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Modeling And Machining Of Sheet Metal Dies And Inspection Fixtures

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Abstract - Extrusion is a metal forming process, In this process the material is pushed or drawn through a die of desired cross-section to create long object of a fixed cross-section area, extrusion may be continuous (producing infinitely long material) or semi continuous (producing many pieces). The extrusion process can be done with the material hot or cold. There is gradual deformation which results in the uniform microstructure. Anon-linear converging cosine dies profiles are used for square to square extrusion process. Extrusion through mathematically contoured die plays a critical role in improvement of surface finish of extruded product. The cosine die profile designed using CATIA, Solid works and MATLAB was used to find out the coordinate of the cosine die profile and solid model was generated using CATIA the STL files of extrusion dies generated by solid work and CATIA. The STL files are used in DEFORM-3D Software for FEM simulation. The work piece, punch and container with cosine die profiles are used in DEFORM-3D software for simulation purpose. Extrusion was assumed to be isothermal condition, for extrusion purpose Al- 6062 work material are used in DEFORM-3D Software. FEM modeling determine damage Strain-effective (mm/mm), strain rate-effective ((mm/mm)/sec), stress- effective (M Pa), stress-Max principal (M Pa), Velocity Total V el (mm/sec) and Temperature (C^0). The results optioned during FEM simulation of Al-6062[FEA] are compared with the FEM simulation results of Tellurium Led [FEA]. For Extrusion process of Al-6062, the Extrusion load and pressure are more as compared to extrusion of Tellurium Lead under same percentage of Reductions and comparisons of load and pressure between Aluminum and Tellurium Lead during deformation process.

1. INTRODUCTION

Forming is the processes in which the wanted shape and size are achieved through the plastic deformation of a material .The stressed induced during forming process are greater than the yield strength, But less than the fracture strength of the material. Metal Forming operations such as forging, Rolling, Drawing etc. are capable of yielding high productivity compare to other metal working techniques. Metal forming is one of the most important process in manufacturing of a large variety of products. Metal forming or metal working process is divided into two parts; Bulk forming and sheet metal forming. The Bulk forming refers to processes like Forging, Rolling

Extrusion etc. where there is a controlled plastic flow of material into required shapes. Forming process can be divided into three categories.
Cold Working < 0.4 T_m
Warm Working 0.4 - 0.6 T_m
Hot Working > 0.6 T_m
Where T_m is melting point of material (K)

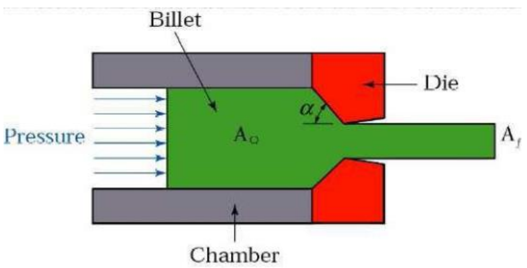
Slab method of analysis: This method assumes that the metal deforms homogeneously in the deformation zone. A square lattice placed in the deformation zone would be inaccurate into four-sided elements. It is the easiest method and widely used in strength of material. It calculates the in homogeneity due to friction but neglects the in homogeneity due to friction at the die-work piece interface and also the influence of transverse stress. It calculates the average forming stress from the work of plastic deformation.

Slip line field theory: This method adopts or assumes the no homogeneous deformation and it is based on the element that any general state of stress in plain strain consists of pure shear plus a hydrostatic pressure. Slip line is in element of two [29] dimensional vector diagram, which shows the deviation of maximum shear stress identified with the direction of slip at any point. Slip line is always a network of lines passing through each other at right angle .It is made up by trial and error method.

Lower bound solution The power of deformation calculated from statistically admissible field which satisfies the Stress equilibrium and yield criterion is always lower than the actual one, it is called lower bound solutions. Lower bound solutions are those, which provide values for the total power, which are lower than the actual one. Here the first step is the design of a stress tensor, which is far more difficult to look on. It is more complex to examine, so less work has been achieved. For lower bound, the requirements are more stress free and the following conditions are not necessarily fulfilled. No need to maintain compatibility, No need to satisfy stress strain relation and Geometrical boundary condition don't have to be satisfied thus, only equation of equilibrium, yield criterion and statistical boundary conditions only wants. The assumed stress field i.e. velocity field is never of such universal form as to take in all admissible fields due to our limited capability in handling the mathematics in the most universal form.

