Simulation Study of Material Behavior and Optimization of Die Angle in Indirect Extrusion Process using AFDEX Software

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Abstract: ***Aim of our study is optimizing die angle in indirect extrusion process. This project also aims to study the material behavior in the indirect extrusion process. Die angle being one of the important parameter in extrusion process is varied and its effect will be analyzed. Combined use of AFDEX_V16& Solid Edge V19 simulating software is utilized for achieving this purpose. The parameters considered in this work are die angle, coefficient of friction, ram velocity etc. Modeling of dies and work-piece is carried out in Solid Edge V19 and simulating of indirect extrusion process is performed into AFDEX software. Results will be analyzed for optimal parameters. 27 iterations were performed in order to get optimized process parameters. The type of forming is hot and initial temperature of billet is kept at 480^{o}C. The different die angels considered are 30^o, 45^o and 60^o for indirect extrusion process.***

Keywords: Solid edge, AFDEX, Die Angle

1. Introduction

For items with a predetermined cross-sectional profile, the extrusion method is used. Dies with the required cross-section are used to force a material into shape. Pressure on work piece causes plastic deformation, which results in an end product with required shape. There are two basic types of extrusion:

1) Direct extrusion: Metal flowing into same way like ram traverses in this sort of extrusion operation.
2) Indirect extrusion: Metal flowing into opposite way of ram passage in an indirect extrusion operation.

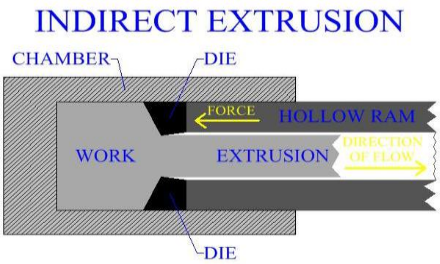


Figure 1: Indirect Extrusion Process

Die corner radius,die angle, extrusion ratio, ram velocity, frictional coefficient, operating temp so on, are all factors that affect extrusion process.

2. Literature Survey

Durmus Karayel [1] **Simulation of Direct Extrusion Process & Optimum Designing of Technology Constraints Utilizing FEM &ANN.** With the use of both finite element method as well as ANN, researchers in this study want to model and simulate direct extrusion processes in order to find the best process parameters. ABAQUS/ EXPLITIC finite element code was used to build die set for direct extrusion of aluminum rod, & numeric simulation was created using this code. As a result, critical stress levels & process parameter values based on extrusion load were both calculated.

Vikram.GOza, Mr. B. Gotawala [2] **Analyzing& optimizing extrusion process utilizing Hyperworks.** Based on the Simulation Analysis technique, an optimization strategy is devised. During the aluminum extrusion process, a simulation method is used to reduce the quantity of scrap that is created. The model is based on data from an actual extrusion plant. Significant reductions in scrap were achieved by employing the proposed methodology. As compared to current nonscientific methods, utilizing sound simulated analysis procedures considerably reduces waste and saves money.

A. E lontos, D.A. Demosthenous, F. A Soukatzidis, A.K. Baldoukas [3] **Outcome of Extrusion Constraints& Die Geometry upon Production of Billet Quality Utilizing FEM.** Studying extrusion characteristics (extrusion temperature& speed) as well as die geometry, such as extrusion radius, is the primary goal of this article, which employs a FEM approach to analyze billet integrity (Comparable stress and strain). In order to do this, the Deform-2D F.E.A. program was utilized to construct up the two-dimensional finite element model of heated aluminum extrusion (2D). With a 40mm dia& 50mm length, 6061 Aluminum was utilized as billet material. We experimented with a range of extrusion parameters including speed (1–3 mm/s), temperature (400–500 oC), and die radius (1–4 mm).

A. S. Chahare, K. H. Inamdar[4] **Optimization of Aluminium Extrusion Process utilizing Taguchi Method**.In order to achieve the optimal constraints of characteristic angularity of 2-track top profile utilized in commercial frame assembly, this research evaluated direct hot extrusion from Al 6063 aluminum alloy. The experimental findings were analyzed using the Taguchi design of experiments. The investigation revealed that a temperature of 500oC for the pre-heating of the billet, a vessel temp of 400^{o}C, and a ram speed of 6.0mm/sec were the optimal levels of processing factors regarding characteristic angularity.

