THE EFFECTS OF DIE PARAMETERS AND OPERATING CONDITIONS ON THE FLOW OF EXTRUDED LEAD

By:

S. G. Ahmed and Senad O. Elmahadi

ABSTRACT

This paper reviews the work carried out in the design of extrusion dies. It investigates the effects of temperature, die entrance angle and type of lubricant used on the flow of extruded lead. These parameters are to be used in order to optimize the design of extrusion dies.

الملخص:

يتناول هذا البحث العوامل التي تؤثر في تصميم قوالب البثق والتعقيدات التقنية التي تتحكم في أدائها. يركز البحث على عوامل التشغيل مثل درجة الحرارة وزاوية مدخل القالب ونوع زيت التزليق للحصول على أفضل تصميم للقالب يوفر الطاقة المستهلكة مع الحصول على منتج عالي الجودة. تقدم ورقة البحث نتائج التجارب المعملية التي تم اجراؤها مع التوصيات التي يوصي الباحث باتباعها للحصول على تصميم مناسب مع ظروف التشغيل المتاحة.

INTRODUCTION

General Concept of Die Design: An extrusion die is a shaped orifice made in a block of steel or other suitable material that is worn and corrosion resistant. The function of the die is to receive the melt stream emerging from the extruder screw and to reshape it to the required form. In some instances, this is the final shaping operation, and in others, post-die shaping equipment completes the shape to the required form[1].

Designing dies requires an accurate knowledge of flow characteristics of the particular material to be processed. The designer must determine the precise shape of the flow channel(s) in the die, and the exact shape of the exit orifice. Unfortunately, the amount of data available to a designer is quite limited. In fact, much of it is still considered proprietary information by die-makers or by extruder operators[2, 3, 4].

Most of the work carried out in the area of die design for metal extrusion is concerned with streamlined dies.

Nagpal and Altan[5] developed a technique for the design of dies for lubricated extrusion of non-circular aluminium shapes. Their approach is such that the geometry of the die should be optimised to:

i- Give a defect free extrusion with minimum post extrusion treatment (twist and straightening).

ii- Require minimum load and energy.

iii-Maximum output at minimum cost.

The procedure, which they followed to achieve these objectives, is as follows:

1- Define the die geometry
2- Calculate extrusion loads as a function of the die geometry.
3- Optimize and determine the die (entry) shape.

To minimize extrusion pressure they fitted smooth polynomial curves between the boundary of the (circular) die entrance and the die orifice. They noted that the pressure is not sensitive to the shape of the polynomial. In effect this leads to streamlined die entry. To define the surface of a "streamlined" die, the circular die entrance is divided into a number of sectors, and the final (exit) cross-section is divided into the same number of segments. This is done while keeping the extrusion ratio (*area of sector in the die entrance/area of corresponding segment in the die orifice*) equal to the over all ratio.

To compare the metal flow predicted theoretically with the actual metal flow, they conducted an experiment in which they partially extruded a copper billet with longitudinal and circumferential lines already marked on its surface. The deformed shape of the marked lines represents the path followed by the material points during steady state extrusion. They found that the theoretical flow lines are quite close to the actual flow lines near the plane of symmetry. However, away from the plane of symmetry, the difference is quite appreci-able. Also the deviation increases towards the die exit, which they anticipated to be due to the effect of friction, which they assumed to be negligible. They also noted that this method couldn't be applied to re-entrant shapes.

Objectives of This Work:

In this work, three design parameters were considered, namely:

1- Temperature of extruded lead
2- Die entrance angle
3- Types of lubricants.

The effect of these parameters are assumed to affect the flow of the extrudate and hence the performance of the die.

Effect of Temperature: A hydraulic press was used to extrude the lead at different

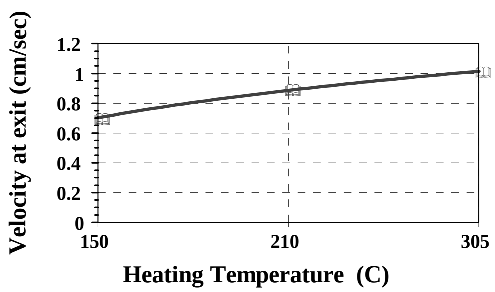

Figure (1) Effect of temperature on extrusion velocity

temperatures ranging between 150^0 C and 305^0 C. The pressure inside the hydraulic press was kept constant at 250 bars.

At a temperature below 150^0C, no extrusion was obtained because the force needed was above the capacity of the hydraulic press. At temperatures above 305^0 C the lead starts to melt, melting temperature of lead is about 327^0 C.

