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EFFECT ON ROD AND TUBE EXTRUSION CONSIDERING VARIOUS DIE ANGLES USING PLASTICINES & NUMERICAL VALIDATION OF EXTRUSION EXPERIMENT RESULTS USING FINITE ELEMENT SIMULATION

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ABSTRACT

Extrusion is a relatively new process and its commercial exploitation started early in the nineteenth century with the extrusion of lead pipes. Extrusion of steels became possible only after 1930 when extrusion chambers could be designed to withstand high temperature and pressure. Extrusion large number of variations in the mode of application.In the past, the extrusion dies was designed based on theoretical relations given in handbooks of metal forming. These are based on experiments carried out at wide number of cases & die behavior under various conditions. In many cases, this trial-and-error procedure is neither optimal nor cost effective in terms of achieving the desired properties in the finished product. Also such approaches lack clarity with respect to mechanics of metal flow, enhances the design time and end with lower efficiency. Extrusion die angle & die landing plays an important role on material flow, micro structural evolution, speed of production and left out material in the die. Faulty die landing may lead to material wastage through large dead metal zone and bad microstructure. In this study an attempt has been made to study the effect of die angle on rod & tube extrusion processes using experiment. The extrusion experiments are carried out by using three dies of different die angle with variable die landing and at the three different speeds. Red and Green colors plasticine is used. Extrusion load increases with increase in ram velocity irrespective of die angle and material. Simulation study reveals a good match between experimental and numerical load stroke curves. It shows that simulation can be effectively used for the analysis of extrusion process. The designed die was further adopted for computer simulation using MSC. Super forge software (based on FE Method) to asses stress, strain and strain rate distributions and load requirements. Using these results, effects of different die angle & die landings at various ram speeds are critically examined. The expectation of this study would provide a new insight into the design of manufacturing process.

Keyword-*Extrusion Dies, Red & Green plasticine, Manufacturing process, Die angles, Tube, Rod, Aluminium*

INTRODUCTION

In extrusion, the work piece is compressed in a closed space, forcing the material to flow out through a suitable opening, called a die. The die opening corresponds to the cross section of the required product.

The equipment consists of a cylinder or container into which the heated is one of the most potential and useful working processes and has a metal billet is loaded. On one end of the container, the die with the necessary opening is fixed. From the other end, a plunger or a ram compress the metal billet against the container wall and the die plate, thus forcing it to flow through the die opening, acquiring the shape of the opening. In this process, only the shape with constant cross-sections (die outlet cross-section) can be produced. It is basically a hot working process; however, for softer materials cold extrusion is also performed.

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MATERIALS AND EXPERIMENTAL PROCEDURES MATERIALS

For the experiment the computer controlled testing machine having load cell capacity of 100 kg as shown in Fig 3.2. This is the electric control machine in this controlling of the speed can be done and the load verses displacement graphs can be obtained directly from it. By making the fixtures for the extrusion process the machine is operated and the load curves are obtained.

Die Fabrication

Three dies of angle 30, 45 and 60 degrees. The cylinder and the die arrangement are made for the machine. A setup has been made to do direct extrusion of the model material, Plasticine, (Red and Green color). The extrusion experiment setup consist of a cylindrical container of external diameter 50 mm and internal diameter 40 mm of made of Steel alloy using machining process which produces an excellent surface finish to produce smooth extruded surfaces. Three dies of different die angles i.e. 30, 45 and 60 degrees are made through different manufacturing process for the better results. The dies were made from Aluminum material. The side view of the three dies (30, 45, 60 degree) respectively is shown in Fig 3.3. The top of the three dies is shown in Fig. 3.4. The top and the front view of the die & container are shown in Fig .3.5 & Fig. 3.6. Mandrel is made for the tube extrusion Fig. 3.7 & Fig.3.8.

Extrusion experiments of rod and tube

The setup of the extrusion process at the time of experiment is shown in the Fig. 3.9.

Preparation for red, green & yellow plasticine

The plasticine is taken from the market and is prepared for the experiment. The billet of the material is prepared of the desired shape of the diameter 40mm and the height of the desired die.

