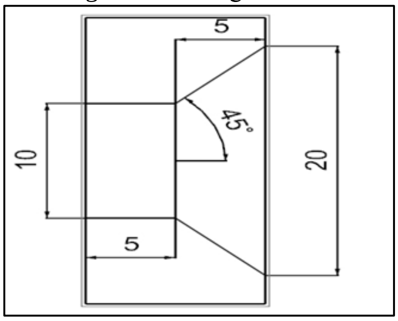


Fig. 1.5: Die angle α=45°

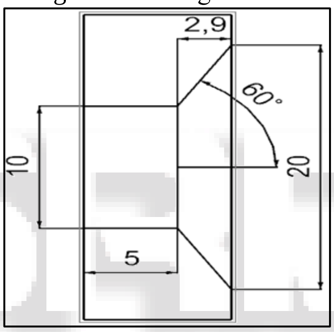


Fig. 1.6: Die angle α=60°

In the present work, flow chart below shows the steps involved in executing the simulation process:

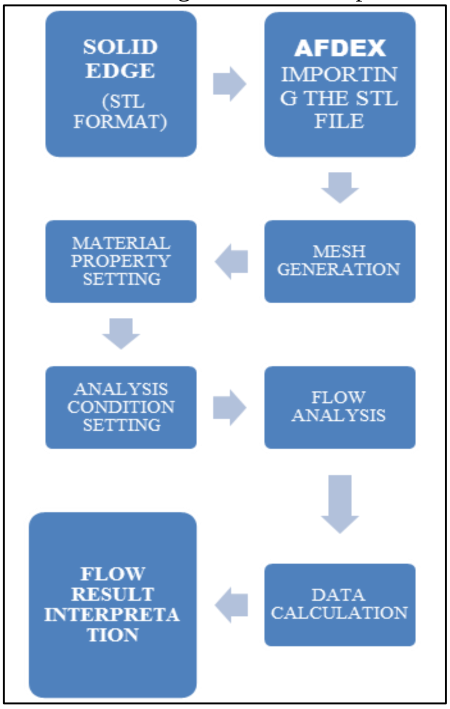


Fig. 1.7: Steps involved in Executing the Simulation

Component	Weight %
Aluminum(Al)	83.39
Magnesium(Mg)	0.80-1.20
Silicon(Si)	0.40-0.80
Iron(Fe)	0.0-0.70
Copper(Cu)	0.15-0.40
Zinc(Zn)	0.0-0.25
Titanium(Ti)	0.0-0.15
Manganese(Mn)	0.0-0.15
Chromium(Cr)	0.04-0.35

Table 4: Material 1- AA6061 Composition

Density	2700g/mm^3
Ultimate Tensile Strength	310Mpa
Tensile Yield strength	276Mpa
Hardness-Vickers	107
Poisson's Ratio	0.33
Modulus of Elasticity	68.9Gpa

Table 5: Material 1-AA6061 Composition

IV. RESULTS

The values and output after simulation are analyzed and tabulated as follows.

A. Final Analysis:

Sl.no	Die angle(deg)	Die land length(mm)	Billet temperature(°c)constant	Co-efficient friction(μ)	Ram velocity (mm/s)	Load (ton)
1	30	5	480	0.1	1	8.308541E-01
2					2	9.421339E-01
3					3	9.290866E-01
4				0.2	1	1.325606E+0
5					2	1.659123E+0
6					3	1.476184E+0
7				0.3	1	1.778379E+0
8					2	2.284031E+0
9					3	2.112111E+0
10	45	5	480	0.1	1	4.828533E-01
11					2	1.056807E+0
12					3	1.031482E+0
13				0.2	1	1.400265E+0
14					2	1.632287E+0
15					3	1.434551 E+0
16				0.3	1	1.458382E+0
17					2	1.540020E+0
18					3	1.337065E+0
19	60	5	480	0.1	1	9.812870E-01
20					2	9.659894E-01
21					3	1.303393E+0
22				0.2	1	1.530931E+0
23					2	1.682849E+0
24					3	1.586040E+0
25				0.3	1	1.385810E+0
26					2	1.886520E+0
27					3	1.130393E+0

