

NEW TEST METHOD FOR DETECTION AND ANALYSIS OF BURRS AND SLIVERS IN TRIMMING AND PUNCHING ALUMINIUM SHEET METAL

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Abstract: A large problem when trimming or punching aluminium sheet is the creation of burrs and slivers which degrade the quality of the produced parts. A semi-industrial test for evaluating trimming of aluminium has been further developed to include pre-stressing and pre-straining of the sheet material before trimming. The semi-industrial test results now show good correlation to industrial production outcomes.

Keywords: aluminium sheet, trimming, stamping, burrs and slivers, smearing.

1. INTRODUCTION

A current focus in the automotive industry is design of lightweight vehicles. Customer demands such as lower emissions, improved safety and improved performance lead to an increased amount of lightweight materials, such as high-strength steels or aluminium alloys, being used in cars. In a study from 2012 it is shown that approximately 160 kg of aluminium is used in a typical car (Ducker Worldwide, 2012). However, of that, aluminium sheet metal parts constitute only a smaller part, about 10 %. Cast aluminium make up more than 60 % of the aluminium used in a typical car.

In the same study, Volvo Cars is positioned slightly above average with 180 kg of aluminium per car, less than 10 % of the weight for evaluated models (Ducker Worldwide, 2012). It is expected that a typical car body will be made of 20 % aluminium in a near future, which would be a significant increase. Some current models from Land Rover, Audi and Jaguar are exceptions with chassis and bodies made entirely from aluminium (Ducker Worldwide, 2012).

One of the challenges with introducing new formable aluminium alloys in the automotive industry is to create robust trimming and punching processes. A large problem when trimming or punching aluminium sheet is the creation of burrs and slivers, small pieces of aluminium which have been detached from the sheet material during the trimming process, which degrade the quality of the produced parts. The industrial consequences are decreased productivity, higher maintenance costs, higher defective work expense, and an increased number of reworked and adjusted parts.

Forming of aluminium sheet metal in large industrial scale is only done by a small number of automotive companies and a lot of the developed process knowledge is kept in-house and is not published in scientific forums. However, some findings have been published. It has been shown that creation of slivers is affected by the tool design and can be reduced with better support for the scrap part during trimming or by using a smaller radius of the trimming edge (Golovashchenko, 2006). Other studies have shown that the creation of burrs is affected by a combination of properties of the specific alloy and process parameters such as clearance as well as trimming edge radius (Li, 2000a, b).

An obstacle for companies wanting to implement forming of aluminium sheet is that large resources have to be spent finding proper process parameters for the different variants of aluminium material that are available on the market.

A greater understanding is needed regarding the mechanisms governing the creation of burrs and slivers when trimming and punching aluminium sheet metal.

The objective of the present study was to develop a new method for testing of aluminium sheet metal alloys with focus on detection and analysis of burrs and slivers created during trimming when varying a number of process parameters.

2. MATERIALS AND METHODS

2.1. Development of test method

Semi-industrial stamping testing, both forming and trimming, has been successfully used at IUC Olofström in several previous research projects. Semi-industrial testing provides the possibility to do longer test series compared to regular lab testing and can produce results regarding long-term effects, such as tool wear, over time. Normal test series can be from a couple of hundreds of strokes up to hundreds of thousands of strokes. Compared to regular production the semi-industrial testing provides the possibility to use smaller components and simpler geometries as well as being a highly controlled environment in addition to the important advantage of not disturbing regular production.

The trimming test setup used in previous research projects was designed for trimming of unformed sheet material. It could accommodate trimming of sheet which had been bent to different angles to test trimming in a non normal direction. However, exactly where the trimming took place the sheet metal was unformed. This setup did not give representative results regarding creation of burrs and slivers when trimming aluminium sheet. In real production it is common that trimming takes place where the sheet material has been formed.

The objective in this study was to develop a new method for testing trimming of aluminium sheet metal alloys. This would be realised by improving the existing trimming test so it would simulate the production process as accurately as possible. In addition, it should be possible to vary process parameters such as die radius, surface roughness and clearance.

The aim was to achieve a strain rate of about 5 to 8 % on a formed part before trimming which is a common level of strain found in real automotive outer panels. Several iterations of sheet forming simulation and practical testing were performed to find a suitable component geometry, see figure 1. In figure 2 the complete progressive trimming die with all stations is shown, including forming and trimming at four different angles and a final cutoff station.

