# Simulation Study of Material Behaviour and Optimization of Die Corner Radius in Forward Extrusion using AFDEX Software

**Ahmed Moizuddin Nadeem[1] Bharat S Kodli[2]**
[1,2]Department of Mechanical Engineering
[1,2]PDA College of Engineering Kalaburagi-585102, Karnataka, India

*Abstract*— The purpose of this paper is to analyze metal extrusion process. The main objective behind this paper is to study the material behavior, 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.

***Keywords:*** Solid Edge, AFDEX, Die Corner Radius

## I. Introduction

Extrusion process is used to create objects of a fixed cross-sectional profile. A material is pushed through a die of the desired cross-section. Plastic deformation takes place on the account of the pressure applied on the work piece and hence a product of desired shape is obtained. 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.

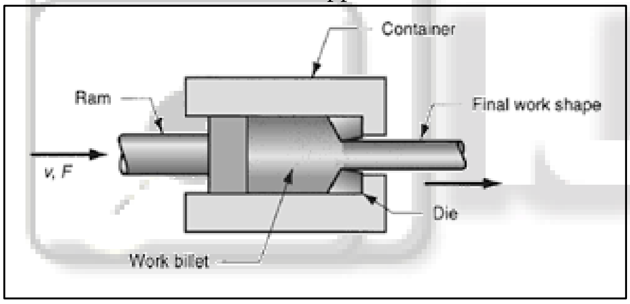



Fig. 1: Forward Extrusion Process

The parameters which influence the extrusion process are die angle, extrusion ratio, die corner radius, ram velocity, friction coefficient, working temperature, etc.

## II. Literature Survey

Antonios Lontos, Filippos Soukatzidis [1] 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 [2] 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.

Govindraj Karalgikar, Bharat S Kodli [3] 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.

Durmus Karayel[4] 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.

## 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

In this project Die Angle, Ram velocity is varied for various die corner radius (0.1, 0.2, 0.3) with constant co-efficient of friction 0.1. The iterations for assumed die corner radius are carried out as per the below table.

| Sl. No | Friction co-efficient (μ) | Die angle (deg) | Ram velocity (mm/s) |
|---|---|---|---|
| 1 | 0.1 | 30 | 1 |
| 2 | | | 2 |
| 3 | | | 3 |
| 4 | | 45 | 1 |
| 5 | | | 2 |

| | | | |
|---|---|---|---|
| 6 | | | 3 |
| 7 | | 60 | 1 |
| 8 | | | 2 |
| 9 | | | 3 |

Table 1: Parameters Considered

The details of the component are given below.

| 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

### A. *Die Sketches*

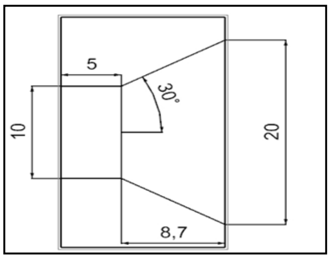



Fig. 2: Die Angle 30°

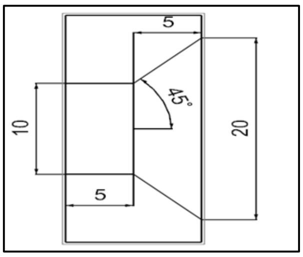



Fig. 3: Die angle 45°

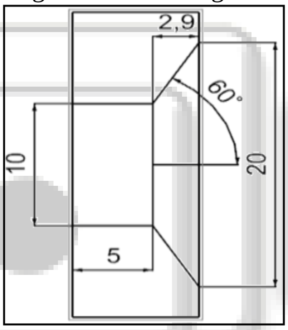



Fig. 4: Die angle 60°

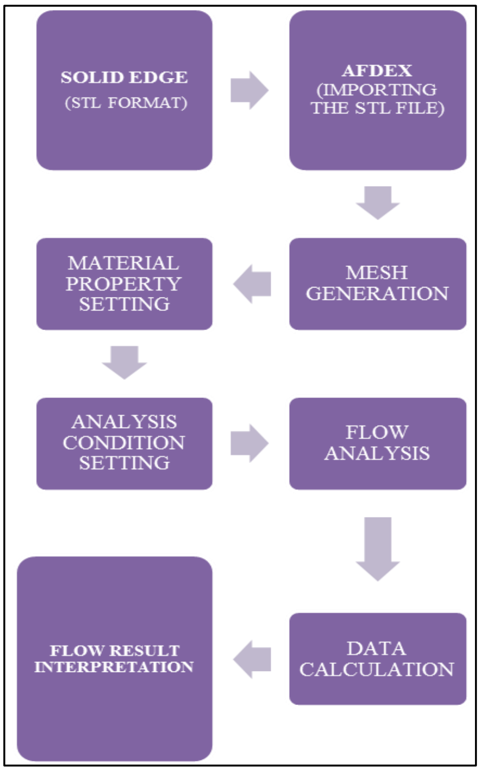
| Component | Weight % |
|---|---|
| Manganese | 0.3 |
| Silicon | 0.4 |
| Chromium | 0.18-0.3 |
| Copper | 1.2-2 |
| Iron | 0.5 |
| Zinc | 5.1-6.1 |
| Aluminum | Remainder |
| Magnesium | 2.1-2.9 |
| Titanium | 0.2 |
| Others | 0.005-0.15 |

