Review on "Different Die Profile for Extrusion Process"

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***Abstract*- In the extrusion process, the geometry of the die constitutes an important aspect of die design. Two prominent methods of converting raw material into a product have been metal forming and machining. Metal forming involves changing the shape of the material by permanent plastic deformation. After converting non-porous metal into product form by metal forming processes, the mass as well as the volume remains unchanged.**

In the present review paper a brief review about different die shapes i.e. Third-order polynomial die, Cosine die and Conical die. It is concluded on the basis of previous research the Cosine die is best among all the die considered for the study i.e. Cosine Die, Third-order polynomial Die and conical die.

***Index Terms*- Extrusion, die design, die shapes, Cosine Die, Third-order polynomial Die and conical die.**

INTRODUCTION

1.1General

However, in the case of metal forming of porous metal, volume does not remain unchanged. The advantages of metal forming processes include no wastage of the raw material, better mechanical properties of the product and faster production rate.

Metal forming is the process of plastically deforming the raw material into product form. It is broadly classified into two classes—bulk metal forming and sheet metal forming. In the bulk metal forming processes, usually the work-piece has a high volume to surface area ratio. Examples of such processes are rolling, wiredrawing, extrusion, forging *etc*. In the sheet metal forming processes, usually the work-piece sheet has a low volume to surface area ratio. The sheets usually have a thickness less than 6 mm. In sheet metal working, the change in thickness during plastic deformation is not desirable. Examples of sheet metal forming processes are deep drawing, stretch forming, bending, spinning *etc*. Figure 1.1 shows the most important metal forming processes.

1.2 Extrusion

In extrusion processes, the metal – in the form of a cast billet – is shaped by pressing it through a die orifice of appropriate shape. When this is done, the metal flows out of the orifice in a continuous manner and appears as a long profile, with cross-sectional shape approximately the same as that of the die orifice. In extrusion the metal must first be placed inside the container, where it is pressurized. As depicted in Figure 1.2, this is done by placing a die at one end of the container, and a punchor a ram at the other end of it.

Hence, for copper and brasses, there are strong limitations as regards the complexity of the shape of the profiles that can be extruded with sound process economy. For steels, the conditions in extrusion are even worse; extrusion temperatures of 1000–1200◦C are required. Continuous extrusion processes applied for steel, on the same principles as for aluminum, copper, and brass, are therefore rare. Conditions are so severe that it is difficult to find die materials that will survive for a sufficiently long time. For steel materials, however, a lubricated hot-extrusion technique based on use of *glass lubrication*, which melts down ahead of the die, has been developed. With this technology, it is possible to extrude small sections with low shape complexity. Continuous hot extrusion of steel is, however, highly specialized and isnot so commonly used.

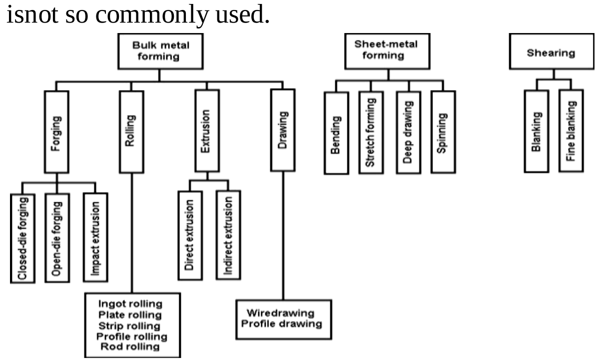

Figure 1.1 the most important metal forming processes

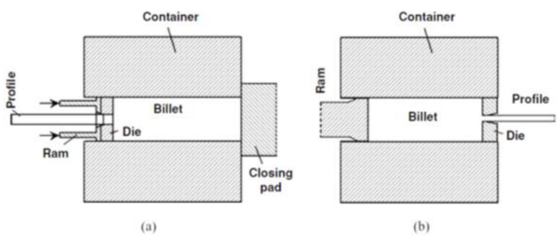

Figure 1.2 Two main extrusion methods: (a) forward extrusion and (b) backward extrusion

II-Literature Review

1.J. Xu, T. Yang, B. Jiang, J. Song, J. He, Q. Wang, Y. Chai, G. Huang, F. "Pan, Improved mechanical properties of Mg-3Al-1Zn alloy sheets by optimizing the extrusion die angles: Microstructural and texture evolution", Journal of Alloys and Compounds (2018), doi: 10.1016/j.jallcom.2018.05.083.

