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Investigation of die radius arc profile on wear behaviour in sheet metal processing of advanced high strength steels

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ABSTRACT

Advanced high strength steels (AHSS) are increasingly used in sheet metal stamping in the automotive industry. In comparison with conventional steels, AHSS stampings produce higher contact pressures at the interface between draw die and sheet metal blank, resulting in more severe wear conditions, particularly at the draw die radius. Developing the ability to accurately predict and reduce the potential tool wear during the tool design stage is vital for shortening lead times and reducing production cost. This paper investigates the effects of draw die geometry on the sheet metal tool wear distribution over the draw die radius using numerical and experimental methods. A numerical tool wear model is introduced and applied using the commercial software package Abaqus. Channel bend tests are carried out using an Erichsen sheet metal tester to verify the numerical model. Various geometries of radius arc profiles, including standard circular profiles, high elliptical profiles, and flat elliptical profiles, are numerically investigated, and the wear volume and contact pressure distribution along the radii are determined. The results show that the profile of the draw die radius has a significant effect on the wear distribution, and that a low contact pressure distribution can be achieved by using a combination of circular and high elliptical curved geometries.

1. Introduction

Rising fuel prices and the increasing customer demand for safety have led to the greater usage of advanced high strength steels (AHSS) in the automobile industry. Compared to conventional mild steels, AHSS show higher strength levels as well as improved hardening characteristics which makes them suitable for applications where low weight and improved passenger safety are major design targets.

During sheet metal stamping, however, the higher surface hardness and high material strength of AHSS lead to higher contact stresses between the tooling and the work piece, which results in increased tool wear compared to conventional steel grades [1,2]. To enable widespread application of AHSS in the automobile industry, it is essential to understand the wear behaviour and the influence of various parameters on the magnitude of tool wear, so that steps can be taken to reduce it to an acceptable level. It would then by possible to explore the tool wear reduction measures either by creating hard and low friction tool surfaces using surface engineering methods or by modifying the tooling geometry or by using alternative die materials.

There has been extensive research carried out to study and predict the tool wear behaviour in sheet metal processing of various materials both numerically and experimentally. Skare and Krantz [3] have investigated the tool wear behaviour of high strength steel stampings using acoustic emission techniques and have shown that the surface treatment and surface quality of the tool are important for the tool behaviour. Ersoy-Nurnberg et al. [4] have studied the simulation of tool wear in sheet metal forming tools using the modified Archard's model in which wear coefficient is a function of accumulated wear work and is proportional to the dissipated energy. Hambli [5] has developed a wear prediction model in sheet metal blanking/punching process using finite element analysis with tool wear as a function of normal pressure and material properties. He also studied the effect of tool wear on burr formation. Mackensen et al. [6] have carried out experimental investigation to explore the possibility of reducing cutting forces in sheet metal processing of AHSS. They have specifically investigated the influence of standard shear cutting parameters on the cutting and transverse forces in a blanking process using three different AHSS materials.

Work has also been carried out to prolong tool life through a combination of surface coatings and alternative die materials. Kim et al. [7] have presented an extensive evaluation of various lubricants in stamping process using finite element analysis of deep drawing test using different dry and wet lubricants. Deshmukh et al. [8] have experimentally investigated the wear performance of wide range of lubricant combinations using boric acid and commercial transmission fluid. Klaasen and Kubarsepp [9] have analysed the wear behaviour of advanced titanium carbide-base cermets with a steel

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