Rod Extrusion

Rod extrusion is the process in which the extruded product is the rod and the set up of direct rod extrusion is shown in Fig 1.1.In this the rods of two different colored plasticine material were extruded. It was extruded by three different dies of different angles as shown in Fig 1.2 to 3.5 in chapter 3. The three different speeds were taken as 1, 2 and 3 mm/min. The Extrusion ratio is kept constant. The two different colours are red & green. Different cases were experimented by the combination of die angle and the speed on both materials. The Load/Displacement graph were plotted for the cases and studied. By this the effect of the different die angles on the material at different speeds with different colours is studied.

Tube Extrusion

Tube extrusion is the extrusion of seamless tubes over a mandrel. The extrusion of tubes through a welding chamber die is, therefore classified under the section extrusion. The direct extrusion of the tube is performed in the experiment. The yellow coloured plasticine material is used for tube. The mandrel of diameter 6mm is used. The same three different die angled dies were used. The extruded tube arrangement is shown in Fig. 3.10. The tube is extruded and the load/displacement graphs were plotted. Material modeling of the plasticine is carried out using power law equation given below:

$$\sigma = k \in^{n} \qquad (3.1)$$

Where k = strength co-efficient,

n = strength exponent.

Fig1.1 : Front view of 30, 45 and 60degreedies

Fig. 1.2: Top view of 30, 45 and 60 degreedies

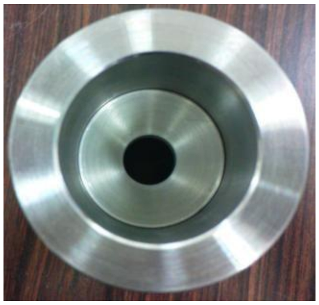

Fig. 1.3: Top view of diewith container

Fig. 1.4: Front view of die withcontainer

Fig. 1.5: Side viewof mandrel

Fig.1.6:TubeExtrusion

Software MSC. Marc

Finite element analysis (FEA) is a critical part of the virtual design process. But because most FEA programs are linear, they can only study parts that deform a small amount, certainly not enough to deformation to exceed the linear elastic range of the materials. But Marc has no such limitations. A nonlinear FEA program, Marc enables you to assess the structural integrity and performance of parts undergoing large permanent deformations as a result of thermal or structural load. The types of deformations the program can study include geometric nonlinearities (metals bending) and material nonlinearities. Marc is used to simulate deformable, part-to-part or part-to-self contact under varying conditions that include the effects of friction—critical for analyzing nonlinear behavior in tool-and-die set-up, spring coil clash, or a windshield wiper system.MSC. Marc has four comprehensive libraries, making the program applicable to a wide range of uses. These libraries contain structural procedures, materials, elements, and program functions.

