

Analysis of Trimming Processes for Advanced High Strength Steels

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ABSTRACT

Current die design recommendations attempt to limit the production of burrs through accurate alignment of the upper and lower edges. For common automotive exterior sheet, this translates to a gap less than 0.06mm. Unfortunately, the tolerances required by such standards often exceed the capabilities of many trim dies. The objective of the research described in this paper is to study the mechanisms of burrs generation and their impact on AHSS formability in stretch flanging. Experimental results on influence of trimming conditions on the shape of the sheared surface will be combined with the results of stretching strips after trimming.

INTRODUCTION

The quality of a trimmed surface for advanced high strength steels (AHSS) is defined by several factors. The higher strength of these materials compared to low carbon steel results, the greater is the load on the trimming tool. This circumstance results in increased wear of the shearing edge and in some cases its failure, requiring expensive maintenance of the trim die.

Trimming dies for body panels require a clearance of 0.06mm, which is difficult to maintain along the trim line and requires significant alignment efforts. In addition, the trim die has to be sufficiently robust such that the opening of clearance between the shearing edges, remain within an acceptable tolerance. In case of small clearances, overlapping of the upper and lower shear edges can occur due to unbalanced forces in the trim die. This condition can lead to failure of the shearing edges, intensified wear, poor trimmed surface and reduced trim die life. In addition, poor quality of the trimmed surface may reduce formability of the blank in flanging and hemming operations, especially in cases when a stretching load is applied along the trimmed surface. The objective of this paper was to study the

influence of trimming conditions on trimmed surface quality and the ability to stretch for AHSS blanks.

Experiments were conducted for both conventional trimming process [1] and a new version of recently developed robust trimming process [2]. In both cases we considered perpendicular trimming (a cutting angle equal to zero) as shown in Fig.1. The blank was initially clamped to the lower trim steel and the upper trim steel moved down to trim the panel. The robust trimming process [2] demonstrated excellent results for aluminum alloys, resolving the issues of slivers, burrs and split of the trimmed surface. The concept of trimming with the scrap support eliminates bending of the offal. In order to initiate crack propagation from the lower trim steel, the angle of the lower trim edge was reduced from 90° to 85°. Such trimming conditions are intended to reallocate burrs from the trimmed surface of the part to the sheared surface of the offal. Below the process shown in Fig 1b will be called robust trimming process.

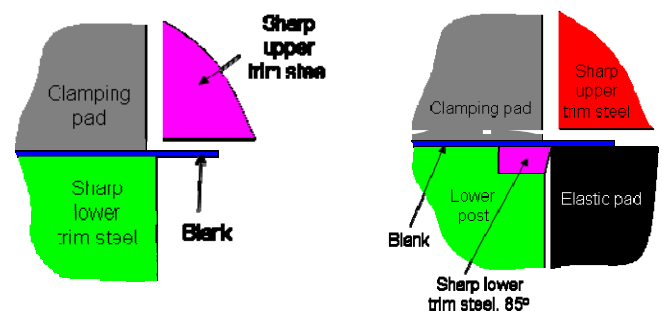


Fig.1. Schematics of the trimming processes:
a) conventional trimming process; b) robust trimming process.

EXPERIMENTAL TECHNIQUE

During experimental study the samples of AHSS sheet were first trimmed and then stretched parallel to the trimming direction. The following steps were performed:

1) 12.7 mm samples were trimmed from 300 mm long and 75 mm wide strip. The trimmed surface of the part is shown by dashed lines in Fig.2. Solid lines indicate the offal side of the trimmed surface.

2) "Half-a-dog bone" shaped samples on the offal side were fabricated using EDM in order to prevent localization of the deformation near the area of clamping.

Samples were stretched parallel to the trimming line. Experiments were repeated 10 times for each trimming condition and the results were averaged out of 10 samples.

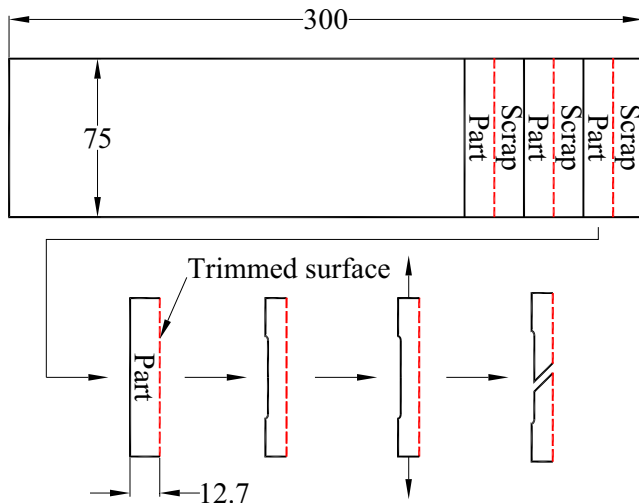


Fig.2. Steps of the experimental study.