1.1 EXTRUSION PROCESS

It is a plastic deformation process in which a block of billet is forced to flow by compression through [24] the die opening of a smaller cross-sectional area. Show in Fig. 1.1 The forcing of solid metal or work piece through a suitable shaped orifice under compressive forces, extrusion is slightly similar to squeezing toothpaste through a tube, although some cold extrusion processes more nearly look like forging, which also deforms metals by application of compressive forces. Most metals can be extruded, although the process may not be economically feasible for high-strength alloys. The most widely used method for producing extruded shapes is the direct, hot extrusion process. In this process, a heated billet of metal is placed in a cylindrical chamber or rectangular chamber and then compressed by a hydraulically operated ram. The extrusion of cold metal is variously termed cold pressing, cold forging, cold extrusion forging, extrusion pressing and impact extrusion. The cold extrusion has become popular in the steel fabrication industry, while is widely used in the nonferrous field. The advantages of cold extrusion are higher strength because of severe strain-hardening, good surface finish, dimensional accuracy and economy of the product and minimize the machining requirement of the output product.



1.2 The classification of extrusion processes are as follows,

There are several ways to classify metal extrusion processes;

1. By direction:-Direct / indirect extrusion or forward /backward extrusion.
2. By operating temperature: - Hot /cold extrusion.
3. By equipment: - Horizontal and vertical extrusion.

2. DIE PROFILE DESIGN

For 30% Reduction Cosine Die profile equation

Here A_0=20×20 mm², A_f =16.7332×16.7332 mm² and L_0=40 mm

W=10mm and A= 8.3666 mm

For R= 60% reduction cosine die profile equation

Here A_0=20×20 mm², A_f =12.6491×12.6491 mm² and L_0 =40 mm

W=10mm and A= 6.3245 mm.

For R= 90% Reduction Cosine Die profile equation

Here A_0=20×20 mm², A_f =6.3245×6.3245 mm² and L_0=40 mm

W=10mm and A= 3.16225 mm

Table 4.1 the dimension of dies with different-different % of Reduction.

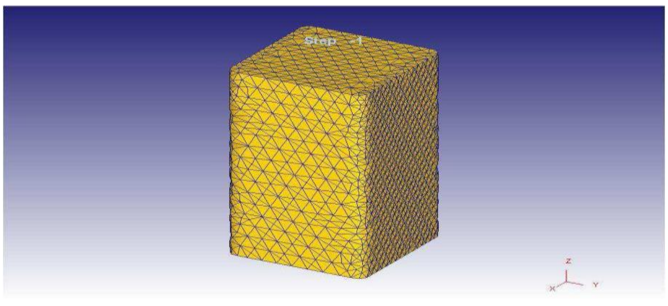
sl. No.	% Of Area Of Reduction	Input Side mm	Input Side Area mm²	Output Side mm	Output Side Area mm²	Height Of Die mm
1	30	20	400	16.73	279.9	40
2	60	20	400	12.64	159.9	40
3	90	20	400	6.32	39.9	40

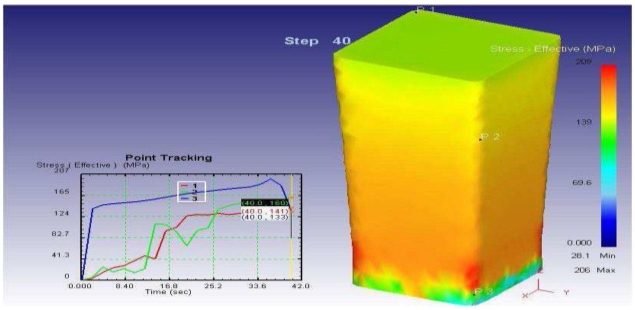
3. FINITE ELEMENT ANALYSIS

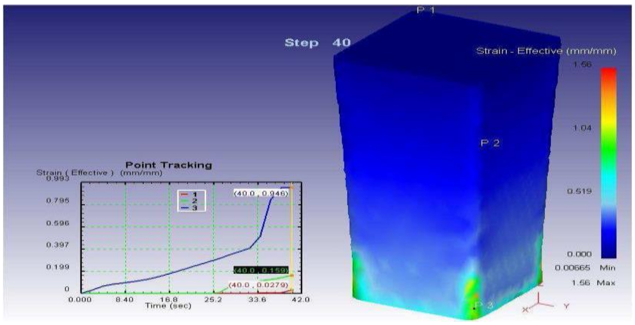
FEM modeling is a powerful technique used for different metal deformation problems including extrusion. In the present study, FEM modeling has been carried out for extrusion of square section from square billet with cosine Die profile, using DEFORM-3D software. Damage, effective strain (mm/mm), effective Strain rate ((mm/mm/sec)), effective stress (M Pa), max principal stress (M Pa), Total Velocity and Temperature (C°) distribution obtained during simulation process.