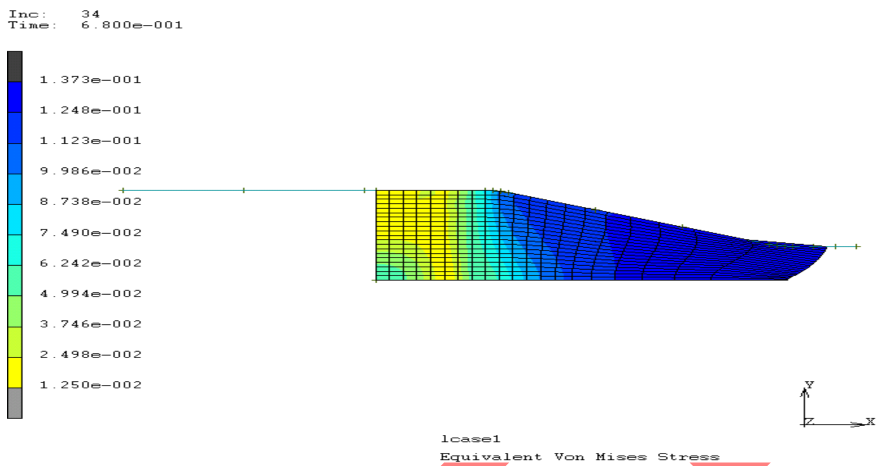

Fig.1.7 : Simulation of extruded rod with the von mises stress

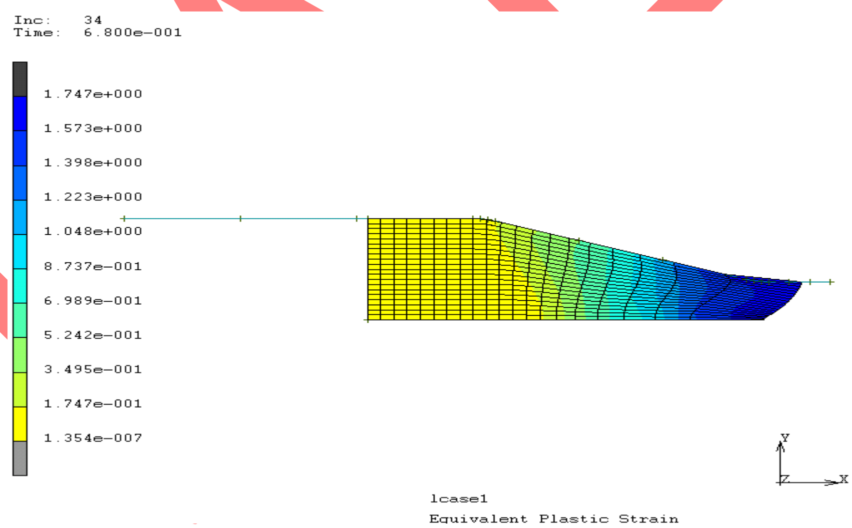

Fig. 1.8: FEM simulation with Plastic Strain

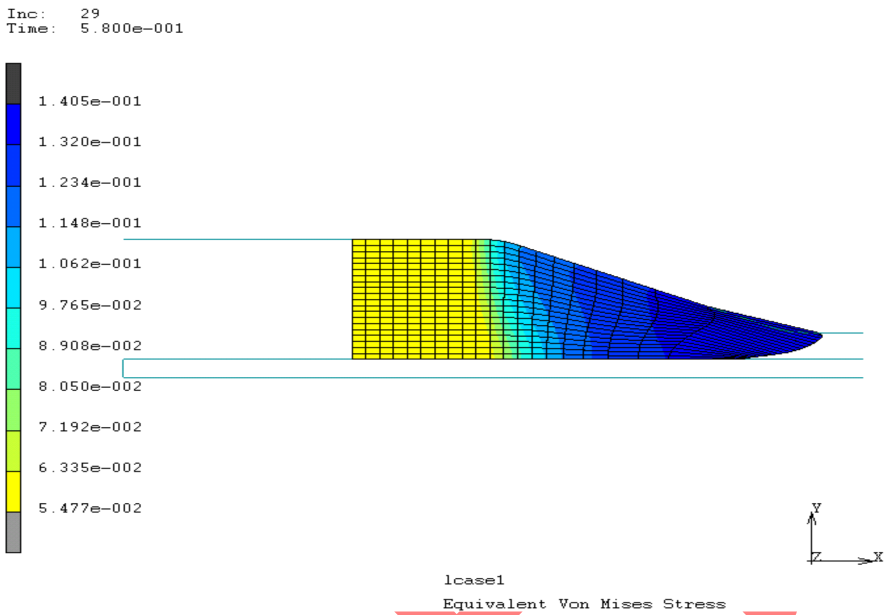

Fig. 1.9: Simulation of extruded tube with the von mises stress

RESULT & DISCUSSION

Results of experiment & computer simulation are described under following heads:

Experiment of Rod Extrusion

The extrusion process is done by using three dies of different angles and at the three different speeds. The results were observed that as the die angle increases the load decreases as seen in the Table. 2.1 for red and in Table. 2.2 for green plasticine. The effect of the velocity is seen that as the velocity increases the load increases and at less speed the load is low. The surface finish of the extruded roads is different for the die angles. The finish of the 30 degree die rod is more and the finish of the rod of 60 degree is showing the cracks on the surface in Fig. 2.4. The Load /Displacement graphs for the rod extrusion with the three Die (30,45,60) and with three speeds (1,2,3 mm/min) and by using two different colour plasticine (Red & Green) is shown in Fig. 2.12 to Fig.2.29.In these graphs the three series are shown which shows the three reading for one set of die and speed.