3. Simulation

In our experimentation, modeling of upper die, lower die and work-piece is carried out in SolidEdge V19 and the files are saved in .STL extension. The .STL extension files are then imported in AFDEX_V16 in which the simulation of indirect extrusion process is done.

AFDEX (Adviser for Forging Design Expert)
For both traditional & novel creative bulk metal-forming processes, AFDEX-V16 is a regular utilisation metal developing simulating program. Depending upon rigid-thermoviscoplastic finite element approach, AFDEX is theoretically

Features of the software:

- Pre-processor: The pre-processor aids in the compilation of the simulation's input data. Data input may be better understood and analyzed by user when it is represented graphically.
- Post-processor: In most cases, the Post-Processor is used to view and analyze the results. The post-processor may use saved results from solver to plot them in either graphical or text form.
- Exclusive Forming Solver: simulation engine or solver is responsible for the actual FEM computation. The solver initiates necessary formulas and performs necessary computations progressively based upon supplied data.
- Material data base: Work piece & die data in terms of their material properties. The data should adequately describe material's behavior over complete deformation cycle, which it will plausibly endure.

4. Methodology

Into our project Die Angle, Ram velocity& Co-efficient of friction is dispersed whereas die land length, initial temperature (480°C), die corner radius (0.5mm) are kept constant. Meshing (20,000) is kept in auto mode and type of forming is hot. In indirect extrusion process the low die is fixed whereas upper die in moving. Main advantage of indirect extrusion process is the friction between billet & lower die is zero since there is no relative motion in between the lower die and billet.

Table 1: Component Details

Component	Round Bar (Solid)
Material Used	AA7075T6
Extrusion Type	Hot
Extrusion Ratio	4
Die Type	Conical
Initial Billet Temperature	480°C

Design of Dies
The die angles are provided on the upper die, whereas the lower die acts as container which holds the billet. The below figures represents different die angles

A. Die Sketches

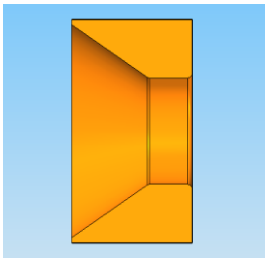


Figure 2: Die Angle 30°

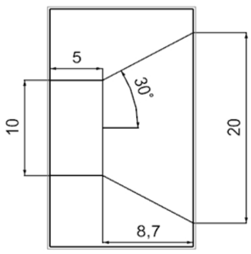


Figure 3: Draft view (30°)

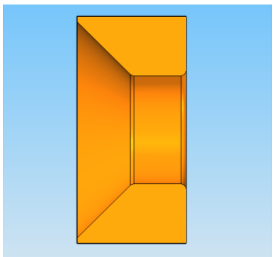


Figure 4: Die angle 45°

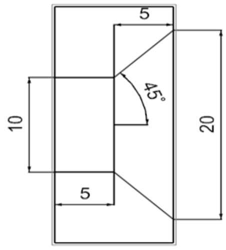


Figure 5: Draft view (45°)

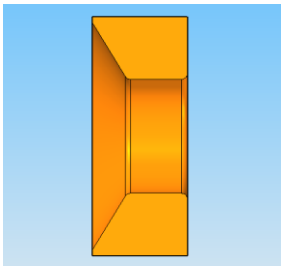


Figure 6: Die angle 60°

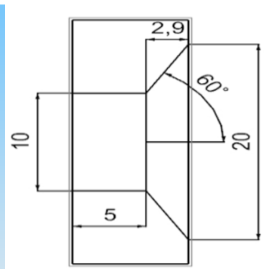


Figure 7: Draft view (60°)

