Remanufacturing of metal components:
    reforming of sheet metal blanks

Rico Haase, M. Sc.  |  Fraunhofer IWU

December 9th 2020
Recent developments of secondary raw material

Typical properties of secondary raw materials (SRM)

Challenges for use of SRM in an re-manufacturing approach

SRM material market

Re-Manufacturing of SRM material
Recent developments of secondary raw material

- State of the art is recycling of metals on very basic raw material level
- Significant resource consumption for re-melting and subsequent milling process: 9.54 MWh/t [InnoCaT: Green Carbody Technologies]
- Environmentally friendly alternative: re-introduction of material on a higher level of the metal working value chain ➔ characteristic sheet shape is preserved
Process Design for further lifecycle based on pre-used material

- Pre-used component (1st life)
- Blank extraction from rooftop
- Blank: 1485x785 mm²
- Deep draw operation
- Cut of blank for further processing
- Round blanks Ø ~320 mm
- Final component
- Springback & mech. properties
- Remanufacturing tool

CarE-Service
due to previous lifecycle, a part of the formability is consumed already
to limit the individual characterization effort, global degradation of material properties is assumed
⇒ increased initial strength while lowered elongation

### Yield/Tensile Strength of test specimen

<table>
<thead>
<tr>
<th></th>
<th>HC180B</th>
<th>Virgin material (typ. value)</th>
<th>after work hardening</th>
<th>after bake hardening</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Yield Strength</strong></td>
<td></td>
<td>(205 ± 25) MPa</td>
<td>~ 220 MPa</td>
<td>~ 255 MPa* increase</td>
</tr>
<tr>
<td><strong>Elongation to fracture</strong></td>
<td></td>
<td>&gt; 34%</td>
<td>~ 25%</td>
<td>~ 9% decrease</td>
</tr>
</tbody>
</table>

* Impact of bake hardening quantified in InnoCaT (Green Carbody Technologies)
Challenges for the use of SRM

- The use of secondary raw materials (SRM) in a conventional forming process is challenging in terms of:
  - mechanical properties (scaled for better visibility)
    - forming limit curve FLC $\rightarrow$ lowered
    - initial strength of the material $\rightarrow$ increased
The use of secondary raw materials (SRM) in a conventional forming process is challenging in terms of:

- mechanical properties
  - forming limit curve FLC
  - initial strength of the material
- geometric appearance of the SRM blank
  - single- / double-curved shape
  - varying sheet metal gauges across the SRM blank

The re-manufacturing process need to be robust towards those impacts. Establishment of SRM material categories is proposed to qualify material.
Challenges for the use of SRM

- The use of secondary raw materials (SRM) in a conventional forming process is challenging in terms of:
  - geometric appearance of the SRM blank
    - varying sheet metal gauges across the SRM blank ➔ tolerance
    - single- / double-curved shape: radii and orientation

\[ K = k_1 \cdot k_2 = \frac{1}{r_1} \cdot \frac{1}{r_2} \]

[Wikipedia: Hyperbolische Paraboloidschale]
SRM material market

- SRM raw blanks can be harvested easily from the outer shell of wrecked cars. Both, mechanical and laser cutting technology can be applied.
- SRM blank material is offered through the CarE-Service portal.
SRM material market

- shaped blanks are cut from SRM raw blank by means of flexible metal working technologies - several blanks can be nested for material efficiency
SRM material market

- shaped blanks are cut from SRM raw blank by means of flexible metal working technologies - several blanks can be nested for material efficiency
SRM material market

- shaped blanks are cut from the SRM raw blank by means of flexible manufacturing technologies
- different blanks can be nested into a single raw blank for best material efficiency
- Formability of a brake disk cover part has been validated.
- The replacement of virgin material by SRM blanks can be accessed by means of a FEA validation and material properties supplied by the SRM provider.
Re-Manufacturing of SRM material

- Formability of a brake disk cover part has been validated.
- The replacement of virgin material by SRM blanks can be accessed by means of a FEA validation and material properties supplied by the SRM provider.
Re-Manufacturing: Shortcut in the recycling loop

Further Information:
https://www.careserviceproject.eu/
REMANUFACTURING OF METAL COMPONENTS: JOINING - DISASSEMBLY - TECHNOLOGY