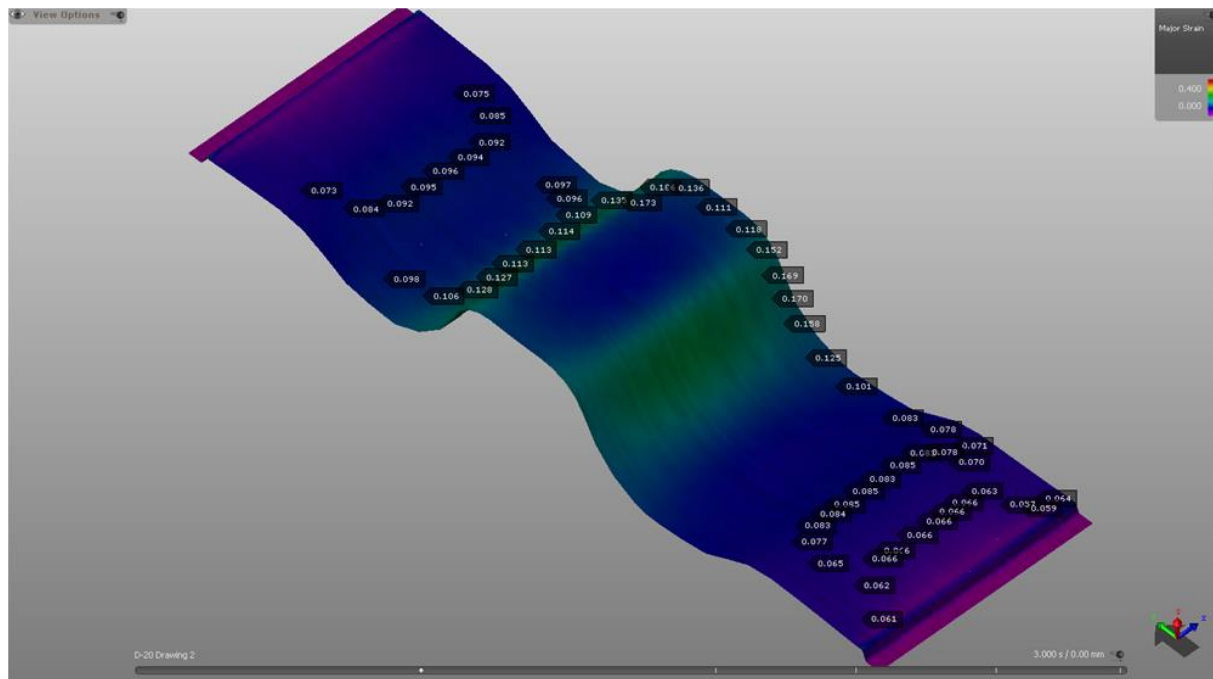


Fig. 1. Simulation showing strains after forming in station 1.

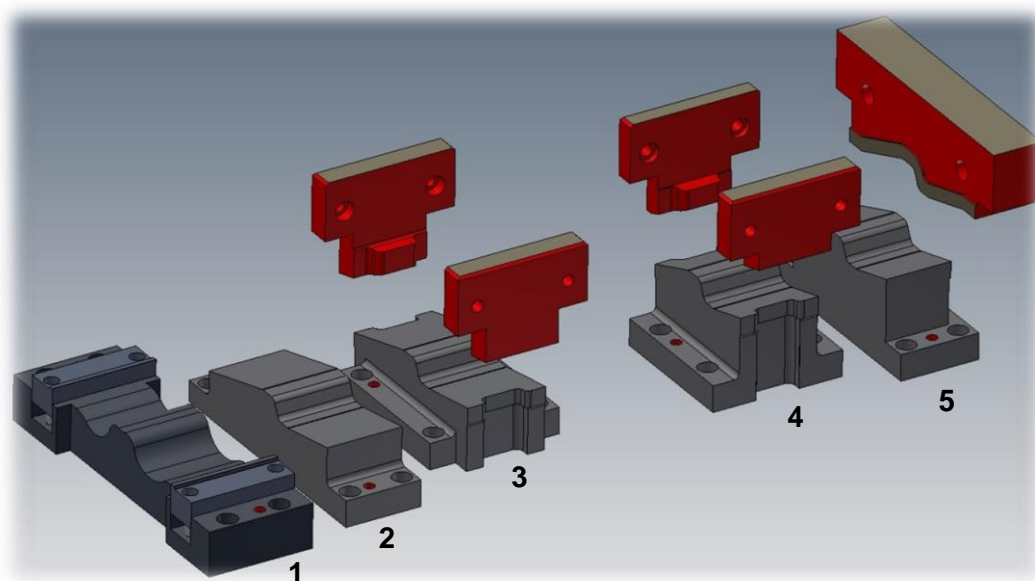


Fig. 2. Stations of the progressive trimming die.