1) Iteration: 01

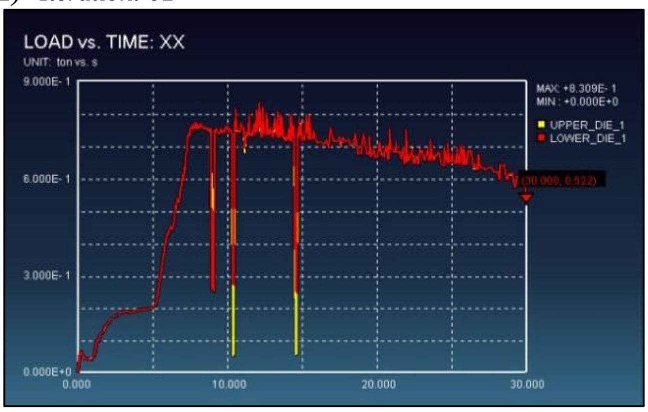


Fig. 1.8: Load v/s Time Graph: XX

The above graph shows the load variation during the course of extrusion. The load increases initially, then it is fluctuating and gradually decreases. The lowest load obtained from the Iteration 1 the parameters considered for simulation are Die angle 30°, co-efficient friction 0.1 and ram velocity 1mm/sec, whereas Die land length and Billet temperature were kept constant then the simulated load result obtained is 8.308541E-01 ton.

2) Iteration: 02

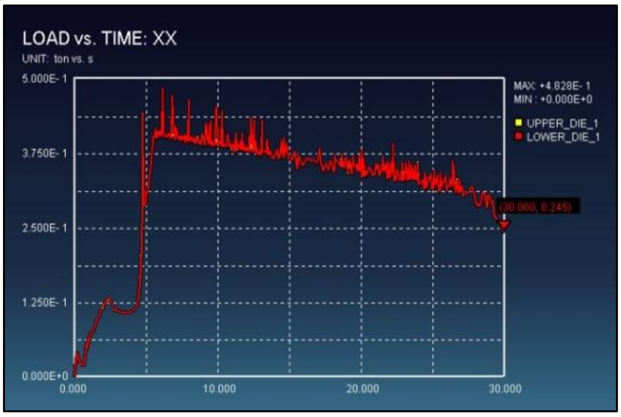


Fig. 1.9: Load v/s Time Graph: XX

The above graph shows the load variation during the course of extrusion .The load increases initially, then it is fluctuating and gradually it decreases and from the iteration 2 the parameters considered for simulation are Die angle 45°, co-efficient friction 0.1 and ram velocity 1mm/sec, whereas Die land length and Billet temperature kept constant then the simulated load obtained is 4.828533E-01 ton.

3) Iteration: 03

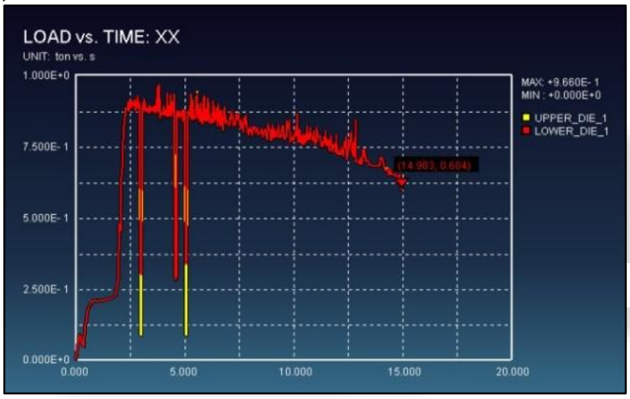


Fig. 2: Load v/s Time graph: XX

The above graph shows the load variation during the course of extrusion .Here the load increases initially then it is fluctuating and it's gradually decreases from the iteration the parameters considered for simulation are Die angle 60° ,co-efficient friction 0.1 and ram velocity 2mm/sec . Where as Die land length and Billet temperature kept constant.then the simulated load is 9.659894E-01 ton.

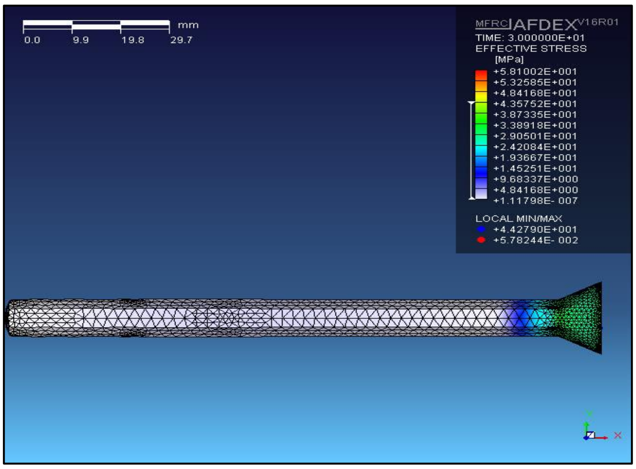


Fig. 2.1: Component after simulation of iteration 1

Where Die angle 30°, Co-efficient friction 0.1, Ram velocity 1mm/sec, Die land length 5mm, and Billet temperature 480°c.