FOR (30%)

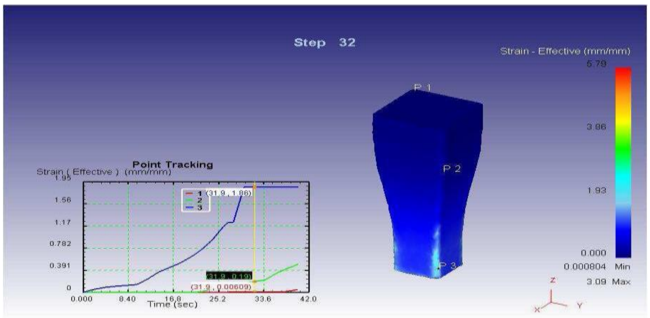
Mess formulation for square billet (Size Ratio=1; Number of elements =25000)

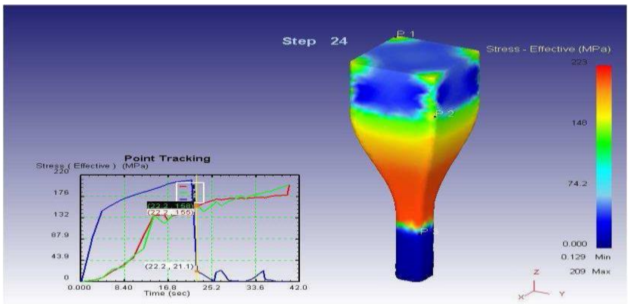




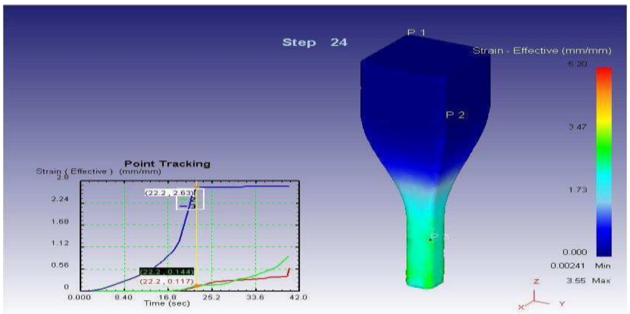


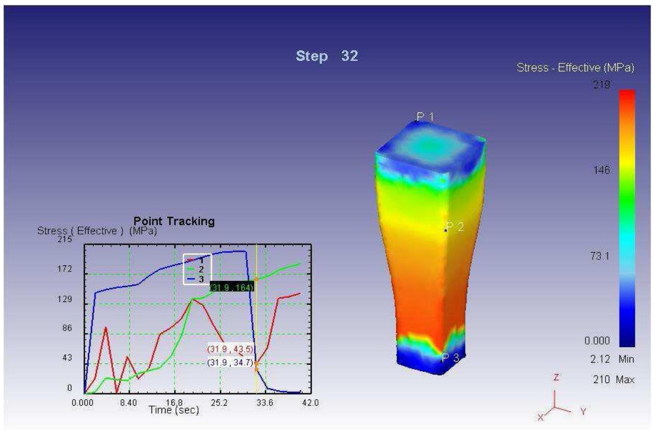
FOR (60%)



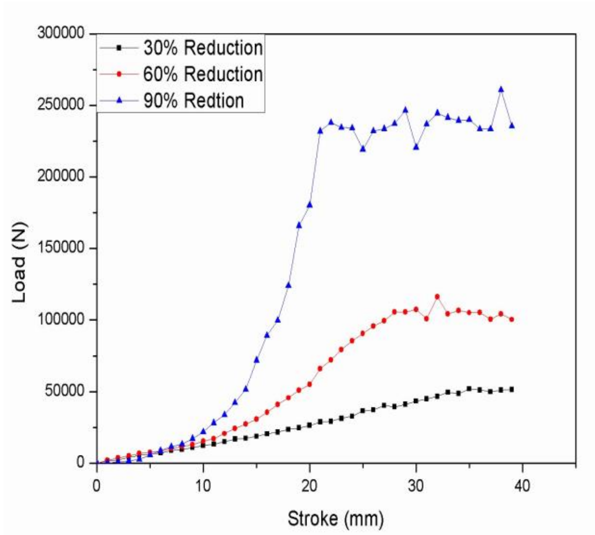


FOR(90%)

