Simulation Study of Material Behavior in Forward Extrusion

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Abstract— 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, then extrusion simulation was performed using AFDEX.
Key words: CAD technology, 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*

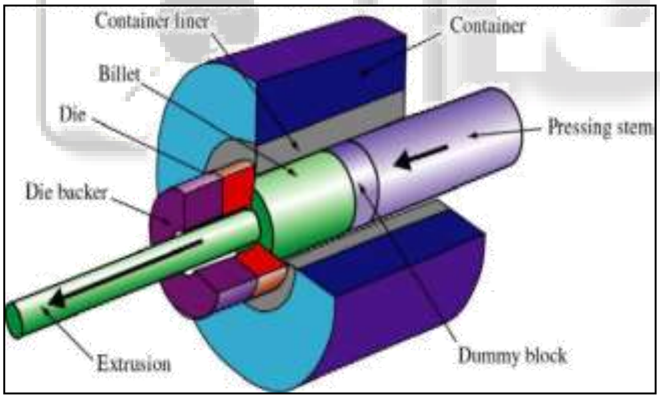

Fig. 1: Direct Extrusion

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

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

Table 1:

The main objective of this Paper is to simulate and analyze the material behavior in forward extrusion. The extrusion process is affected by so many parameters such as, work-piece material, ram speed, extrusion ratio, die angle, working temperature and so on. The model and STL files of die billet and ram is done in Unigraphics. The simulation and analysis of extrusion is performed by AFDEX Software.

II. Simulation

In this Project, Unigraphics software is used to design and AFDEX – 2012 is 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-thermoviscoplastic finite element method.

III. Methodology

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

Component	Hexagonal Bar (Solid)
Material Used	AA6061 T6
Extrusion Type	Hot
Die Type	Conical
Initial Temperature Of Billet	495ºC

Table 2:

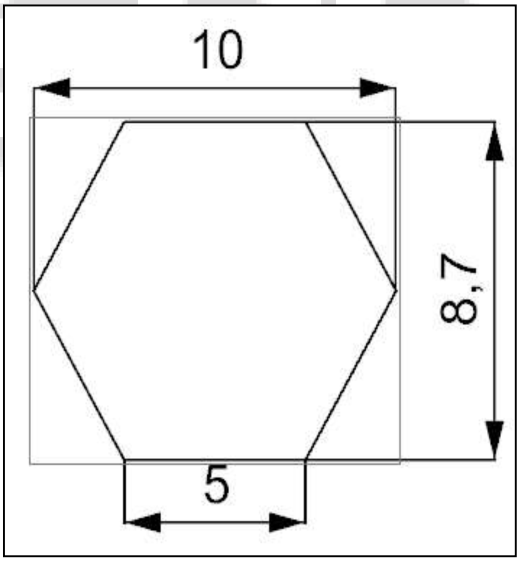

Fig. 2:

A. *Parameters Considered*

Sl No	Die Angle	Friction Co-efficient	Ram Velocity
1.	30	0.20	1.0
2.	45	0.25	1.5
3.	60	0.30	2.0

Table 3:

B. Die Sketches

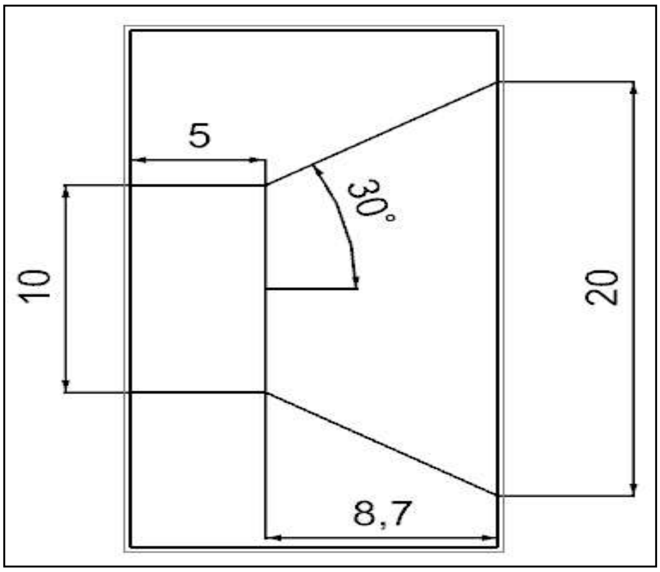

Fig. 3:

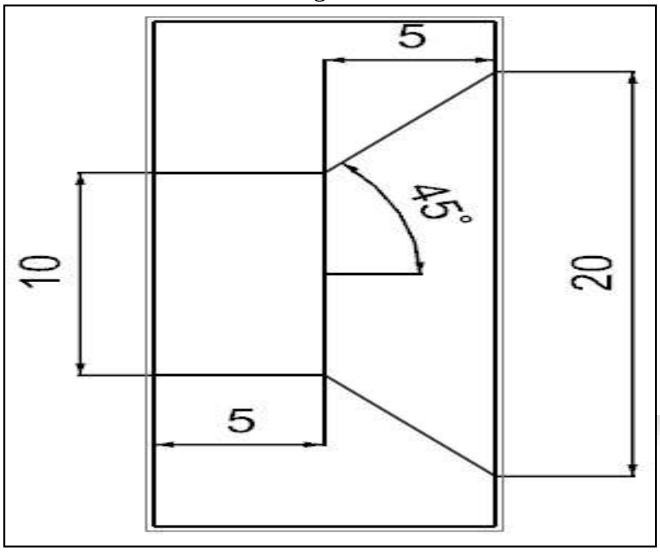

Fig. 4:

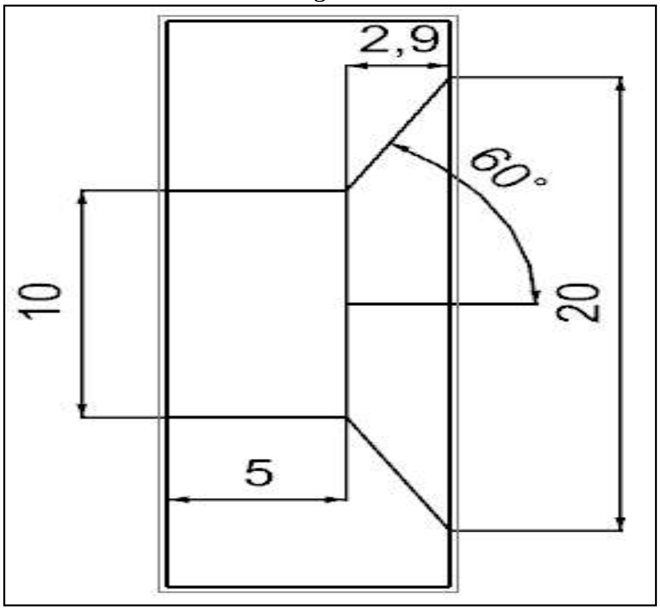

Fig. 5:

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

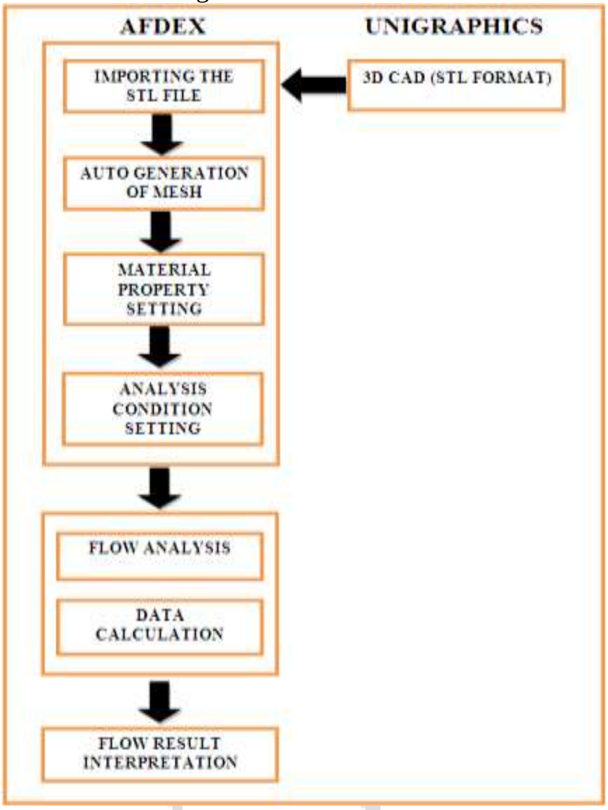

Fig. 6:

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 4: Material 1 – AA6061 T6 Composition

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

Table 5: AA6061 T6 Properties

IV. RESULTS

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

Iteration	Friction Co-efficient (μ)	Ram Velocity (mm/s)	Load (ton)
1	0.20	1.0	1.022 E+0
2	0.20	1.5	1.057 E+0
3	0.20	2.0	1.097 E+0
4	0.25	1.0	1.095 E+0
5	0.25	1.5	1.189 E+0
6	0.25	2.0	1.203 E+0

7	0.30	1.0	1.112 E+0
8	0.30	1.5	1.195 E+0
9	0.30	2.0	1.210 E+0

Table 6: Case 1 Die Semi-cone angle α=30°

Iteration	Friction Co-efficient (μ)	Ram Velocity (mm/s)	Load (ton)
1	0.20	1.0	9.919 E-1
2	0.20	1.5	1.015 E+0
3	0.20	2.0	1.043 E+0
4	0.25	1.0	1.049 E+0
5	0.25	1.5	1.088 E+0
6	0.25	2.0	1.141 E+0
7	0.30	1.0	1.048 E+0
8	0.30	1.5	1.113 E+0
9	0.30	2.0	1.144 E+0

Table 7: Case 2: Die Semi-cone angle α=45°

Iteration	Friction Co-efficient (μ)	Ram Velocity (mm/s)	Load (ton)
1	0.20	1.0	9.664 E-1
2	0.20	1.5	1.023 E+0
3	0.20	2.0	1.054 E+0
4	0.25	1.0	1.042 E+0
5	0.25	1.5	1.092 E+0
6	0.25	2.0	1.125 E+0
7	0.30	1.0	1.060 E+0
8	0.30	1.5	1.109 E+0
9	0.30	2.0	1.126 E+0

Table 8: Case 3: Die Semi-cone angle α=60°

Fig. 7: Graph 1 Die angle-30°, friction co-efficient 0.20 and ram velocity 1.0 mm/s

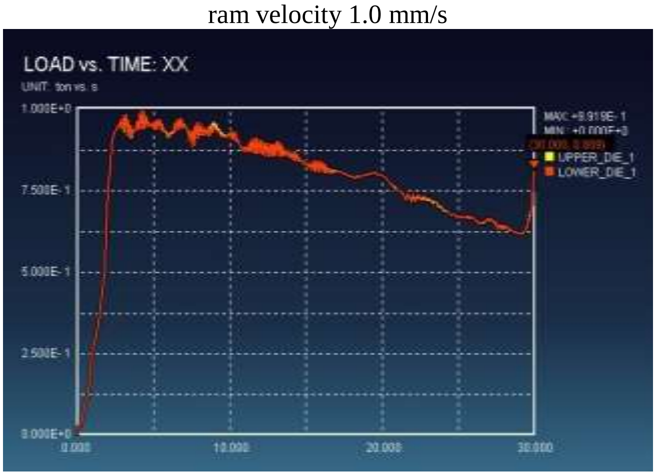

Fig. 8: Graph 2 Die angle-45°, friction co-efficient 0.20 and ram velocity 1.0 mm/s.