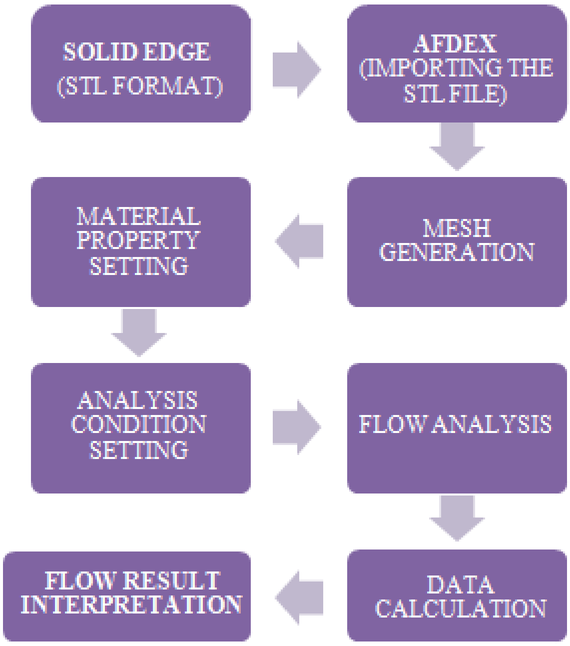
Table 2: AA 7075 T6 Composition

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	Remainder
Magnesium	2.1- 2.9
Titanium	0.2
Others	0.005- 0.15

Table 3: AA 7075 T6 Properties

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

The following flowchart shows the sequence of phases carried out in execution of simulations in present study



5. Results

Table 4: Load values for numerous die corner radius

Sl. No.	Die Angle	Co-efficient of friction (μ)	Ram Velocity (mm/s)	Load Values (ton)
1	30°	0.1	1	6.979576E-01
2			2	8.063931E-01
3			3	8.114694E-01
4		0.125	1	7.701265E-01
5			2	8.129904E-01
6			3	7.759744E-01
7		0.15	1	7.322957E-01
8			2	8.645742E-01
9			3	8.764061E-01
10	45°	0.1	1	6.631320E-01
11			2	8.016509E-01
12			3	8.520768E-01
13		0.125	1	7.384086E-01
14			2	8.002023E-01
15			3	8.270008E-01
16		0.15	1	7.855554E-01
17			2	7.942442E-01
18			3	8.890852E-01
19	60°	0.1	1	6.456274E-01
20			2	8.998478E-01
21			3	7.504071E-01
22		0.125	1	8.148394E-01
23			2	9.162051E-01
24			3	8.653498E-01
25		0.15	1	7.746899E-01
26			2	8.751812E-01
27			3	9.094550E-01

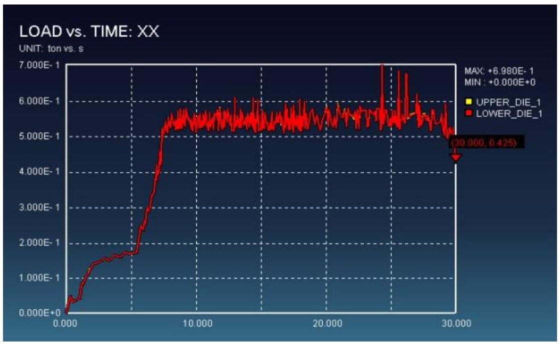


Figure 8: Graph 1 Die angle-30°, friction co-efficient-0.1, ram velocity-1.0mm/s

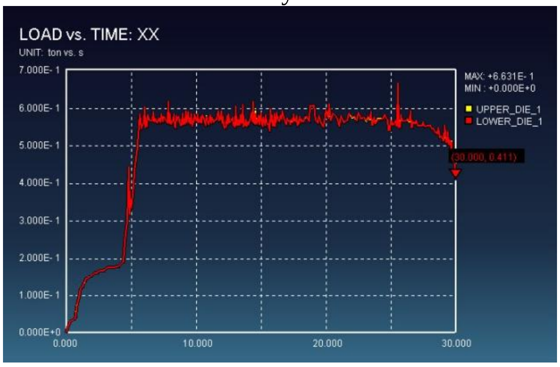


Figure 9: Graph 2 Die angle-45°, frictional co-efficient-0.1, ram velocity-1.0mm/s

