A STUDY OF DRAWING AND EXTRUSION PROCESSES

BY

RAJNISH PRAKASH

Mechanical Engineering Department

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C E R T I F I C A T E

This is to certify that the Thesis entitled,"A Study of Drawing and Extrusion Processes" being submitted by Shri Rajnish Prakash to the Indian Institute of Technology, Delhi for the award of the Degree of Doctor of Philosophy in Mechanical Engineering, is a record of bonafide research work carried out by him. He has worked under my guidance and supervision and has fulfilled the requirements for the submission of this Thesis, which has reached the requisite standard.

The results contained in this Thesis have not been submitted in part or in full, to any other University or Institute for the award of any degree or diploma.

(B.L.Juneja)
Professor,
Mechanical Engineering Department,
Indian Institute of Technology,Delhi

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R. Prakash

(Rajnish Prakash)

ABSTRACT

Drawing and extrusion processes have assumed importance among the modern industrial manufacturing processes. Both circular and non-circular sections are drawn and extruded on commercial scale. However, due to the complexities of metal behaviour and the friction over the tool material interfaces, only approximate analyses of drawing and extrusion processes have been possible. Even these solutions have been limited to round sections, and no general solution to processes involving flow through a die exists. In the present study an upper bound analysis has been constructed for polygonal sections. Also, a general upper bound solution is given for axi-symmetric contained flow processes. A constant frictional shear stress is assumed to be acting over the tool-material interface and the metal is assumed to be isotropic, rigid perfectly plastic obeying von Mises' yield criterion. The thesis gives the theoretical and experimental studies carried out by the author to aid the understanding of the influence of various parameters on the process variables in drawing and extrusion. The contents of the various chapters are as follows.

Chapter 1 deals with general mathematical formulation of metal behaviour and interfacial friction during drawing and extrusion processes with suitable assumptions.

Chapter 2 gives the analysis of flow of metal through converging polygonal dies. The original and final sections are taken to be similar. The solution gives optimum die angle,

dead zone and critical angles. The deformed grid patterns as may emerge on the final product surface and the central section are predicted. The analysis is extended to any polygonal section which has an inscribed circle. The analysis directly applies to wire and rod drawing. The drawing through a conical die is shown to be a special case of the above analysis.

In Chapter 3 the analysis of flow through a converging polygonal die is employed to analyse direct, indirect and piercing extrusion of regular polygonal or such irregular polygonal shapes, which have an inscribed circle. Numerical solutions are given for different conditions of the processes.

Chapter 4 gives the analysis of metal flow through an axi-symmetric curved die and mandrel. The solution is general and covers processes of tube drawing and extrusion with stationary or moving mandrel, fixed conical or curved plug. When the mandrel radius is taken as zero, the solution reduces to that of rod or wire drawing or extrusion. Some of the solutions obtained by various authors have been shown as special cases of this general solution.

In Chapter 5, the general solution obtained in Chapter 4 has been extended to layered piecewise homogeneous metal tubes (composite material tubes). The analysis is applied to analyse composite rod drawing and conditions leading to proportional or cladding type deformation are given.

It is assumed generally, that the effect of friction on the change in tube-wall thickness after sinking through a conical die is of thinning. However, no experimental evidence is known to justify this assumption. Similarly it is generally accepted that the change in wall thickness after sinking through a conical die is gradual as reduction in outside diameter increases from zero. In Chapter 6 the experiment conducted to study the effects of friction and small reductions on the change in wall thickness is described. Based on the observations of the experiment, it is concluded that the effect of friction on the change in wall thickness is that of thickening it rather than thinning. Also for small reductions the wall thickness is found to undergo a sudden thinning. For further increase in reduction of outside diameter, the wall-thickness recovers and finally the change becomes gradual. The solution for composite rod drawing through conical die of Chapter 5 is used to give the wall thickness change after sinking through conical die, by the use of minimum energy approach [89]. The solution predicts the correct trends as observed experimentally. The earlier theories do not predict correctly, the effects of friction and small reductions over change in wall thickness during sinking through a conical die.

The thesis is concluded with scope for future work and the references consulted for the above work have been given.

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