Table 3: AA 7075 T6 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 4: AA 7075 T6 Properties

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




## V. RESULTS

| Sl. No. | Die Corner Radius (mm) | Die Angle (deg.) | Ram Velocity(mm/s) | Load Values (ton) |
|---|---|---|---|---|
| 1 | | | 1 | 6.560478E-01 |
| 2 | | 30 | 2 | 6.815753E-01 |
| 3 | | | 3 | 7.447779E-01 |
| 4 | | | 1 | 6.954262E-01 |
| 5 | 0.1 | 45 | 2 | 7.868719E-01 |
| 6 | | | 3 | 8.063300E-01 |
| 7 | | | 1 | 7.976357E-01 |
| 8 | | 60 | 2 | 8.184326E-01 |
| 9 | | | 3 | 8.994383E-01 |
| 10 | | | 1 | 6.437587E-01 |
| 11 | | 30 | 2 | 7.368007E-01 |
| 12 | | | 3 | 8.099061E-01 |
| 13 | | | 1 | 6.796044E-01 |
| 14 | 0.2 | 45 | 2 | 7.602351E-01 |
| 15 | | | 3 | 8.133696E-01 |
| 16 | | | 1 | 6.973690E-01 |
| 17 | | 60 | 2 | 7.963648E-01 |
| 18 | | | 3 | 8.392845E-01 |
| 19 | | | 1 | 7.059049E-01 |
| 20 | | 30 | 2 | 7.347575E-01 |
| 21 | | | 3 | 7.450411E-01 |
| 22 | | | 1 | 6.888627E-01 |
| 23 | 0.3 | 45 | 2 | 7.315914E-01 |
| 24 | | | 3 | 8.309863E-01 |
| 25 | | | 1 | 7.457004E-01 |
| 26 | | 60 | 2 | 7.814095E-01 |
| 27 | | | 3 | 9.591816E-01 |

Table 5: Load values for various die corner radius

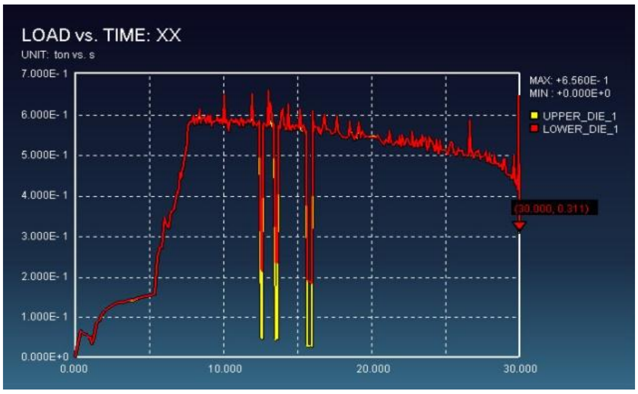



Fig. 5: Graph 1 Die corner radius - 0.1mm, die angle - 30°, friction co-efficient - 0.1, ram velocity - 1.0mm/s

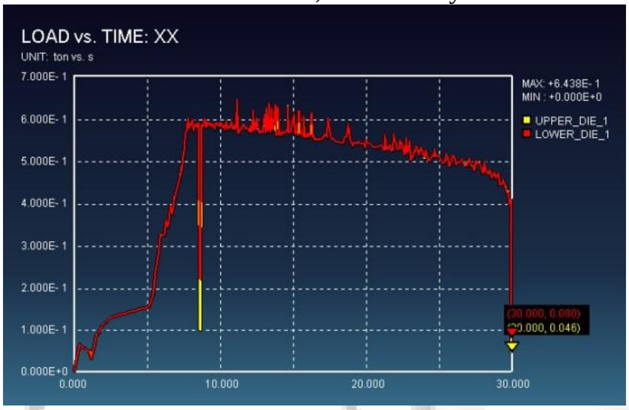



Fig. 6: Graph 2 Die corner radius - 0.2mm, die angle - 30°, friction co-efficient - 0.1, ram velocity - 1.0mm/s

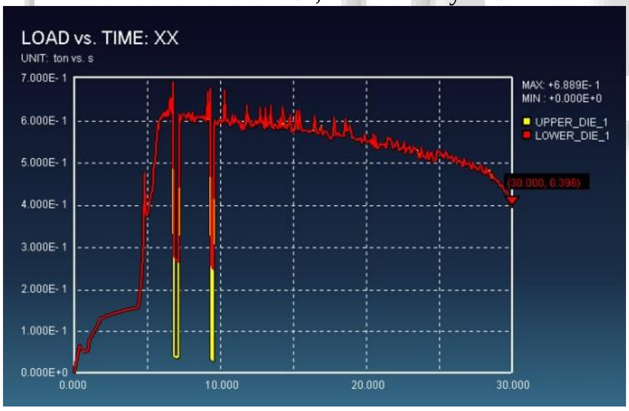



Fig. 7: Graph 3 Die corner radius - 0.3mm, die angle - 45°, friction co-efficient - 0.1, ram velocity - 1.0mm/s

