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3D FEM ANALYSIS OF EXTRUSION PROCESS OF AL2024-BERYL COMPOSITES

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ABSTRACT

Extrusion Process are now getting importance for its abilities to give improved mechanical properties, high production rate and less material waste when compared with that produced by machining, casting or by assembling the individual parts produced by different manufacturing processes. In its simplest form extrusion process, is widely adopted now a day's in the industry. 3D Finite Element Modeling and Analysis of extrusion process was performed using DEFORM Software. In the Present study, Finite Element analysis was carried out for Al-2024-Beryl composites with wt % of 0, 4, 6, 10 & 12 Beryl Particles respectively. Al2024-Beryl Composites were cold extruded, and results such as stress, strain, velocity vectors, displacements, have been plotted and discussed briefly in this paper.

KEYWORDS: *Extrusion, FEM, Al2024-Beryl Composites, DEFORM Soft Ware, Cold Extrusion.*

1 INTRODUCTION

For the best use of metals, it is necessary to shape the metals into required form. Casting is one of the process for giving the desired shape to metals, but it is not feasible in all cases. Metal forming is another method of shaping metals to desired forms where casting is not desirable. Metal forming is a manufacturing process in which the forces are applied on the material such that stresses induced in the material is greater than the yield stress and less than the ultimate stress so that material experiences plastic or permanent deformation to change the shape the component as required. Metal forming can be carried out in the form of either hot working or cold working. Formation of material at a temperature less than the recrystalization temperature is called cold working and if the material is deformed at the temperature greater than the recrystalization temperature and less than the melting point temperature is called hot working. The main difference between cold working and hot working is that residual stresses are produced in cold working but not in hot working. For the same amount of deformation the force and energy required for cold working is higher than the hot working. In the cold working process because the component is not heated, the chances of formation of scales are less, hence closing dimensional tolerances are possible, good surface finish can be obtained and coefficient of friction during the process is less. During hot working operation because the component is heated to a higher temperature, the handling of component is difficult. Rolling, Drawing, Extrusion, Forging, Bending and sheet metal operations like Punching, Blanking, Coining etc., are some of the metal forming process.[1]

1.1 Extrusion

Extrusion and Forging are the main metal forming processes used to shape the metal to required shape. Extrusion is a bulk metal forming used to create products of a fixed, cross sectional profile, where the material is drawn through a die to a desired shape at the end of the process. A large variety of complex shapes can be produced through the operation. The process also forms finished parts with an excellent surface finish. In extrusion mainly two types of processes are there. They are forward and backward extrusion processes. In forward extrusion, which is most commonly used process, the ram moves in the same direction of the extruded section and there is relative movement between the billet and the container, leading to high frictional forces. In this paper forward extrusion process is used as shown in Figure 1.

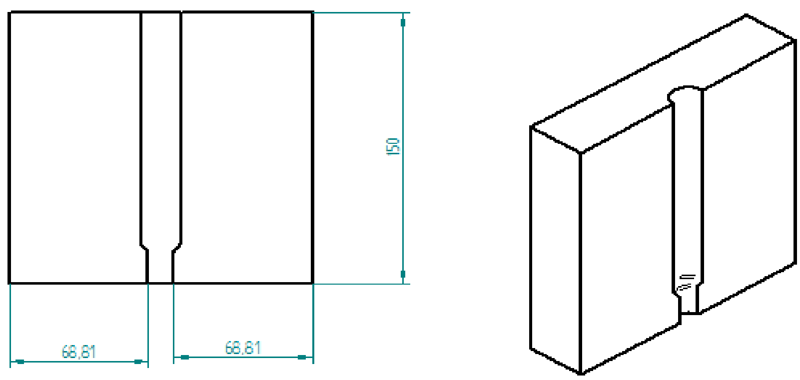


Figure 1: One half of Extrusion Die

1.2 Research Objectives

The main objective, of this work is to manufacture the product, with enhanced mechanical properties, less material wastage less cost compared to other processes like casting, forging and machining. The other objectives are as follows

1. Estimation of forming force for required product shape using extrusion process.
2. Simulation of the extrusion process using FEM (Finite Element Method) based software package DEFORM 3D.
3. Designing of dies and setup for the required product to produce.
4. Performing experimentation using aluminum as a billet on 350 ton hydraulic press.
5. Comparing the results obtained from Experimental investigation and simulation process. Estimation of extrusion force required to produce products.