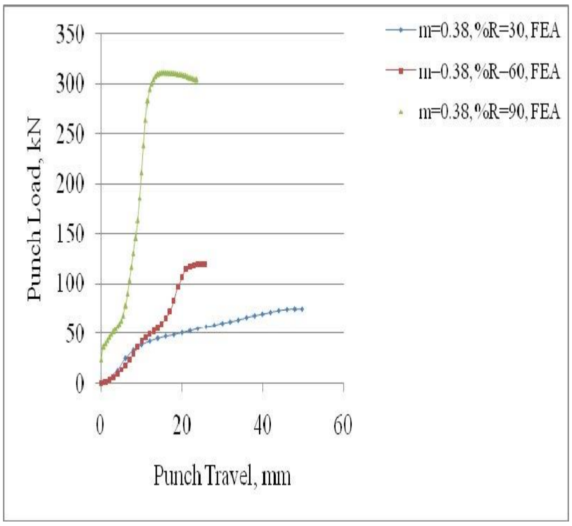




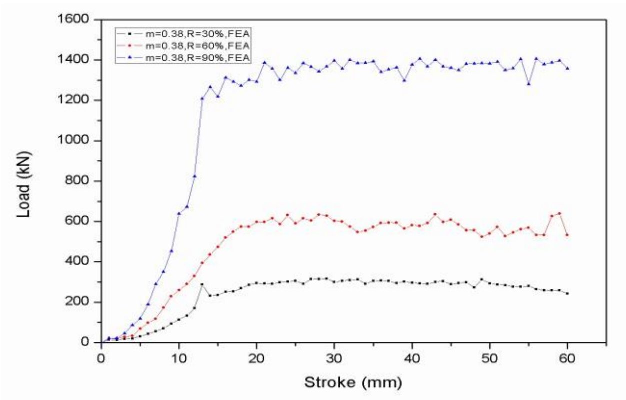
RESULTS AND DISCUSSIONS



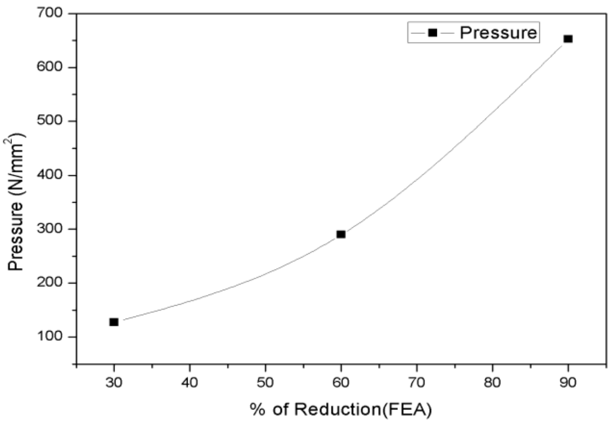
Load vs. Stroke with 30%, 60% & 90% Reduction (FEA)



Load vs. Stroke with 30%, 60% & 90% Reduction (FEA)



Pressure vs. % of Reduction



Punch load vs. Punch travel for wet condition

CONCLUSIONS

A non-linear converging die profile has been designed for extrusion of square section from square billet using cosine profile function. The extrusion load and pressure increases with increase in reduction. The extrusion load for non-linear converging die is less as compared to linear converging die under same simulation condition. The flow of material in non-linear (Cosine) converging die appears to be gradual mainly in higher reduction. The effect of friction is more predominant in high reduction. Adie profile function has been developed for extrusion of square section from square billet using a mathematically contoured die profile. The procedure can also be used to develop other die profiles. Solid CAD models of curved die profiles have been developed for extrusion of square section. FEM modeling has been carried out for extrusions of square section from square billet using DEFORM 3-D software through cosine shaped die using Al-6062 rigid-plastic material model. The Strain-effective (mm/mm), The Strain Rate-effective (mm/mm/sec), The Stress-effective (MPa), the stress-max principal (MPa), the Velocity-Total(mm/sec),the temperature distribution during deformation has been determined from FEM modeling. The Extrusion load and Pressure both for Al-6062 are more as compare to the Tellurium Lead for extrusion process.

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