Stations of the progressive trimming die (figure 2):

1. Forming operation to introduce stresses and strains into the component.
2. Second forming operation to ensure proper detail geometry.
3. Trimming operation with two different angles for the flanges, negative 15° and positive 10°.
4. Trimming operation with two different angles for the flanges (angle change adjusted with a pad), negative 20° and positive 15°.
5. Cutoff operation.

After initial testing it was clear that the final cutoff had to be moved towards the centre of the component because of too little support resulting in too much burrs and slivers. Figure 3 shows the adjusted position for the cutoff.

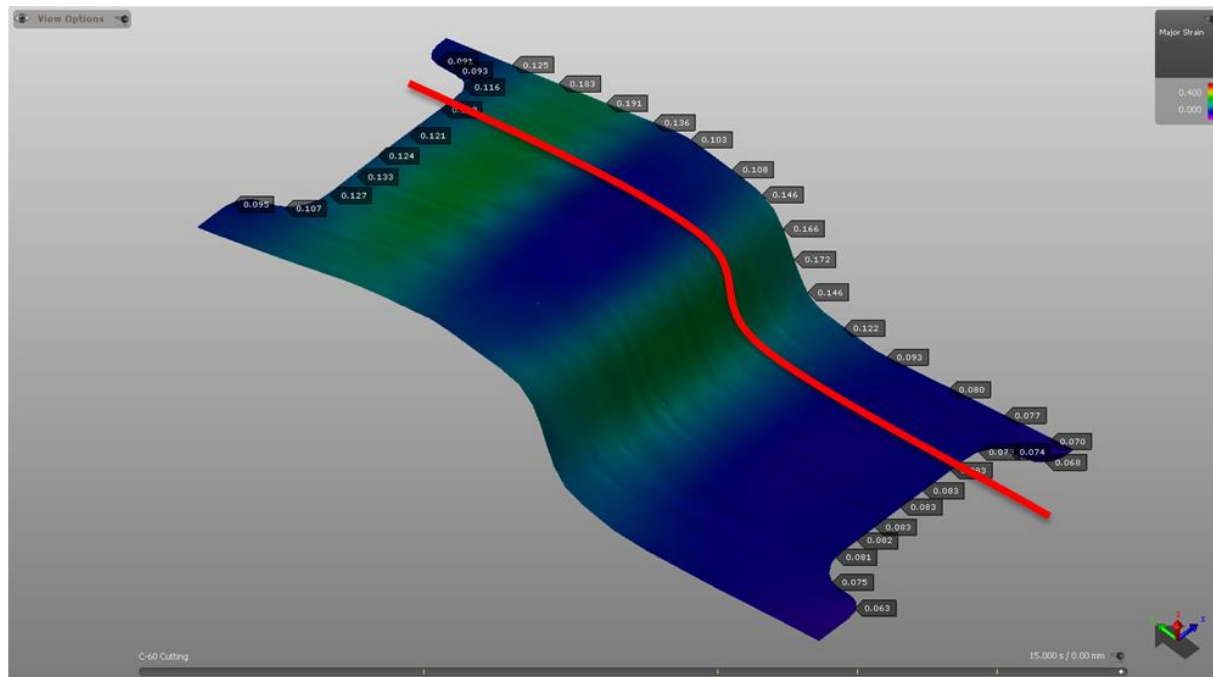


Fig. 3. Simulation showing the last cutoff operation and the adjusted position for the cut.

2.2. Experimental setup

Measurements and evaluations:

- Side force measurements were made continuously at each station in the progressive die.
- The presence and amount of burrs and slivers was evaluated at each station by regular visual inspection.
- Smearing of sheet material on the trimming edges have been evaluated at each station at regular intervals by microscopic inspection and documentation.
- Quality of the cut edges of the component have been evaluated at each station.
- The amount of lubrication on the sheet metal has been measured continuously during the testing.