1.3 Present Problem

Many researchers have carried out on extrusion process. But in present research, 3D Finite Element Analysis was carried out on extrusion and results like stress, strain, and velocity vectors were evaluated.

2 MATERIALS

Isotropic and rigid-perfectly plastic material type was used. The commercially available Aluminum 2024 is chosen as the material. The flow stress of the material is taken from the experimental results.

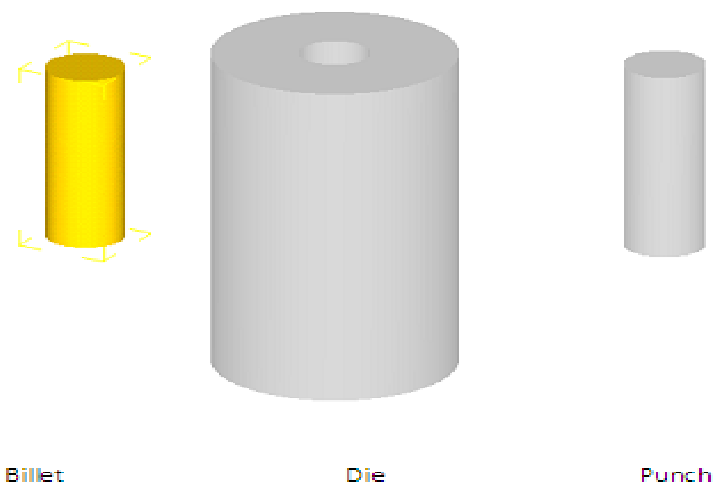


Figure 2: Objects required for simulation process.

2.1 Boundary Condition

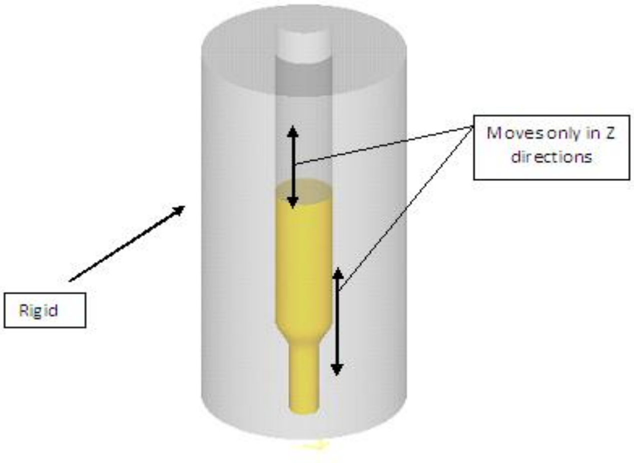


Figure 3: Die design with Boundary Condition.

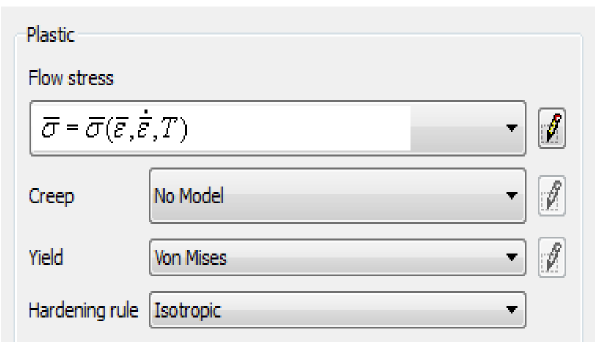
From the Figure 2 & 3 the die design and the boundary condition, movement of the punch in the z direction and the bottom die is rigid and the billet moves only in the z direction.

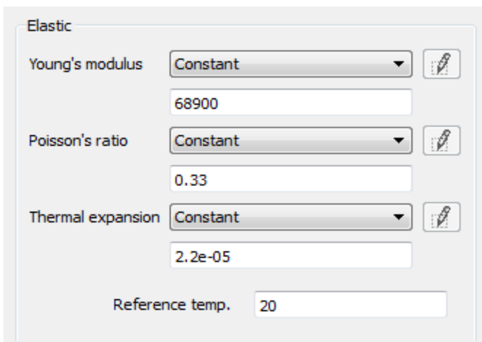
Table 1: Show the Process parameters used in the simulation.

