"EFFECTS OF DIE LANDING ON EXTRUSION USING EXPERIMENTAL & NUMERICAL TECHNIQUES"

Keerti Sharma[1], Ashish Saxena[2], Dr.Pushpendra Kumar Sharma[3], Dr.K.K.Pathak[4]
[1] M.Tech Research Scholar in LNCT, Bhopal
[2] M.Tech Research Scholar in NRI-IST, Bhopal
[3]Professor & HOD (NRI-IST, Bhopal)
[4]Sr.Scientist (CSIR, AMPRI),
Author Email-keertisharma06@yahoo.com,ashishsaxena_1234@yahoo.com

ABSTRACT

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. 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 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 landing on rod extrusion processes using experiment. The extrusion experiments are carried out by using three dies of different die landing and at the three different speeds. A blue color plasticine is used. The experimentation results show that as the die land height increases the load also increases the designed die was further adopted for computer simulation using MSC. Super forge software (based on FV Method) to asses stress, strain and strain rate distributions and load requirements. Using these results, effects of 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.

Key words: *Extrusion Dies, Blue Plasticine, Die landing 5mm, 10mm, 15mm.Finite Volume Method, Aluminum.*

1.1 Introduction

Manufacturing involves turning raw material to finished product to be used for various purposes. In the present age there have been increasing demands on the product performance by way of desirable exotic properties such as resistance to high temperature, higher operating speeds and extra loads. These in turn would require a variety of new materials and its associated processing. Also, exacting working conditions that are desired in modern industrial operations make large demands on manufacturing industries. A detailed understanding of the manufacturing process is thus essential for every engineer. This helps him appreciate the capabilities, advantage and also the limitation of the process. This in turn helps in the proper design of any product required from him. Firstly he would be able to assess the feasibility of manufacturing from his designs. He may also find that there is more than one process available for manufacturing a particular product and he can make a proper choice of the process which would require the lowest manufacturing cost and would deliver the product of desired quality. He may also modify his design slightly to suit the particular manufacturing process he chooses.

1.2 Extrusion Principle

Extrusion is the process of confining the metal in a closed cavity and then allowing it to flow from only one opening so that the metal will take the shape of the opening. The equipment consists of a cylinder or container into which the heated 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. The extruded metal is then carried by the metal handling system as it comes out of the die. A dummy block which is a steel disc of about 40 mm (0.05 to0.75 of diameter) thick with a diameter slightly less than the container is kept between the hot billet and the ram to protect it from the heat and pressure.

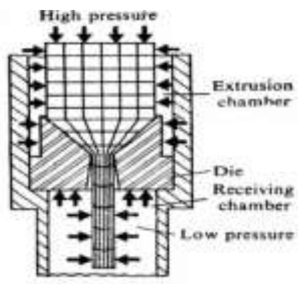


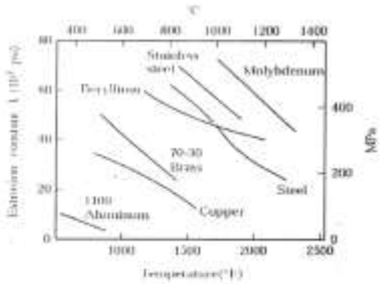
Fig 1.1Principle of Extrusion

1.3 Extrusion Force

The force required for extrusion depends on the strength of the billet material, the extrusion ratio, friction between the billet and the chamber and die surfaces, and process variables such as the temperature of the billet and the speed of extrusion. We can estimate the *extrusion force, F,* from the formula eq.1.1.

$$F = A_0 \, k \ln (A_0/A_f) \qquad \text{……….. (1.1)}$$

Where k is the extrusion constant, and A_0 and A_f are the billet & extruded product areas, respectively. The k values for several metals are given in Fig 1.18 for a range of temperatures

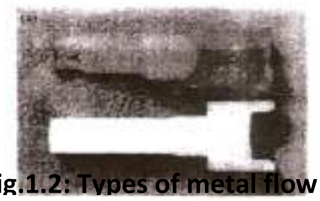


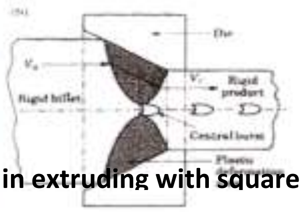
1.4 Metal Flow in Extrusion

The metal flow pattern in extrusion, as in other forming processes, is important because of its influence on the quality and the mechanical properties of the final product. The material flows longitudinally, much like incompressible fluid flow in a channel; thus extruded products have an elongated grain structure (preferred orientation).