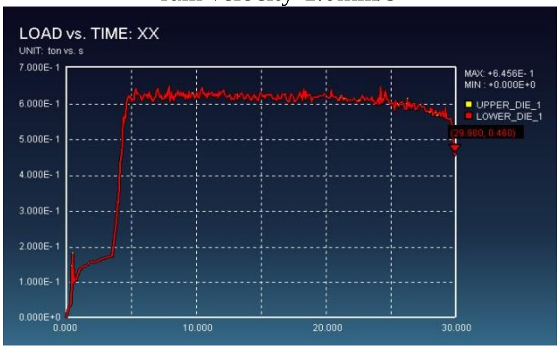


Figure 10: Graph 3 Die angle - 60°, friction co-efficient-0.1, ram velocity - 1.0mm/s

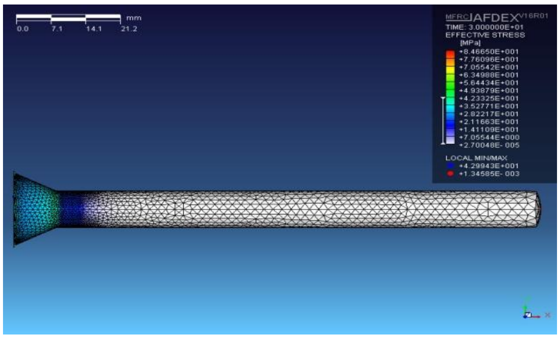


Figure 11: Module afterwards of simulation (die angle 30°)

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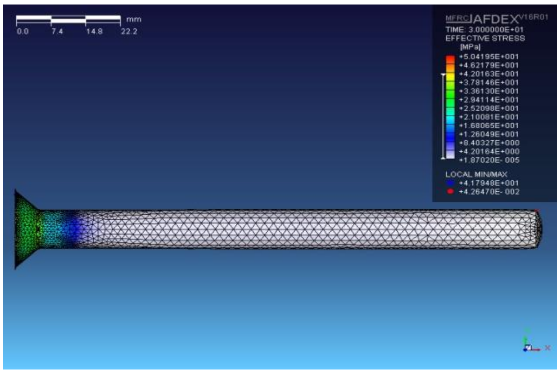

Figure 12: Component after simulation (die angle 45°)

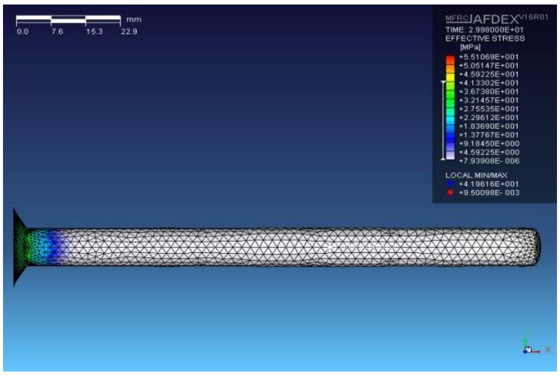

Figure 13: Component after simulation (die angle 60°)

6. Conclusion

AFDEX program was used for 27iterations,also findings reported here were achieved by varying die angle, coefficient of friction, as well as ram velocity. Initial billet temperature (480^0C) and meshing were kept constant.

The extrusion least load are as follows.

- When die angle is 30°, µ=0.1 and the ram velocity=1mm/s, it is found that the load is 6.979576E-01ton.
- When the die angle is 45°, µ=0.1 and the ram velocity=1mm/s, it is found that the load is 6.631320E-01ton.
- **When the die angle is 60°, µ=0.1 and the ram velocity=1mm/s, it is found that the load is 6.456274E-01ton.**

Thus we can conclude that,

- When value of die angle increases load value decreases and hence reduces power usage.
- Increase in ram velocity tends to increase in the load values.
- Increase in fiction co-efficient also leads to increase in the load value and hence low friction coefficient value is suitable for indirect extrusion process.

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