Billet length	70mm
Billet temperature	20
Friction factor	neglected
No. of mesh element	3000
Limiting strain rate	0.01/s
Punch speed	0.05m/s
Average strain rate	1/s

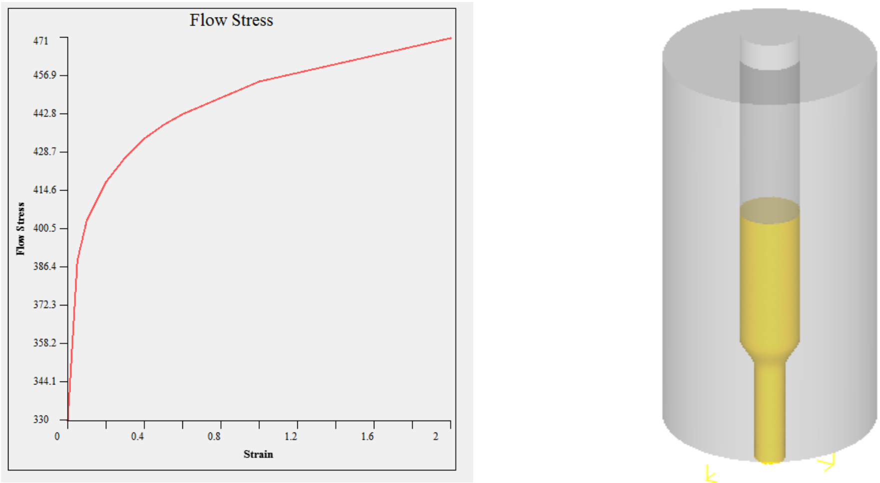
From the Table 1 it clearly shows the detail parameter used in the analysis such as billet length, billet temperature, friction factors, limiting strain rate, punching speed and average strain rate used in the analysis.

3 Materials Properties





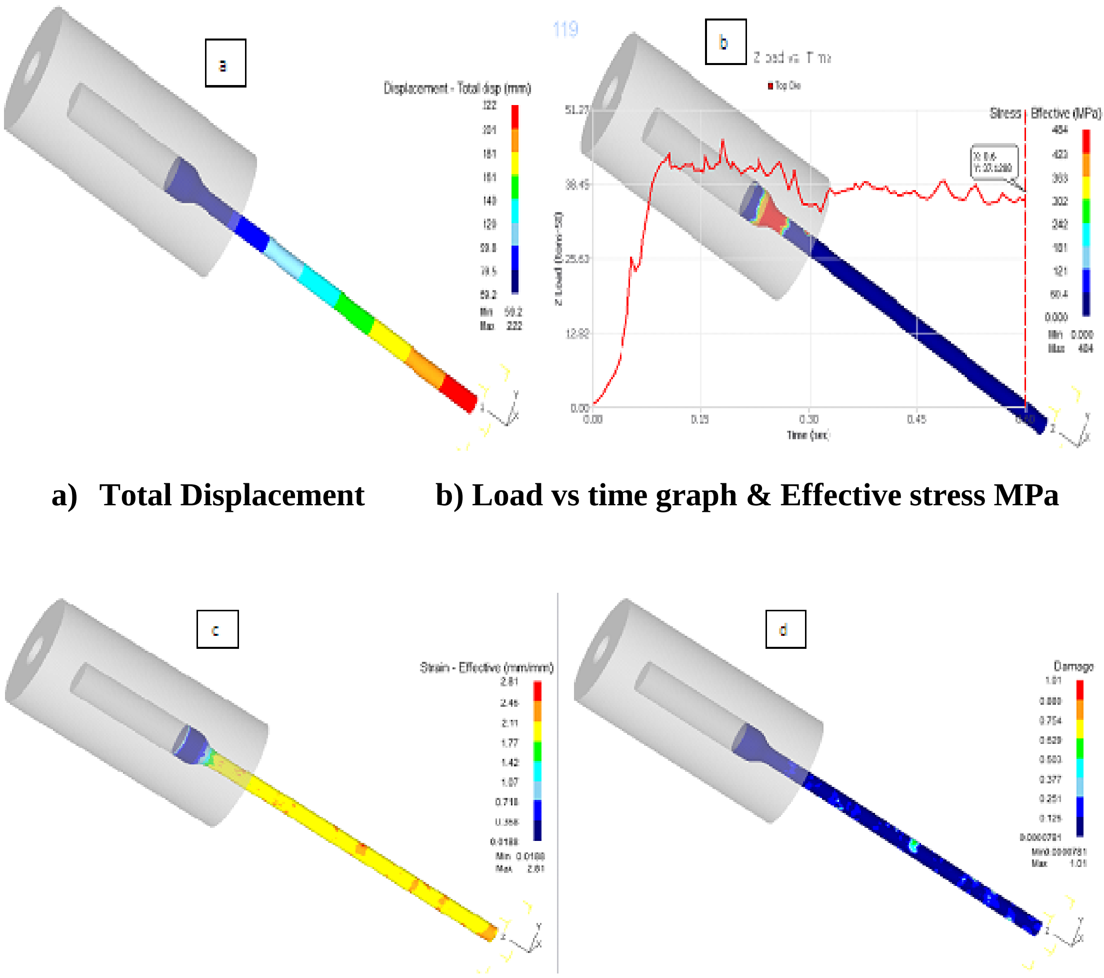
a) Material Property Plastic. **b) Material Property Elastic.**