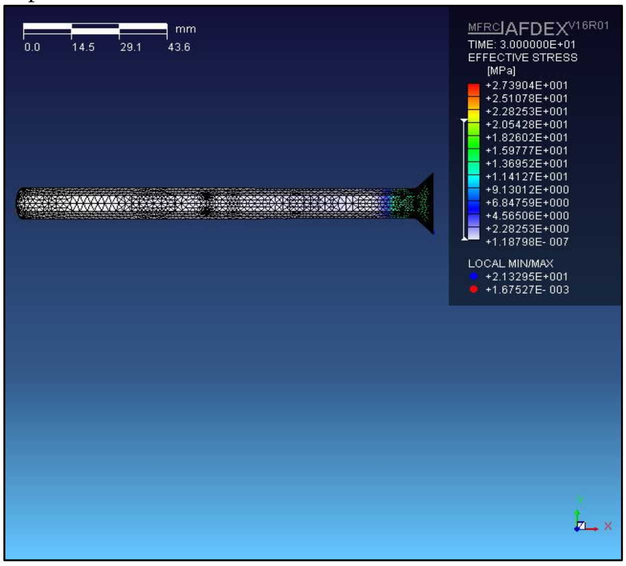


Fig. 2.2: Component after simulation of iteration 2

Where Die angle 45°, Co-efficient friction 0.1, Ram velocity 1mm/sec Die Land length 5mm, Billet temperature 480°c.

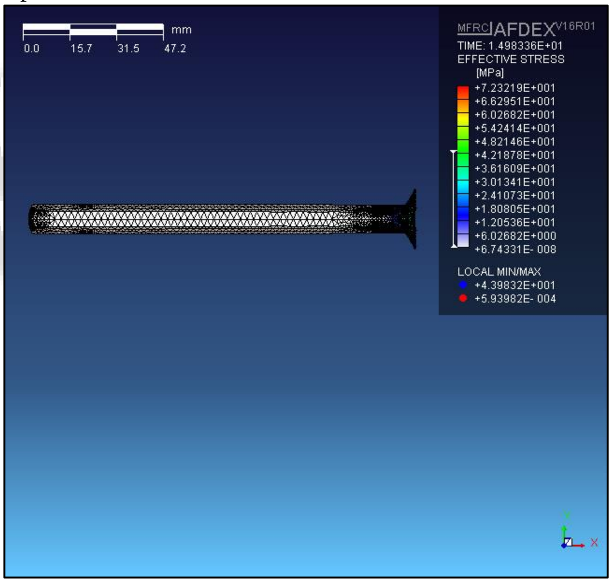


Fig. 2.3: Component after simulation of iteration 3

Where Die angle 60°, Co-efficient friction 0.1, Ram velocity 2mm/sec, Die land length 5mm and Billet temperature 480°c.

V. CONCLUSIONS

In this project Twenty seven iterations were carried out in the Advisor for Metal Forming Process Design Expert(AFDEX) software and results were discussed which are obtained by using various types of parameters such as Co-efficient friction, Die angle, Die land length ,Ram velocity ,Billet temperature. Whereas Billet temperature and Die land length are kept constant during simulation the final results were obtained in iteration 2 in which parameters considered as Die angle 45°,Co-efficient friction 0.1,Ram velocity 1mm/sec , Die land length 5mm, Billet temperature 480°c . So the optimized Die angle is 45° in iteration 2 in that we obtained least load i.e is 4.828533E-01 ton. It is clearly evident that load value obtained for the above said parameters is least as compared to other iterations.

ACKNOWLEDGEMENT

The author take the opportunity to express our gratitude to all the concerned people who have directly or indirectly contributed towards contribution of this project .I extend my sincere gratitude towards the Department of Production Engineering, Department of Mechanical engineering P D A college of Engineering Kalaburagi for providing the opportunity and resources to work on this project.

I am extremely grateful to his guide Prof. Bharat S Kodli, Department of Production Engineering his inspiration, guidance, constant supervision, direction and discussions in successful completion of the project.

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