Experimental conditions:

- The aluminium sheet metal used in the study was AC170PX which is a common material for automotive outer panels. Material thickness was 0.95 mm. The aluminium sheets were coated with two different hot melts: ALUB 55 from Zepf Schmierstoffe and ANTICORIT PL 39 SX from Fuchs, both used regularly in production.
- Two levels of trimming edge radius were tested: 10 and 100 μm , where 10 μm is considered to be a sharp edge and 100 μm is considered to be an edge designed to give a process with a lower risk for early failure. These levels and larger are found in production.
- Clearance was tested in three levels: 5, 10 and 15 % of sheet material thickness, where 10 % is a level used in production.
- The testing lasted 200 strokes for each combination of parameter level. Not all parameter level combinations were tested. Together with the hot melt ANTICORIT PL 39 SX only 10 % clearance was tested. Thus, 8 combinations of parameter levels were tested.

The parameter level combination that is most like conditions in real production at Volvo Cars is:

- Hot melt: ALUB 55 from Zepf Schmierstoffe
- Trimming edge radius: 100 μm
- Clearance: 10 % of sheet material thickness




This combination will be called 'case 1' in the results presented below. The difference in 'case 2' is that the clearance is 5 %. These two combinations were selected for a more detailed presentation of results sections 3.1 and 3.2 below. Case 1 because it is the most representative for production at Volvo Cars and case 2 because it shows some differences in the outcome which demonstrate the effect of too small clearance. Results for all combinations are summarised in section 3.3.

3. RESULTS

3.1. Smearing on trimming edges

After 200 strokes there was very little or no smearing on trimming edges in case 1. Case 2 shows more smearing, especially at the negative flange angles and at the cutoff. See table 1 below.



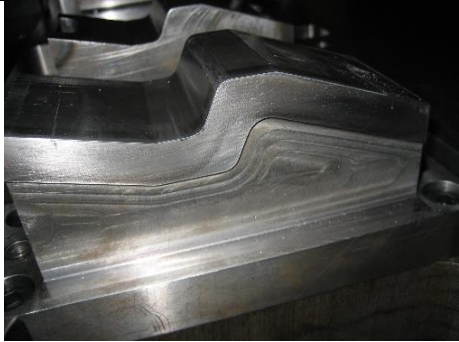
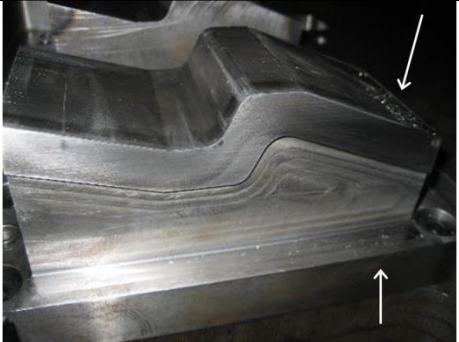
Table 1. Smearing on trimming edges after 200 strokes.

	Case 1	Case 2
Positive 10°		
Positive 15°		
Negative 15°		
Negative 20°		
Cutoff		

3.2. Burrs and slivers

In case 1 not much burrs or slivers were produced at the cutoff station. In case 2 some more burrs were found at the cutoff. See table 2 below.

Table 2. Burrs and slivers at cutoff station after 10 strokes and after 200 strokes.

	Case 1	Case 2
After 10 strokes		
After 200 strokes		

3.3. General results

There were more smearing at trimming stations with a negative flange angle. Smaller trimming edge radius as well as smaller clearance also increased the amount of smearing.

After adjusting the cutoff position towards the centre of the component, to increase the support, less burrs and slivers were created at the cutoff station.

In most cases, the results show good correlation to what is found in real production.

4. DISCUSSION

The results indicate that because of good support and holding of the sheet not much burrs or slivers are created during the trimming. A lot of burrs and slivers were created at the cutoff before the cutoff position was adjusted toward the centre of the component. These outcomes gives good support to the findings referred to in the introduction (Golovashchenko, 2006).

Different combinations of clearance and trimming edge radius have produced different amounts of smearing and smearing with different properties. It is conceivable that the smearing will end in creation of burrs and slivers with longer test series.

The tests have not yet been repeated so there is some uncertainty regarding the constancy of the results.

In addition to the process parameters included in this study it also possible to vary parameters as:

- Sheet material
- Tool material
- Surface treatment and coating of the tools
- Surface roughness of the tools

5. CONCLUSIONS

- A semi-industrial test for evaluating trimming of aluminium has been further developed to include pre-stressing and pre-straining of the sheet material before trimming.
- The semi-industrial test results now show good correlation to industrial production outcomes.
- The developed test enables efficient evaluation of trimming of new aluminium sheet materials.

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