c) Flow stress curve used in the analysis d) 3D Model of Extrusion Die

Figure 4: a b c d Materials Properties for Al2024-Beryl MMC's.

C) RESULT AND DISCUSSION



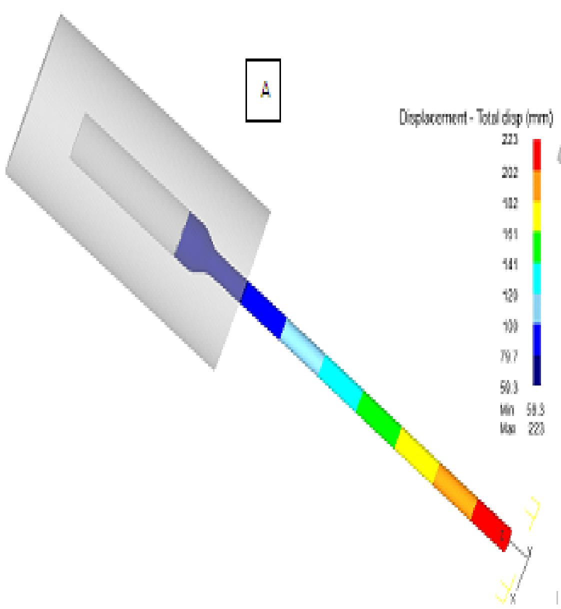
a) Total Displacement b) Load vs time graph & Effective stress MPa

c) Strain Effective d) Damage shown ie cracks

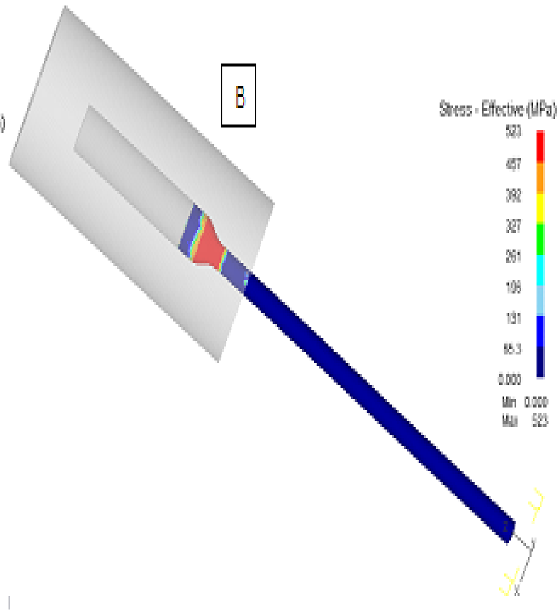
Figure 5: a b c d Finite Element result of Displacement, Stress, Strain and Damage for 0%wt of Beryl particle.

Figure 5 shows the results of 0% the displacement is nearly about 222 mm for all the cases shown in Figure 5, 6, 7, 8, 9 respectively, the stress is around 484MPa and the load required for deformation is nearly about 51.22 tons, the strain induced is nearly about 2.81mm/min and another important parameter is the damage which is 1.01 means that the after extrusion from the Figure d) patch like which is having a light sky blue color, in the extruded product cracks are observed which can also be modeled and can be shown in this DEFORM software.