A common technique for investigating the flow pattern is to section the round billet in half lengthwise and then mark one face with a square grid pattern. The two halves are placed in the chamber together and extruded. The products are then taken apart and studied shows typical flow patterns obtained by this technique in direct extrusion with square dies (90° die angle).

The conditions under which these different flow patterns occur are described in the figure caption. Note the dead-metal zones in Fig. 1.19 b and c. where the metal at the corners is essentially stationary. This situation is similar to stagnation of fluid flow in channels that have sharp turns.





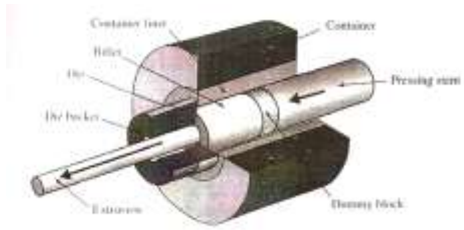


Fig.1.2: Types of metal flow in extruding with square dies, (a)

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1. Experimental studies on rod extrusion considering various die landing using plasticines.
2. Numerical validation of extrusion experiment results using FV simulation.

1.6 Experimental Setup

For the experiment the computer controlled testing machine having load cell capacity of 100 kg as shown in Fig 3.1. 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.

Fig. 1.3: Computer controlled Testing machine with the extrusion process fixtures

1.7 Die Fabrication

Three dies of landing 5mm, 10mm and 15mm are manufactured on lathe machine. 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, (Blue). The extrusion experiment setup consist of a cylindrical container of external diameter 50 mm and internal diameter 40 mm made of steel alloy using machining process which produces an excellent surface finish to produce smooth extruded surfaces. Three dies of same die angles i.e., 45 degrees is made through different manufacturing process for the better results. The dies were made from Aluminum material. The front view of the three dies (5mm, 10mm, and 15mm) respectively is shown in Fig 1.4. The top of the three dies is shown in. The top and the front view of the die & container.

Fig. 1.4: Front view of 5mm, 10mm and 15mm dies

1.8 Preparation for Blue 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.

1.9 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 1.5.

In this the rods of Blue plasticine material was extruded. It was extruded by three different dies of same angles as shown in Fig 1.4 . The three different speeds were taken as 5, 10 and 15 mm/min. The Extrusion ratio is kept constant. The colors is Blue. Different cases were experimented by the combination of die landing 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 landing on the material at different speeds with Blue colors is studied.

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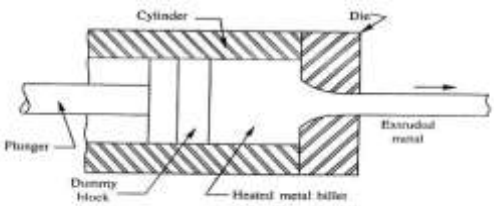

Fig. 1.5: Rod Extrusion Setup

Fig. 1.6: Rod extrusion arrangement

2.0 Material Data & Process Data

The material data was taken from the material database of MSC.SuperForge, as Specified in Table 1.1. To conduct the simulation.

Table 1.1: Material specification for Die & Process data (Die material)

Die material	DBH-13
Work piece	AISI 1080
Young modulus	$21x10^{10}$ pa
Poisson ratio	0.3
Density	$7800kg/m^3$
Mini yield stress	$40x10^5$ pa

Die Temperature	20^0
Young modulus	$724x10^8$ pa
Density	2780 kg/m3
Mini yield stress	$188x10^5$ pa
Poison ratio	0.33
Yield constants(c)	386796000pa
Strain hard.exp (N)	0.154
Velocity	1mm/sec
Coulomb friction static coefficient	0.1
Work piece element size	0.6mm
Die element size	0 mm

2.1 Result & Discussion

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

2.2 Experiment of Rod Extrusion

The extrusion process is done by using three dies of different die landing and at the three different speeds. The Load /Displacement graphs for the rod extrusion with the three Die landing (5, 10, 15 mm) and with three speeds (5, 10,15mm/min) . In these graphs the two series are shown which are the two readings for one set of die and speed. The average load Vs speeds for the three die landing are given in Table 1.2. The results show that as the die land height increases the load increases. Show graph between Load and speed. The effect of the velocity is seen that as the velocity increases the load increases and at low speed the load is also low . The variation of load and speed are summarized . The extruded rods of blue plasticine for different landings . It can be observed that, surface finish of the extruded rod is dependent on die landing. The surface finish of the rod extruded using 15 mm die landing is better than of rod extruded using die landings of 10 and 5 mm which show the hair line cracks on the surface.

