Modelling of metal extrusion using ABAQUS

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Abstract: The mechanical properties of processed metal depend greatly on the micro-structural changes during the extrusion process. A clear theoretical concept of the thermodynamics and tribology of the metal extrusion process with respect to the major process parameters, namely temperature and strain rates are necessary to decide the optimum values of machine settings. This paper discusses the essential theoretical understanding of the process of metal extrusion, including the effects of die geometry, flow pattern and other variables with the help of the finite element program ABAQUS.

Keywords: ABAQUS; Extrusion; Modelling and Simulation

1 Introduction

In extrusion, heat is generated by both the frictional work and deformation work. This heat is transported with the extruded material and conduction takes place simultaneously. Some of the generated heat remains in the extruded material, some is transmitted to the container and die and some increases the temperature of the part of the billet that is not yet extruded. It is a thermo-mechanical process and it involves interaction between the process parameters, tooling and deformed material. The whole process is composed with two distinctly different stages, namely the transient state at the beginning and steady state in the rest of the cycle. Further the wear process on the die bearing is dependent on the thermodynamics of extrusion which is very much influenced by the effects of extrusion variables. The tribology in metal extrusion has direct influence on the accuracy of shape and the surface finish of the workpiece.

Therefore, for the process of optimisation of the metal extrusion, we should consider all the primary understanding of the above mentioned phenomenas. At present, optimisation of the design of extrusion dies and procedures in domestic companies are principally based on an empirical approach. In order to improve quality and reduce cost of extrusion, it is very important to get more insight in the course of action that occur during extrusion. To obtain such insight, numerical simulation is a very popular and cost effective tool.
A variety of numerical and analytical techniques have been available in the literature ([8], [3],[11]) to solve extrusion problems. Early work was mainly concerned with 2-D extrusion problems or 3-D geometries with low extrusion ratios. With the increase of computer power more complex extrusion problems have been modelled.

The novel concept of our study is to determine the optimal conditions of isothermal extrusion with regards to billet temperature, container temperature, extrusion pressure, extrusion speed and microstructure for the non-adiabatic die profile. In this paper we analyse the metal extrusion process using the finite element software ABAQUS to set up a foundation for our proposed study.

2 Problem Description

Extrusion is an elasto-plastic deformation process in which a block of metal (billet) is forced through the die opening of a smaller cross sectional area than that of the original billet as shown in Figure (1)[10]. In the metal extrusion process the plastic deformation is very much larger than elastic deformation. Strain is a measure of deformation and at high strain rates metal flow is analogous to fluid flow[1]. Therefore the material behavior can be described as that of fluid flow. Based on the available literature ([1], [7], [9], [13]) the governing equations of