Fig. 9: Graph 3 Die angle-60°, friction co-efficient 0.20 and ram velocity 1.0 mm/s

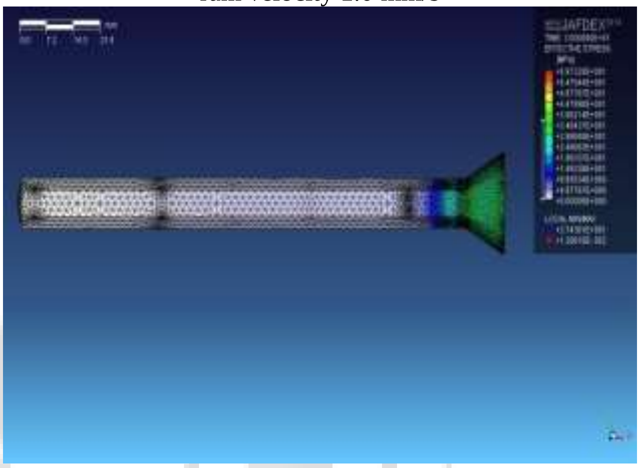

Fig. 10: Component after simulation (die angle 30°)

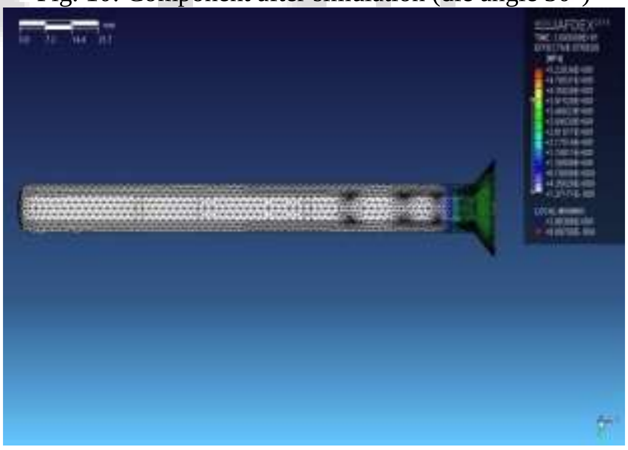

Fig. 11: Component after simulation (die angle 45°)

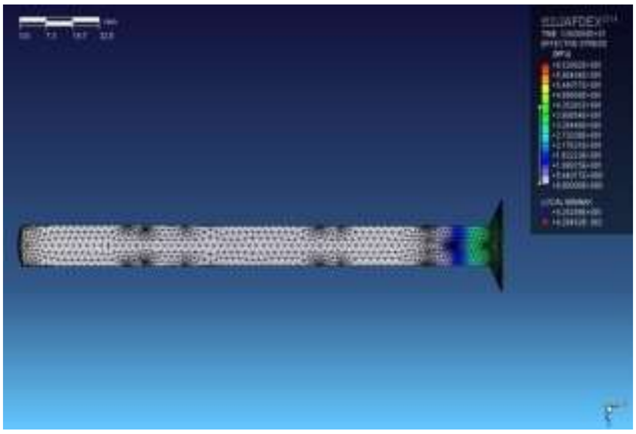

Fig. 12: Component after simulation (die angle 60°)

V. Conclusions

Twenty seven analyses have been realized by using different values of the parameters which consist of die angle, coefficient friction and punch velocity.

The maximum stress occurs on the blank 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 punch velocity increased. The minimum extrusion load occurs if punch velocity and friction coefficient are minimum and die angle is maximum. The extrusion load has fluctuated for some cases.

When the die angle is 30°, µ=0.2 and the ram velocity=1mm/s, it is found that the load is 1.022E+0 ton.

When the die angle is 45°, µ=0.2 and the ram velocity=1mm/s, it is found that the load is 9.919E-1 ton.

When the die angle is 60°, µ=0.2 and the ram velocity=1mm/s, it is found that the load is 9.664E-1ton.

So conclusion can be made by considering the results obtained by performing several iterations during which the parameters like die angle, friction co-efficient and ram velocity were varied.

1) As the die angle increases, the friction between the billet and the die surface decreases which in turn reduces the load required to extrude the component.
2) As the ram velocity is increased, the load acting on the billet is also increased.
3) The extrusion load is minimum when the friction co-efficient and ram velocity is minimum and the die angle is maximum.

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