Table 1.2: Average Load Vs Die landing

Load/ Die landing (mm)	Average Load(N)		
	V=5 mm/min	V=10 mm/min	V=15 mm/min
5	117.6	140.63	142.15
10	136.075	152.93	159.985
15	142.575	161.93	164.485

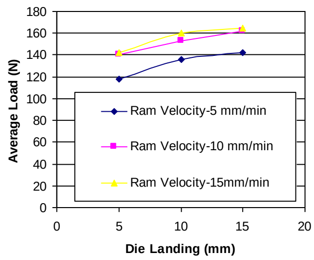

Fig.1.7: Graph between extrusion load and die landing

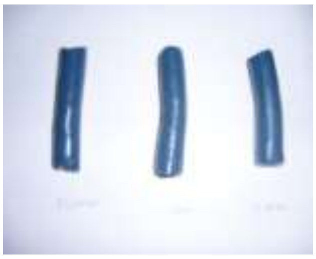

Fig.1.8: Extruded rod by extrusion process

2.3 Computer simulation

The FV simulation of the rod extrusion is done and the graph between the *load & time* are plotted. It can be observed that load increases as the speed increases. Extruded rod 5mm, 10mm and 15mm landing simulation diagram & Graph .for 5mm landing the effective plastic strain, effective stress and Graph between load and time .For 10mm landing the effective plastic strain. effective stress and Graph between load and time for 15mm landing the effective plastic strain, effective stress and Graph between load and time .The load time plots for the landing . It can be observed the load increases with increases in landing which was also observed in case of experiment with plasticine. The comparative table is prepared for the Rod, the simulated results It is also significant to observe that load difference between 5mm landing and 10mm landing is quite high but between 10mm and 15mm it is very close.This is also observed in case of experiment. Hence experimentation with plasticine can be helpful in studying the die effect on real material

Table 1.3 Comparative Extrusion load (5mm, 10mm and 15mm landing)

Die landing (mm)	Simulation Load (N)	Experiment Load (N)
5	3.720×10^3	142.15
10	4.766×10^3	159.985
15	4.836×10^3	164.485

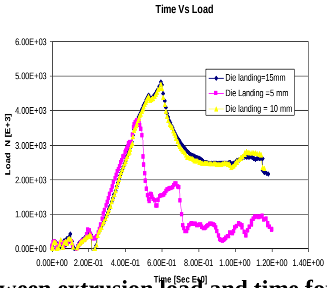

Fig. 1.9: Graph between extrusion load and time for blue plasticine

2.4 Conclusion

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

3 Extrusion load increases with increase in die landing irrespective of ram velocity and material geometry.

4 Extrusion load increases with increase in ram velocity irrespective of die landing and material.

5 Material effect on extrusion load with respect to velocity is observed.

6 Maximum increase in extrusion load for blue plasticine is 15mm die at 15 mm/min

7 Maximum decrease in extrusion load for blue plasticine is 5mm die at 5 mm/min ram velocity.

8 Surface finish is excellent in 15mm die landing and poor in 5mm die landing cases; visible hair line cracks can be observed by necked eyes

9 It is also significant to observe that load difference between 5mm landing and 10mm landing is quite high but between 10mm and 15mm it is very close.

10 Simulation study reveals a good match between experimental and numerical load Graph. It shows that simulation can be effectively used for the analysis of extrusion process.

11 This is also observed in case of experiment. Hence experimentation with plasticine can be helpful in studying the die effect on real material.

11.2 Scope of Future work

1. This study is related to extrusion simulation using plasticine. The same may be extended to real material like Aluminum, Lead etc.
2. In this study extrusion, is carried out at room temperature. The same may be attempted at warm or hot conditions.
3. Plasticine extrusion is attempted for symmetric sections, the same may be attempted for non symmetric sections, like I – section etc.

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