(Fig. 1) shows the effect of temperature variation on the flow of extruded lead. As expected the flow increased as the lead temperature increases, this is because the yield strength decreases with the increase of temperature. Moreover the plastic force needed to deform the lead decreases above the crystallization temperature, which is for lead about 200^0 C.

Effect of Die Entrance Angle: The extrusion was carried out at room temperature. Four dies with different entrance angles were used. The result of the extrusion is shown in (fig. 2). From the graph the following observations can be concluded:

1- The velocity of extrusion rapidly increases with the increase of die angle until it reaches a maximum value at 80^o and then drops sharply to almost zero at 110^o. This is because of the excessive distortion, which occurs at large angles.

2- At small angles the velocity is very low because of the wedge.
3- Effect and hence excessive friction.
4- Distortion of extrudate was observed at extreme, small and large, dies angles. Banana shape and piping defects were common.

Effect of Lubricant on Extrusion Velocity: Four types of lubricants were used, namely: SAE 32, SAE 50, graphite and soap. The behaviour of the extrudate is shown in (fig. 3).

Observations:

1- With lubricant SAE 50, the extrusion speed was low and no defects were observed.
2- When lubricant SAE 32 was used, the piping effect was noticed.
3- The behaviour of graphite was different from the above mentioned lubricants. The speed of the extrudate varies with time. This is related to the discontinuity of graphite as lubricant.
4- The effect of soap was to some extent similar to that of SAE 50 bu the speed was very low.

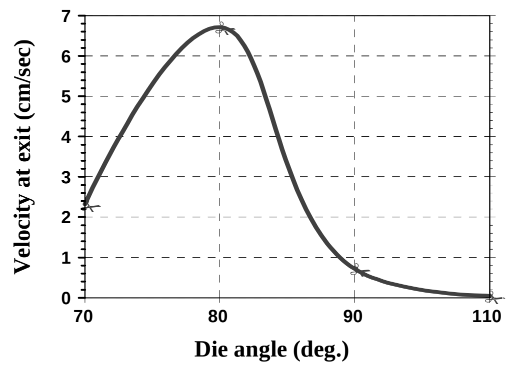

Fig. (2): Effect of Die Angle on the Exit Velocity

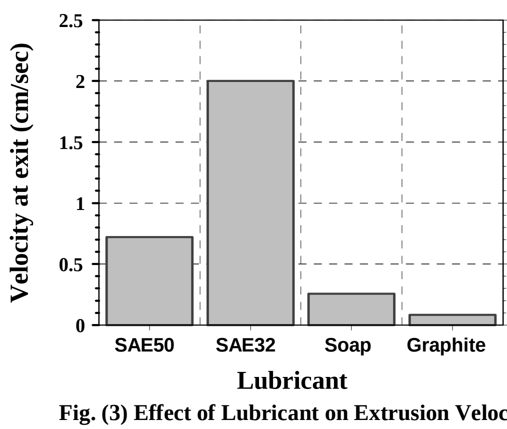

Fig. (3) Effect of Lubricant on Extrusion Velocity

CONCLUSION

To optimize extrusion of lead the following points should be taken into consideration:

1. A die entrance angle of 80^{O} is recommended
2. The lead should be heated to 300^{0} C

3. SAE 50 is the most suitable lubricant for defect free extrusion.

REFERENCES

1- **Michaeli, W.** (1991), Extrusion Dies Design and Engineering computations, second edition, Hanser Publisher, Munich.

2- **Michaeli, W.** (1991), Extrusion Dies Design and Engineering computations, second edition, Hanser Publisher, Munich.

3- **Dubois, J. H., and Pribble, W. I.** (1987) Plastics Mold Engineering Handbook, Fourth edition, Van Nostrand Reinhold, New York.

4- **Huneault, M. A., Lafleur, P. G. and Carreau, P. J.** (1990). Extrudate Swell and Drawdown Effects on Extruded Profile Dimension and Shape. Polymer Engineering and Science, **Vol. 30:** 23, PP 1544 -1550.

5- **Nagpal, V. and Altan, T.** (1976), Computer Aided Design and Manufacturing of Dies for Lubricated Extrusion of Shapes. Journal of Mechanical Working Technology. **Vol. 1**, PP 183 - 201.

6- **Sun, D. W., and Peng, Y. C.** (1991), A Practical Method to Design Hollow Profile Dies. Plastics, Rubber and Composites Processing and Applications**, Vol. 16:** 2, PP 109-114.