Mg-3Al-1Zn (AZ31) alloy sheets fabricated using extrusion dies with angles of 30°, 45°, 60° and 90° were investigated. Finite element method was used to analyze the effective strain distribution in AZ31 Mg alloy during extrusion by *Jun Xu et al; 2018*. The microstructure, texture and final mechanical properties were determined and compared among various extruded AZ31 sheets. Results demonstrated that the difference of effective strain was introduced during extrusion due to the variation indie angles. In the case of the 45° extrusion die, a large difference in effective strain along normal direction could form during sheet forming, which resulted in a uniform micro structure and weak basal texture of extruded AZ31 sheet. Therefore, the sheet processed using 45° extrusion die showed lower yield strength and *r*-value, but higher ductility and *n*-value. This study suggested that optimization of extrusion die angle could be an effective method to improve the mechanical properties of AZ31 Mg alloy.

2.A. García-Domínguez, J. Claver, A.M. Camacho, M.A. Sebastián; 2015, "Comparative Analysis of Extrusion Processes by Finite Element Analysis", Procedia Engineering 100 (2015) 74 – 83

A. García-Domínguez et al; 2015 presented a comparative study of extrusion processes (solid and cup extrusion), considering both direct and indirect forming conditions and showing the most interesting differences between them. The comparison is realized by Finite Element simulation of the processes, using the code DEFORM F2. The material is alow carbon steel (AISI-1010) and the same extrusion ratio and ram displacement are considered in all cases. By comparing therequired forces it can be concluded that required loads are higher in cup extrusion processes than in solid extrusion ones.Regarding the friction load, the maximum contribution due to the die-billet contact in cup extrusion is much higher than in thecase of solid extrusion. On the contrary, the maximum friction load contribution due to the container wall is much higher in thecase of solid extrusion than in cup extrusion.

3.Ding Tang, Wenli Fang, Xiaohui Fan, Dayong Li, YinghongPeng; 2014, "Effect of die design in micro-channel tube extrusion", 11th International Conference on Technology of Plasticity, ICTP 2014, 19-24 October 2014, Nagoya Congress Center, Nagoya, Japan

Micro-channel tube (also called Multi-port extrusion tube) with sub-millimeter-diameter ports in the cross-section is a newly developed type of aluminum extrusion with the basis for its design in micro-scale heat transfer theory. Comparing to traditional heat exchanger tube with channel diameter more than 2 mm, micro-channel tube has great advantage on high heat transfer efficient, light weight, high pressure bearing capacity. The main difficulty on the tube fabrication is the extrusion porthole die design. In the work carried out by *Ding Tang et al 2014*, design of the extrusion die of the microchannel tube is studied with both numerical method and experiments. Seam welding strength and microstructures of the tube formed with different designs of die are investigated. Forming experiment and hydrostatic pressure tests to the tubes formed is done for validation. And microstructure of the tube is observed using electron backscatter diffraction (EBSD) method.

4.O.P. Gbenebor, O.S.I. Fayomi, A.P.I. Popoola, A.O. Inegbenebor, F. Oyawale; 2013, "Extrusion die geometry effects on the energy absorbing properties and deformation response of 6063-type Al–Mg–Si aluminum alloy", Results in Physics 3 (2013) 1–6

The response of 6063-type Al–Mg–Si alloy to deformation via extrusion was studied using tool steel dies with 15, 30, 45, 60and 75 degree entry angles. Compressive loads were subjected to each sample using the AVERY DENISON machine, adapted to supply a compressive load on the punch. The ability of the extrudateto absorb energy before fracture was calculated by integrating numerically the polynomial relationshipbetween the compressive stress and sample strains

5.N.D. Gonçalves, O.S. Carneiro, J.M. Nóbrega; 2013, "Design of complex profile extrusion dies through numerical modeling", Journal of Non-Newtonian Fluid Mechanics 200 (2013) 103–110