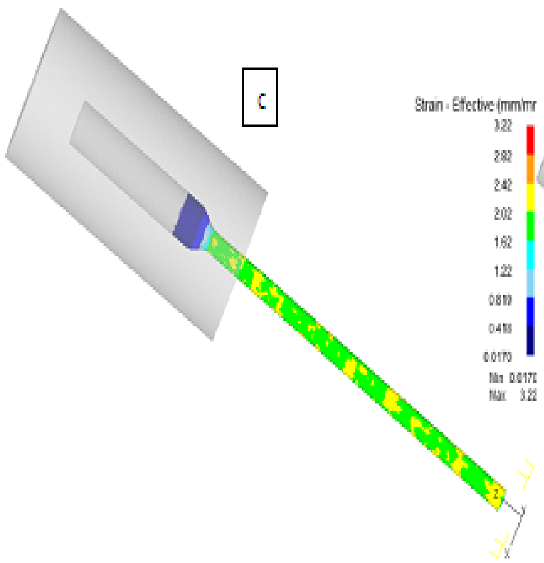
Case 2 for 4% wt of Beryl



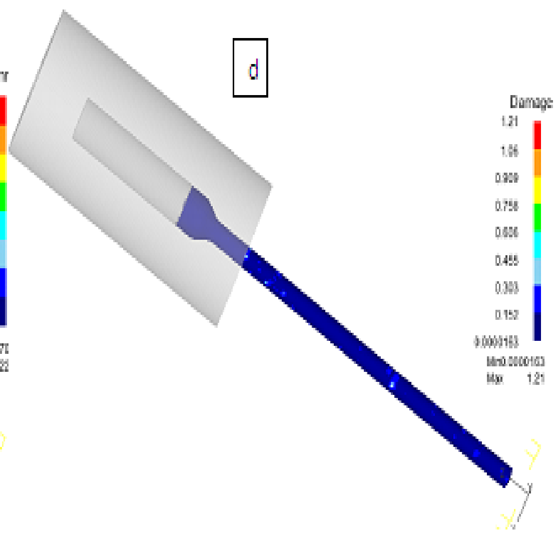
a) Total Displacement



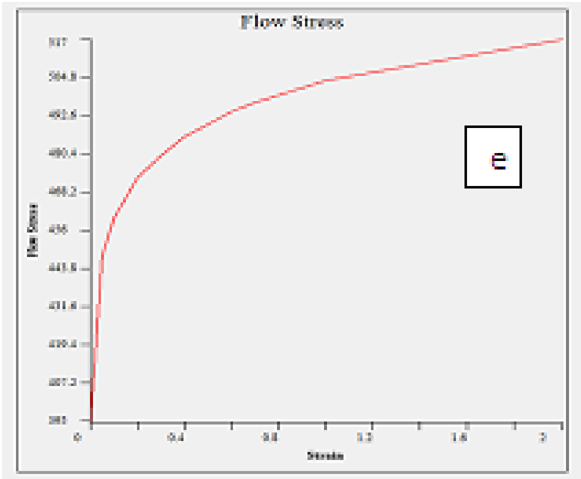
b) Effective Stress MPa



c) Effective Strain

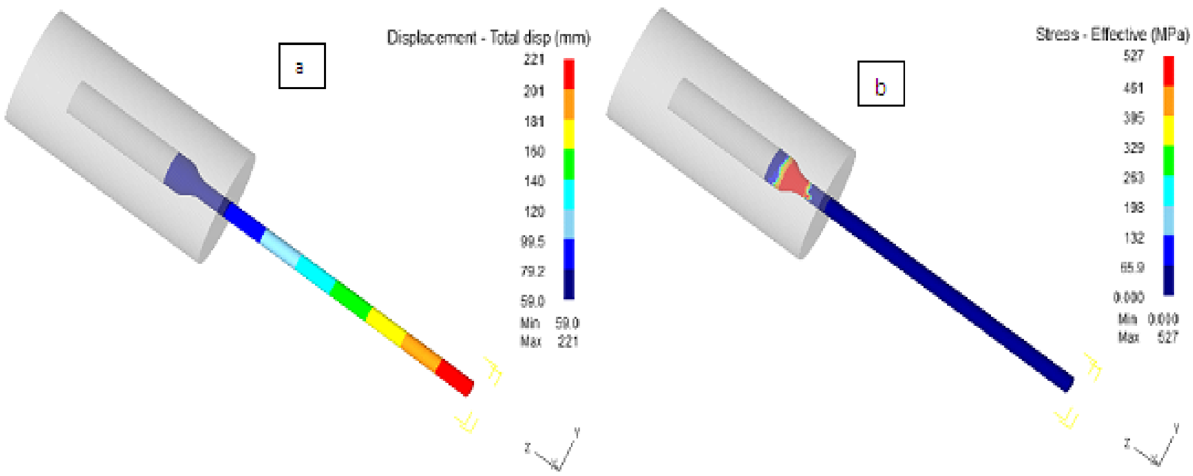