In order to analyze the trimmed surface quality, cross-sections of samples were mounted in epoxy, polished and etched for 15-30 seconds by 4% nital acid. Samples were washed in water and dried by compressed air. To analyze crack propagation, partial trimming was employed. The trimming process was interrupted prior to final separation. Partially sheared samples were then polished and analyzed.

The tooling used in this experiment is shown in Fig.3. It was built on a standard die shoe (432mm long, 280 mm wide, 305 mm high) which included a fixed lower plate and a movable upper plate guided by four columns and attached to four nitrogen cylinders which were able to return the upper plate to its original position. The upper and lower steel blocks were attached to the corresponding plates with bolts and pins. Trimming steels with sharp shearing edges were attached to the upper and lower steel blocks.

These inserts were fabricated from plates of oil-hardenable steel: they were machined, ground and heat treated to HRC60. Great care was taken in mounting to ensure that the upper and lower trim edges were parallel to each other. In order to increase the stiffness of the upper block and to prevent its horizontal movement, an additional stiffening steel block was attached to the lower plate. To facilitate the upper block sliding along the surface of the stiffening block, special sliding plates were mounted on both blocks and accurately adjusted with shims.

Even though the tensile test data indicated that total elongation in longitudinal and transverse direction was

almost identical, the influence of the trimming line orientation to the rolling direction should be studied thoroughly. In this paper we concentrated mostly on comparison of trimming methods and, therefore, limited the investigation to orientation of the trimming line parallel to the rolling direction.

Both trimming and tensile tests were conducted using Instron testing machine, Model 1125. For the trimming experiments, we used a speed of 0.5mm/sec; for partial trimming we lowered the speed of the ram to 0.1mm/sec.

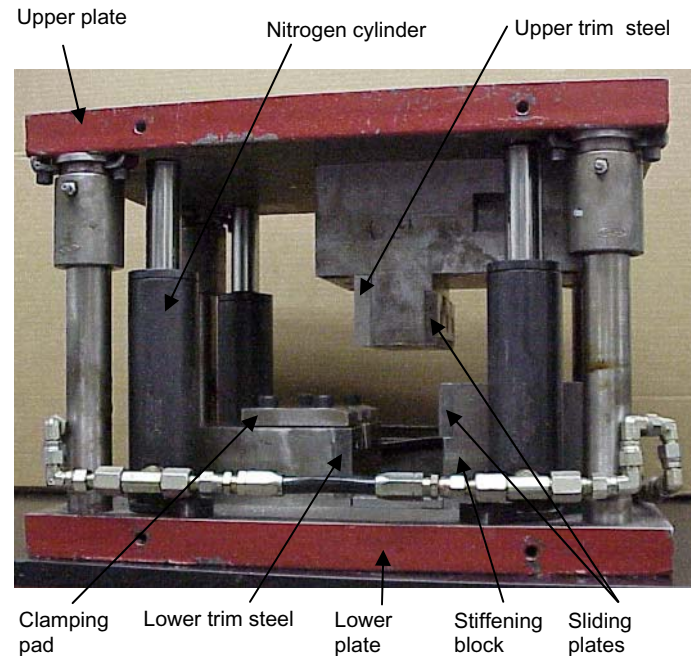


Fig.3. The experimental tooling.

ANALYSIS OF TRIMMED SURFACE FOR CONVENTIONAL AND ROBUST TRIMMING PROCESSES

We start the discussion of experimental results from observing the microstructure and shape of the trimmed samples of DP500 0.65mm thick shown in Fig. 4 and 5. It can be seen that conventional trimming provides a good quality trimmed surface for 10 and 15% clearances between the shearing edges. At 20% a small burr was observed on the part side of the conventionally trimmed surface. The mechanism of sheared surface formation and burr generation was discussed in [3-6] for the trimming of aluminum AA6111-T4. Due to increased material ductility in compression compared to stretching [7,8], crack in conventional trimming usually starts from the upper trim steel. For DP500, we observed a similar mechanism for conventional trimming. For a clearance of 30%, the burrs get significantly larger. For robust trimming, no burr was observed for the clearances of 10%, 15%, 20%, 30% and 40%. Compared to the conventional process, robust trimming has the advantage of not producing burrs. However, the rollover [1] on the part side is larger for robust trimming than the conventional process. It should be indicated that for