Experiment of Tube Extrusion

The tube extrusion is done by using the same set up with the addition of the mandrel and the various Load verses Displacement graphs were plotted. The same effect as that on rod is seen the die angle increases the load decreases. The effect of the velocity is seen that as the velocity increases the load increases and at less speed the load is low. The surface finish of the extruded roads is different for the die angles. The finish of the 30-degree die rod is more and the finish of the rod of 60 degree is showing the cracks on the surface. The Load /Displacement graphs for the tube extrusion with the three Die (30, 45, 60) and with three speeds (1, 2, 3 mm/min) is shown in Fig. 2.30 to Fig. 2.38. In these graphs the three series are shown which shows the three reading for one set of die and speed.of the rod & tube is done and the graph between the load & displacement is plotted for the rod & tube as shown in Fig.2.39 & Fig. 2.40. The Extruded Tube (shown in Fig.2.9) and the tubes extruded by the three different speeds as shown in Fig. 2.10. The section view of the tube is shown in Fig.2.11.In the case of tube also the same pattern of the load and the die i.e. the load increases as the speed increases and the load decreases as the die angle increases. The comparative table is prepared for the Rod, Tube and the simulated results as shown in Table.2.4. By this the percentage error for the rod extrusion experiment and the **FEsimulation**

The FE simulation rod simulation is 6.13 %. The percent error of the tube experiment and the tube simulation is 4.35 %.

Table.2.1: Average load on Redplasticine

Die angle (degree)	Load (N)		
	V = 1 mm/min	V = 2 mm/min	V = 3mm/min
30	567.88	568.73	572.48
45	505.74	519.87	530.83
60	443.66	449.66	465.7

Table.2.2: Average load on Greenplasticine

Die angle (degree)	Load (N)		
	V = 1 mm/min	V = 2 mm/min	V = 3mm/min
30	650	683.84	697.68
45	567.19	574.11	577.74

60	**449.83**	**461.09**	**489.25**

Table.2.3: Average load on Yellow tube plasticine

DieAngle (Degree)	**Load (N)**		
	V =1mm/min	**V =2mm/min**	**V =3mm/min**
30	**701.55**	**709.24**	**752.93**
45	**672.80**	**701.25**	**751.56**
60	**626.12**	**604.00**	**673.45**

Table 2.4: Comparison of Experimental & Simulation results

Type of Test	**Experimental Load (N)**	**Simulation Load (N)**	**% Error**
Rod	**653.72**	**613.60**	**6.13**
Tube	**745.35**	**712.90**	**4.35**