d) Damage shown ie Cracks

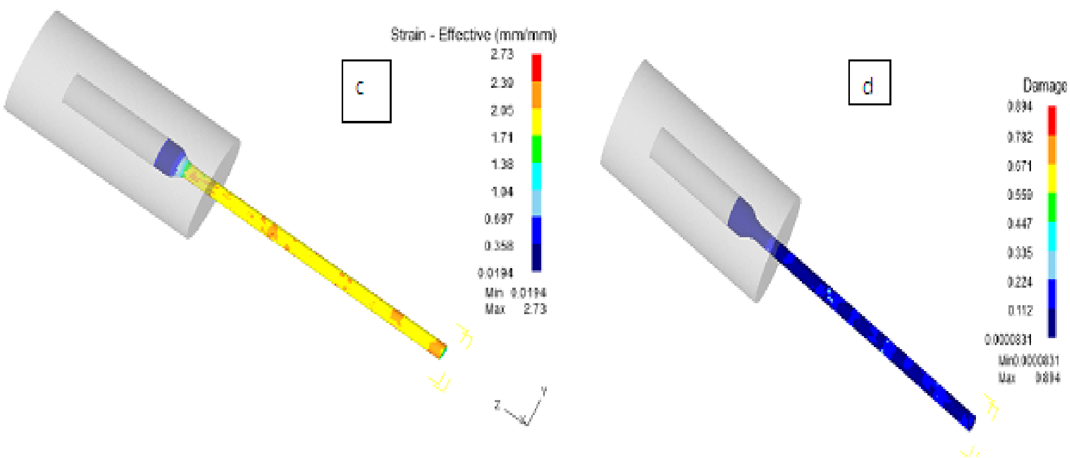


e) Flow stress for 4% Wt of Beryl Particle

Figure 6: a b c d e Finite Element result of Displacement, Stress, Strain, Damage and Flow Stress for 4%wt of Beryl.



