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Notch Shear Cutting of Aluminum Alloys

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Abstract

Researchers at the Institute of Metal Forming and Casting (*utg*) developed the method of notch shear cutting. It allows cutting of brittle high-strength materials, such as manganese-boron-steels, at room temperature without any burrs. Moreover, the cutting forces can be reduced significantly and thus, the stress on the cutting edge is minimized. In this work, notch shear cutting was transferred to ductile 5xxx and 6xxx aluminum alloys in order to improve the cutting surface characteristics and, mainly, to avoid burrs. Furthermore, a reduction of the cutting forces is relevant, especially for car body parts with long intersection geometries. Notches with different geometries were stamped into an initial sheet material on the top or bottom side along a defined line. Afterwards the notched sheets were cut with a conventional shear cutting process at room temperature and an open cutting line. The influence of the notch parameters and positions on the characteristic shear cutting surface appearances and the cutting forces compared to conventional shearing processes were investigated experimentally and by numerical simulations.

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Keywords: Cutting; aluminum; burr reduction

1. Introduction

Lightweight design is a highly topical and frequent issue in both the automotive industry and the field of electric mobility. Especially aluminum alloys offer an enormous potential for weight reduction due to the low density. Even in consumer electronics and the white goods industry, aluminum is used increasingly for reasons of design. However, a reoccurring problem is the formation of burrs in the processing of aluminum components, for example, in conventional cutting processes. If these burrs detach during the component handling in the tool, these sliver particles

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are distributed and cause additional tool wear or they are impressed in the components surface, which lead to defective goods. [1] To prevent injuries during the manual handling, these unwanted burrs must be removed in additional time and cost consuming processing steps or rework processes. A possible way to avoid the burr and reduce the sliver in shear cutting of aluminum alloys is the support of the scrap during the cutting process [2]. [3] shows a possibility to avoid burrs when cutting AHSS and UHSS materials by using an underside notch, which is formed prior to the cutting process. A topside notch allows to reduce the cutting forces and the stresses in the punch, which is very interesting, especially for AHSS and UHSS materials. This study transfers the notch shear cutting technique from manganese-boron-steels to aluminum alloys.

2. Materials

The material of the notch punch, the punch and die, which was used for this experimental investigation, is a conventional high chromium, high carbon tool steel (1.2379). This material is commonly used for shear cutting processes of aluminum alloys. It is usually heat-treated to a hardness of 58+2 HRC [4].

The sheet materials were made of the aluminum alloys AA5754 and AA6014 with a thickness of 1.0 mm. AA5754 (EN AW-AlMg3) is a naturally hard aluminum alloy. A heat-treatment can't increase the hardness any further. The mechanical properties include a yield strength of 80 MPa, a tensile strength between 190 and 240 MPa and a strain of approximately 17 %. Common applications are in the automotive industry for body-in-white-components like inner door elements. [5] AA6014 (EN AW-AlMg0.6Si0.6V) is a heat treatable aluminum alloy. The mechanical characteristics are a yield strength of 90 MPa, a tensile strength of 195 MPa and a strain of nearly 25 %. It is used for outer body-in-white-components, such as door panels, fenders and front flaps. The alloying element magnesium causes a higher strength after a cold forming process. Moreover, the drying step after the painting process acts simultaneously as a heat treatment. After this process (for example at 185 °C/20 min), AA6014 has a yield strength of 225 MPa, a tensile strength of 275 MPa and a strain of 18 %. [6] Both materials are coated with a dry lubricant.

3. Process Setup

3.1. Notch Shear Cutting of Aluminum

Notch shear cutting is a two-step procedure. It allows a better overall cutting performance by influencing the cutting surface quality and the cutting forces. [3] Fig. 1 shows the flow-chart of the process with a topside notch.

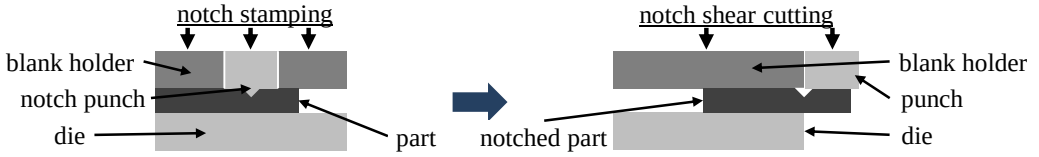

Fig. 1. Flow chart of the notching and the notch shear cutting process of aluminum.

The first step is the notch stamping process. The blank holder holds down the aluminum sheet while the notch punch stamps a notch into the initial aluminum sheet along the projected cutting line. The immersion depth of the notch punch influences the geometry of the notch. The process setup allows to stamp the notch into the topside or the underside of the sheet metal depending on whether the objective is the prevention of burrs or the reduction of the cutting forces. The second step is the notch shear cutting by a full edged shear cutting process using an open cutting line.

3.2. Experimental Setup

For the experimental investigation of notch shear cutting of aluminium alloys the same cutting tool was used as in the previous study regarding press hardened steel [3]. The tool's stiffness ensures that there are no displacements of the notching and cutting elements caused by deflection or shifting, which could distort the results. At the beginning