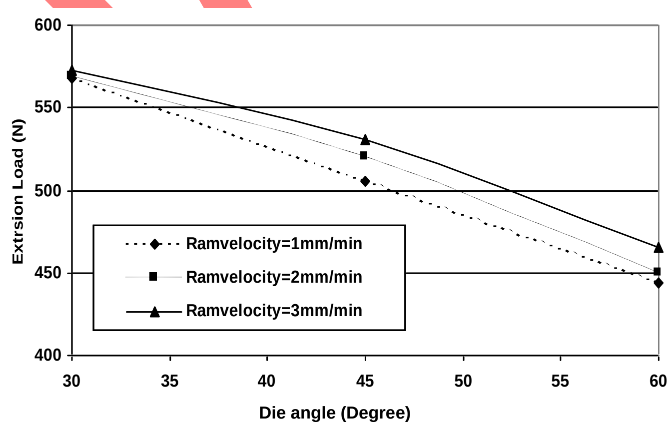

Fig.2.1: Graph between extrusion load and die

Fig.2.2 Extruded rod of red plasticine from 60 degree dies

Fig.2.2 Extruded rod of green plasticine from 60 degree dies

Fig.2.3 : Extruded rod of Red plasticine from 30, 45 and 60 degree dies

Fig. 2.4: Extruded rod of Green plasticine from 30, 45 and 60 degree dies

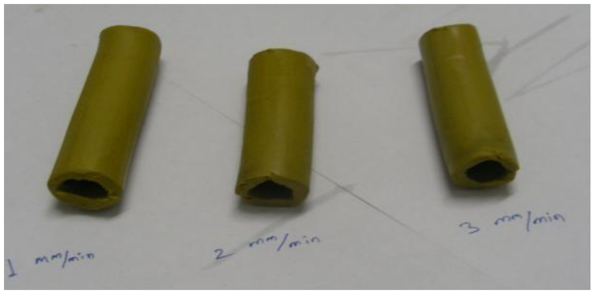

Fig. 2.5: Picture of Tubes with speed 1, 2 & 3 mm/min

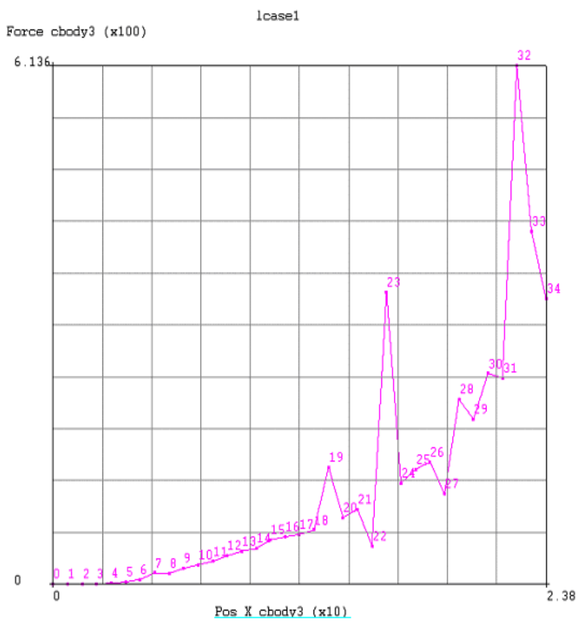

Fig. 2.6: SimulatedGraphbetween Load/ Displacementforrod

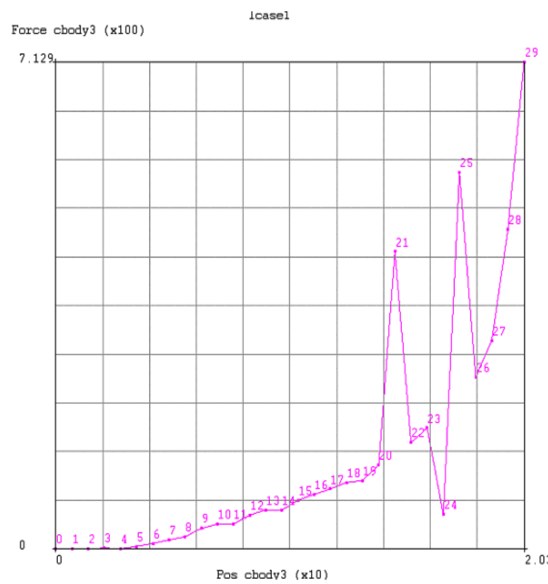

Fig. 2.7: Simulated Graph between Load/ Displacement fortube

CONCLUSION

In this dissertation experimental investigation of rod and tube extrusion using plasticine are attempted. Effects of die angle speed of extrusion and types of plasticines are studied in terms of extrusion loads. FE simulation of the extrusion process is also carried out to assess stress, strain and load requirements. Following are the salient findings of this study:

1. Extrusion load decreases with increase in die angle irrespective of ram velocity and materialgeometry.

2. Similarity between plasticine & RT that with metal at hightemperature.

3. Extrusion load increases with increase in ram velocity irrespective of die angle andmaterial.
4. Material effect on extrusion load with respect velocityobserved.

5. Maximum increase in extrusion load for Red plasticine is 572.8 N for 30-degree die at 3 mm/min (table 5.1) and for Green plasticine 697.68 N for 30 degree dies at 3 mm/min (table5.2).

6. Maximum decrease in extrusion load for Red plasticine cased the three dies is 443.66 N for 1 mm/min ramvelocity.SimilarlymaximumdecreaseinextrusionloadforGreenplasticinecasedthethreediesis 449.83 N for 1 mm/min ram velocity.

7. Surface finish is excellent in 30-degree die and poor in 60-degree die cases; visible cracks can be observed by necked eyes(Fig.5.4).
8. Simulation study reveals a good match between experimental and numerical load stroke curves. It shows that simulation can be effectively used for the analysis of extrusionprocess.

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