a) Total Displacement b) Effective Stress

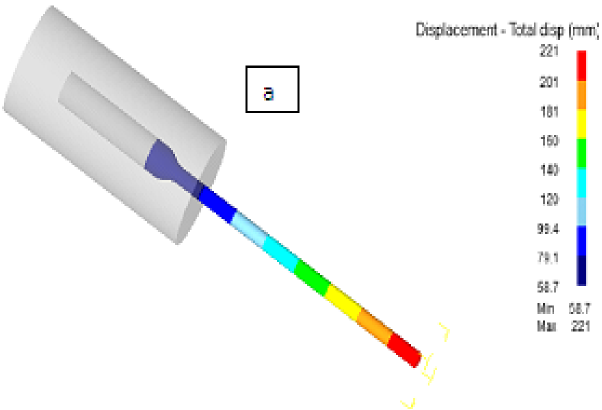


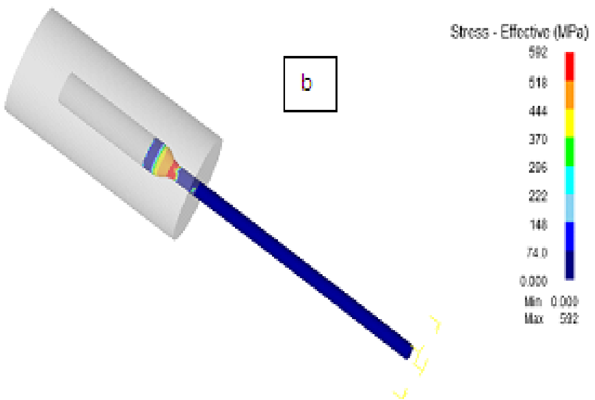
c) Effective Strain d) Damage ie Cracks

e) Flow Stress curve for 4% wt Beryl Particle

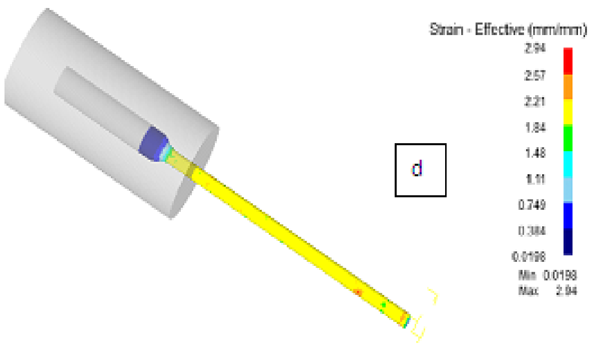
Figure 7: a b c d e Finite Element result of Displacement, Stress, Strain, Damage and Flow Stress for 6%wt of Beryl.

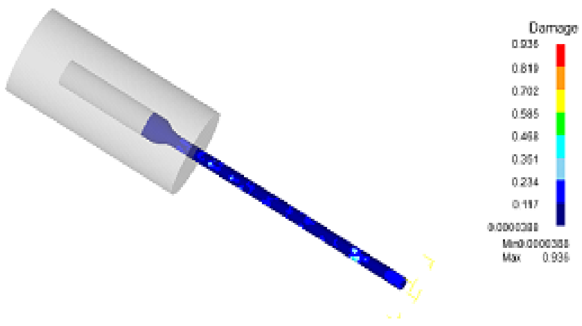
Case 4 for 10%wt of Beryl



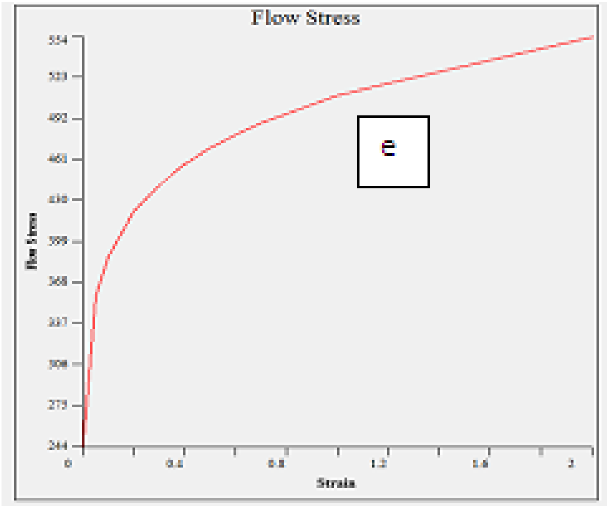


a) Total Displacement **b) Effective Stress MPa**





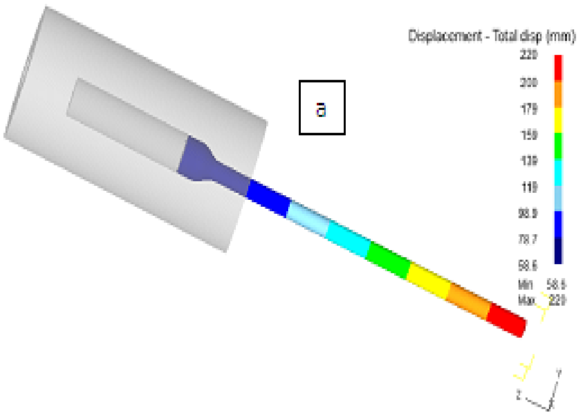
c) Effective Strain **d) Damage ie Cracks**



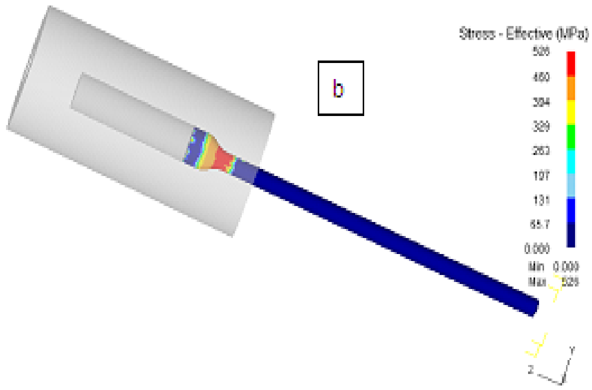
e) Flow Stress curve.