The achievement of a balanced flow is one of the major tasks encompassed in the design of profile extrusion dies. For this purpose numerical modeling codes may be a very useful aid. The research teaminvolved in the work carried out by *N.D. Gonçalves et al 2013* has been working during the last decade on the development of numerical toolsto aid the conception of extrusion dies. The design code developed so far carries out the automaticsearch of a final geometry via an optimization routine coupled with geometry and mesh generators and a3D computational fluid dynamics (CFD) code based on the finite volume method (FVM). This CFD code isable to model the flow of polymer melts in confined channels, but is inadequate to deal with complexgeometries, since it is limited to structured meshes. This work describes the recent efforts made toenlarge the scope of the design procedures that are currently focused on the development of a modelingcode able to deal with unstructured meshes. This code solves the continuity and linear momentum conservationequations, with generalized Newtonian fluids, using a SIMPLE based approach. This paperdescribes the developed numerical modelling code and its employment in a case study that involvesthe design of a medical catheter extrusion die, focused on the search of a balanced flow distribution.The results obtained show that the developed numerical code is able to deal with complex geometricalproblems, being thus a valuable tool to aid the design of extrusion dies to produce complex profiles.

6. L. Pauli, M. Behr, S. Elgeti; 2013, "Towards shape optimization of profile extrusion dies with respect to homogeneous die swell", Journal of Non-Newtonian Fluid Mechanics (2013)

Plastics extrusion is a manufacturing process suited for continuous profiles with a fixed cross-section. Thefunction of the extrusion die is to reshape the melt, which originally has a circular cross-section, to thedesired profile shape. When constructing new extrusion dies, the key challenge is to design the transitionregion between outflow and inflow of the die. While in general the design of the transition region is arbitrary,there are influences on the shape accuracy of the product which need to be considered during diedesign. One of those influence factors is die swell. *L. Pauli et al; 2013*present's first steps towards numerical diedesign with the objective of homogeneous die swell. It introduces a shape-optimization framework andan appropriate objective function. Since the accurate computation of die swell is still a topic of ongoingresearch, the applicability of the Galerkin/Least-Squares stabilization method in a space–time finite elementsetting and in conjunction with the Oldroyd-B and the Giesekus model is discussed. Furthermore,for three space dimensions, we suggest an interface tracking approach combined with a smoothing basedon non-uniform rational B-splines for the definition of the free-surface shape

7. S. Elgeti ,M.Probst, C.Windeck, M.Behr, W.Michaeli, Ch.Hopmann; 2012 "Numerical shape optimization as an approach to extrusion die design", Finite Elements in Analysis and Design 61 (2012) 35–43

Profile extrusion is a manufacturing process used for continuous plastic profiles with a fixed cross section. The key challenge in the development of profile extrusion dies is to design the transition region between outflow and inflow of the die in such a way that the material velocity at the outflow is homogeneous. At the current state of the art, die design is experience based and time-consuming running-in experiments need to be performed for each new die. The aim of the work carried out by *S. Elgeti et al; 2012* is to develop a new design approach based on numerical shape optimization with the idea of significantly reducing the number of running-in experiments. Based on an existing, in-house flow solver, a shape optimization framework has been established. It contains a geometry kernel, which operates on non-uniform rational B-splines. The framework has been applied to two profile extrusion dies for profiles with rising complexity: a slit profile and a floor skirting. Apart from validating the functionality of the framework, the aim of the test cases was to investigate the influence of the use of the Carreau model on the optimization outcome. From flow simulations, it can be observed that the use of the Carreau model has a definite influence on the resulting flow solution in extrusion die scenarios.

However, it is not clear whether this influence extends to the location of the optimal solution.

CONCLUSION

On the basis of previous study it has been observed that at the particular value of die pressure the conical die punch has less displacement as compare to other. The maximum principal strain is higher for Cosine die and it is minimum for conical die at each die pressure.Extrusion processes are quite extended in the manufacturing of long products for a wide range of industrial applications.There are different approaches of extrusion processes, depending on either the final shape of the product to obtain or themaximum loading capacity of the equipment to be used.

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