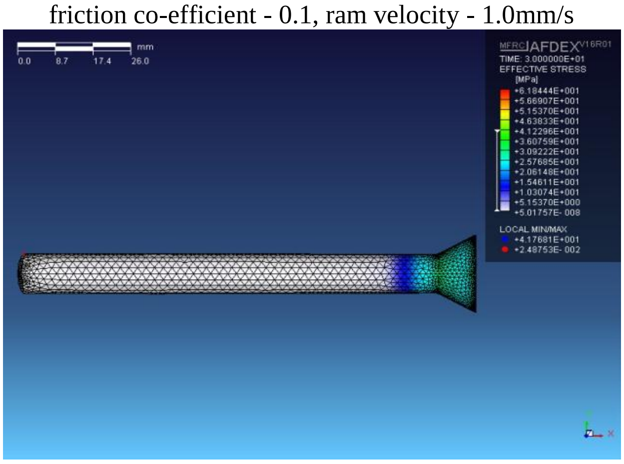


Fig. 8: Component after simulation (die corner radius 0.1mm and die angle 30° )

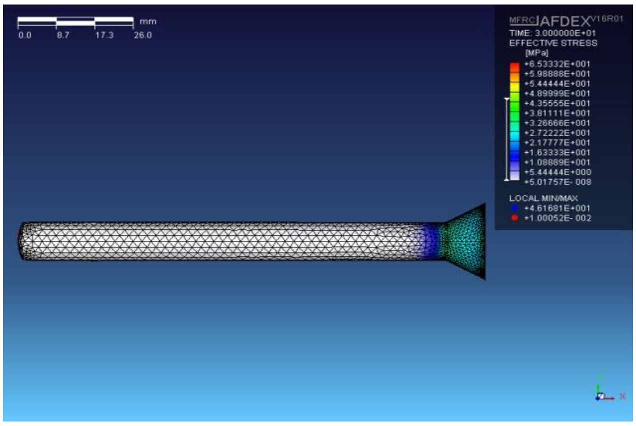


Fig. 9: Component after simulation (die corner radius 0.2mm and die angle 30° )

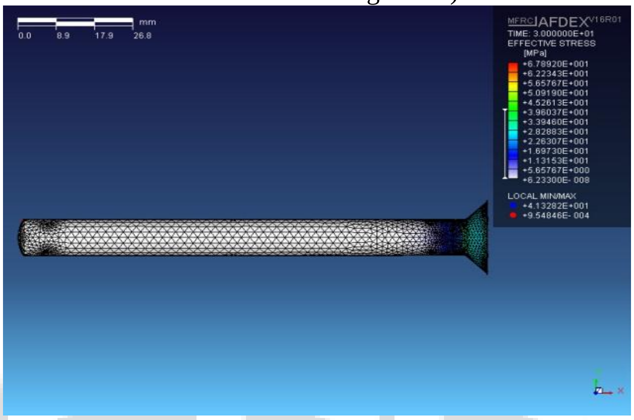


Fig. 10: Component after simulation (die corner radius 0.3mm and die angle 45°)

## VI. Conclusions

Twenty seven iterations were performed by varying the die corner radius, die angle and the ram velocity, where as initial billet temperature and co-efficient of friction were kept constant. The findings from the simulations performed, yielded the optimized parameters as below.

- Die Corner Radius = 0.2
- Die Angle = 30°
- Ram velocity = 1mm/s
- Friction co-efficient = 0.1

The above parameters yielded the load value 6.437587E-01. It is clearly evident that load value obtained for the above said parameters is least as compared to other iterations. It can also be concluded that as ram velocity increases, the load applied also increases.

## Acknowledgement

The authors express immense sense of gratitude towards the Department of Production Engineering, Department of Mechanical Engineering, P D A College of Engineering Kalaburagi for extending the facilities and support during the study. The author express special gratitude to his guide Prof. Bharat S Kodli his inspiration, guidance, constant supervision, direction and discussions in successful completion of project.

## REFERENCES

[1] Antonios Lontos, Filippos Soukatzidis "Effects of extrusion parameters and die geometry on the produced billet quality using finite element method" Mechanical Engineering Department, Frederick University Cyprus, Nicosia-Cyprus
[2] Bhargav C Nadig and Bharat S Kodli "Simulation study of material behavior in forward extrusion" (IJSRD/Vol.4/Issue 04,2016)
[3] Govindraj Karalgikar and Bharat S Kodli "Simulation study of Material behavior and optimization of Die Land Length in Forward Extrusion using AFDEX Software (IJSRD/Vol.5/Issue 05,2017)
[4] Durmus Karayel "Simulation of direct extrusion process and optimal design of technological parameters using FEM and Artificial Neural Network (ANN)" (Key Engineering Materials Vol. 467/Feb 11/2008)
[5] Vikram G Oza and Mr. B.Gotawala "Analysis and optimization of extrusion process using Hyperworks" (IJSRD/Vol.2/Issue 08, 2014)
[6] ASM Metals Handbook Volume 14, Forming and Forging.