Figure 8: a b c d e Finite Element result of Displacement, Stress, Strain, Damage and Flow Stress for 10%wt of Beryl.

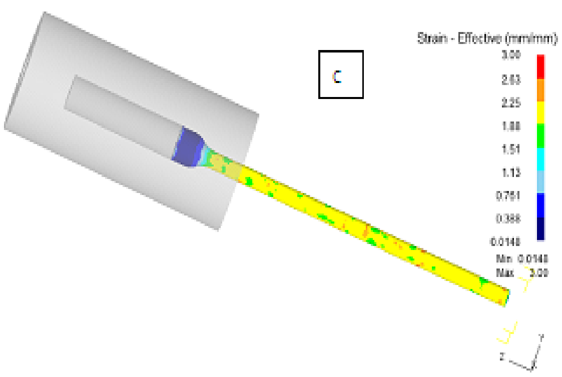
Case 5 for 12%wt of Beryl



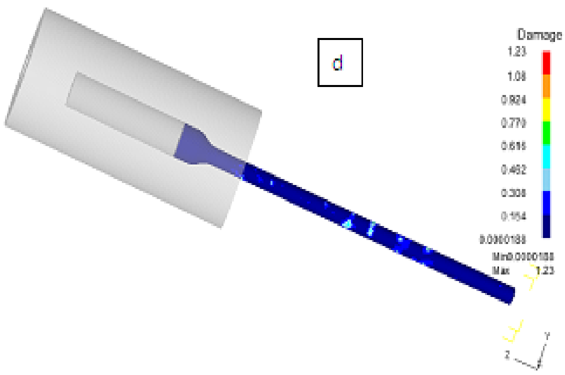
a) Total Displacement



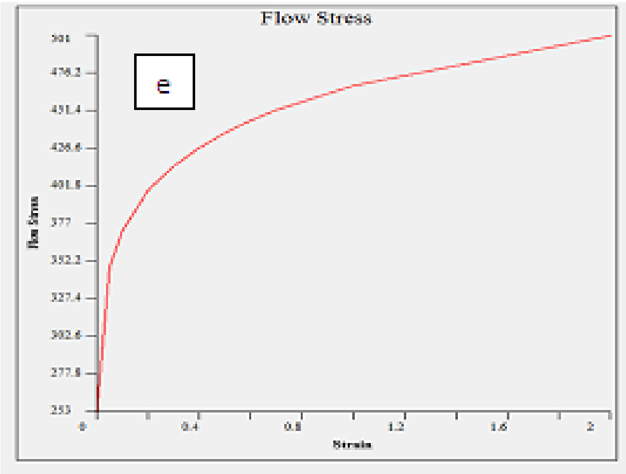
b) Effective Stress



c) Effective Strain



d) Damage ie Cracks



e) Flow Stress Curve.

Figure 9: a b c d e Finite Element result of Displacement, Stress, Strain, Damage and Flow Stress for 12%wt of Beryl.

CONCLUSIONS

1 Finite element based 3D simulation software DEFORM 3D was implemented on extrusion process to analyze effective stress, effective strain, damage, metal flow patterns and flow stress.

2 Simulations are carried out for different Wt% of Beryl Particles.

3 Flow stress of Al2024-Beryl composites are 471, 517, 516, 554 and 501 MPa for 0, 4, 6, 10 & 12 wt% of Beryl respectively.

4 The stress for 0, 4, 6, 10 & 12 wt% of Beryl are 484, 523, 527, 592 and 526 MPa respectively.

5 The strain for 0, 4, 6, 10 & 12 wt% of Beryl are 2.81, 3.22, 2.73, 2.94 and 3.00 respectively.

6 The DEFORM tool is very effective in modeling and analysis of forming processes.

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