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ANALYSIS OF TRIMMING PROCESSES FOR STAMPED BODY PANELS

Sergey Golovashchenko
Ford Motor Company

Andrey Ilinich
Oakland University
1. Introduction – trimming process
2. Trimming issues: burrs, slivers and splits from the trimmed surface
3. Influence of trimming conditions on burrs and slivers generation
4. Robust trimming method
5. Stretching of trimmed surface
   5.1. Cases when stretching of the sheared surface occur
   5.2. Methods of testing
   5.3. Testing technique employed
   5.4. Modes of fracture during stretching of trimmed blanks
   5.5. Influence of trimming conditions on ability of trimmed samples to stretch
6. Conclusions
CONVENTIONAL TRIMMING PROCESS

Schematic of the trimming process

- Quality of trimmed surface is very sensitive to the accuracy of alignment of upper and lower dies
- Burrs, slivers and splits are typical issues in conventional trimming
- Tooling alignment is especially difficult in curved areas of the trimming line
EXPERIMENTAL TOOLING EMPLOYED IN TRIMMING EXPERIMENTS
TRIMMED EDGE OF AHSS DP500 AFTER CONVENTIONAL TRIMMING PROCESS

- Clearance $C \sim 10\% t$
- $C$ can be increased during trimming process
- $C$ may not be uniform around the perimeter of the blank

5% 10% 15% 20% 30% 40%
MECHANISM OF BURR AND SLIVER FORMATION IN CONVENTIONAL TRIMMING

part    offal

steel DP600

Sliver cross-section

Accumulated damage

DQSK steel

sliver on the offal side
ROBUST TRIMMING PROCESS

Cross-sections of trimmed edges from advanced high-strength steel DP500

US Patent 7197970
MECHANISM OF ROBUST TRIMMING

DP600, t=1.48mm

A crack starts from the free surface near the lower trim edge and propagates to the stretched surface on top of the blank.

DP500, t=0.65 mm

CONVENTIONAL AND ROBUST TRIMMING PROCESS (DQSK mild steel, t=0.74mm)

Conventional trimming

- Z=2%
- Z=10%
- Z=20%
- Z=30%
- Z=40%

Robust trimming (with scrap support and dull upper shearing edge)

- Z=2%
- Z=10%
- Z=20%
- Z=30%
- Z=40%
CONVENTIONAL AND ROBUST TRIMMING PROCESS (DP600 steel, t=0.74mm)

Conventional trimming

5%  10%  20%  30%  40%  50%

Robust trimming (with scrap support and dull upper shearing edge)

5%  10%  20%  30%  40%  50%
WHEN SPLITS FROM SHEARED SURFACE ARE EXPECTED?

1. Stretch flanging and hemming

2. Drawing of blanks with with windows

3. Stretching of the sheared edge
## Testing of Sheared Edge Formability

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<td>Sheared surface</td>
<td>Sheared surface</td>
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- **Hole Expansion Test**
  - Reproduces strain gradient
  - Varying the clearance requires multiple tools
  - Typical hole diameter $D = 10\text{mm}$
  - Results may vary as $f(t/D)$
  - Burrs are smaller compared to trimming

- **Half-a-Dog Bone Tensile Test**
  - No strain gradient
  - Requires surface preparation from offal side
  - May reproduce variety of trimming conditions in one tool

- **Strip Tensile Test**
  - No strain gradient
  - Requires min surface preparation
  - Appropriate only for materials with substantial $n$-value
  - May reproduce variety of trimming conditions in one tool
TESTING PROCEDURE EMPLOYED TO DEFINE STRETCHING PERFORMANCE OF TRIMMED SAMPLES

Testing equipment

Tensile test

Trimmed surface

Part

12.7

Scrap

Part

Scrap

Part

Scrap

75
OBSERVED FAILURE MODES

Schematic of the test

Load - displacement curves

Load

Displacement

Failure modes

Mode 1

Mode 2

Mode 2+1

OBSERVED FAILURE MODES

Load - displacement curves

Mode 1

Mode 2

Mode 2+1

Schematic of the test

Load

Displacement

Mode 1

Mode 2

Mode 2+1
OBSERVED FAILURE MODES

Mode 1

Mode 2+1

Mode 2

View A (Mode 2)

Major crack

Multiple starting cracks

Mode 2+1

Mode 2

Mode 1

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FRACTURE INITIATION IN TENSILE TEST

Samples of trimmed with conventional process (C=40% DP500, t=0.65 mm)

Samples trimmed with robust process (C=40%, DP500, t=0.65 mm)

fracture initiation

fracture initiation
FREQUENCY OF FAILURE MODES

Conventional Trimming Process, DP500, t = 0.65mm

Mode 1

Mode 2
FREQUENCY OF FAILURE MODES

Robust Trimming Process, DP500, t= 0.65mm
STRETCHING OF TRIMMED SAMPLES

Material DP500, t=0.65 mm
1. Conventional trimming technology with sharp shearing edges provided good quality of sheared surface and ability to stretch along trimmed surface for DP 500 and DP 600 if the clearance between sharp shearing edges did not exceed 20%.

2. Increasing the clearance over 20% in conventional trimming process resulted in quick deterioration of quality and significant reduction of formability.

3. The robust trimming process provided significantly smaller burrs in a wide variety of clearances between the shearing edges, stable total elongation along trimmed surface, and elimination of slivers.
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