Tibor Paizs | Fraunhofer IWU

December 9th 2020
Principle approach

- experimental equipment: laser processing optics with intelligent temperature control
- process of disassembling with a 1030 nm wavelength laser
- process of disassembling with a 515 nm wavelength laser
- qualify process parameters of disassembling
Principle approach of the Joining-Disassembly-Technology:

Joining

- heat source e.g. laser beam
- single parts
- brazing
- final product

Disassembly

- heat source e.g. laser beam
- melted solder
- melted solder suction
- sheet steel (DC04, HX360, o.ä.)
- melted solder suction
- single parts

Brazed seam of CuSi3, CuAl8---melting temperature: 1040 °C

Sheet steel (DC04, HX360, o.ä.)—melting temperature: 1600°C

Processing window: 1200°C...1500°C
Sheet metal remanufacturing - Agenda

- principle approach

- experimental equipment: laser processing optics with intelligent temperature control
  - process of disassembling with a 1030 nm wavelength laser
  - process of disassembling with a 515 nm wavelength laser
  - qualify process parameters of disassembling
Experimental equipment: Laser processing optic with intelligent temperature control

Configuration of the laser processing optic with intelligent temperature control:

- Wave length of the processing laser: 1050nm
- Wave length of the pyrometer: 1700-2600nm
Experimental equipment: CFX calculation of the gas nozzle

CFX calculation of the gas nozzle:

- Heat source e.g. laser beam
- Melted solder suction

- Supersonic velocity!
- Supersonic shocks

Bearbeitungsrichtung

\[ \alpha = 40^\circ \]

\[ \alpha = 15^\circ \]
Experimental equipment: complete processing Optics

configuration of the laser processing optics with intelligent temperatur control:

- observation camera
- adapter for the fibre of the pyrometer
- collimating lens
- semitransparent-mirror
- focusing lens
- air cleaner
- protection of the optical components
- pyrometer
- DINSE wire feed modul
- high frequency laser beam scanner
- position table for x direction
- Position table for z direction
- adjustable gas nozzle
Sheet metal remanufacturing - Agenda

- principle approach
- experimental equipment: laser processing optics with intelligent temperature control

- process of disassembling with a 1030 nm wavelength laser
  - process of disassembling with a 515 nm wavelength laser
  - qualify process parameters of disassembling
process of disassembling with a 1030 nm wavelength laser

Melted soldered seam
process of disassembling with a 1030 nm wavelength laser

process in detail:

1) 2) 3) 4) 5)
Sheet metal remanufacturing - Agenda

- principle approach
- experimental equipment: laser processing optics with intelligent temperature control
- process of disassembling with a 1030 nm wavelength laser
- process of disassembling with a 515 nm wavelength laser
- qualify process parameters of disassembling
process of disassembling with a 515 nm wavelength laser

→ significantly higher degree of absorption in laser material processing of copper materials with a laser with a low wavelength
process of disassembling with a 515 nm wavelength laser
Sheet metal remanufacturing - Agenda

- principle approach
- Experimental equipment: Laser processing optic with intelligent temperature control
- process of disassembling with a 1030 nm wavelength laser
- process of disassembling with a 515 nm wavelength laser
- qualify process parameters of disassembling
qualify process parameters of disassembling adjustable parameters:

adjustable parameters of the test stand:

- laserpower
- offset of the collimating lens
- laserspot diameter
- frequency and amplitude of the scanner
- position of the gas nozzle
- angle the gas nozzle
qualify process parameters of disassembling adjustable of the laser power (example)

<table>
<thead>
<tr>
<th>Energy per unit length [J/cm]</th>
<th>Wavelength: 1030 nm</th>
<th>Wavelength: 515nm</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>top of the brazed</td>
<td>top of the brazed</td>
</tr>
<tr>
<td></td>
<td>seam</td>
<td>seam</td>
</tr>
<tr>
<td></td>
<td>cross section</td>
<td>cross section</td>
</tr>
<tr>
<td>1140 J/cm $P_L = 950$ W</td>
<td><img src="image1.jpg" alt="Image" /></td>
<td><img src="image2.jpg" alt="Image" /></td>
</tr>
<tr>
<td>1020 J/cm $P_L = 850$ W</td>
<td><img src="image3.jpg" alt="Image" /></td>
<td><img src="image4.jpg" alt="Image" /></td>
</tr>
<tr>
<td>900 J/cm $P_L = 750$ W</td>
<td><img src="image5.jpg" alt="Image" /></td>
<td><img src="image6.jpg" alt="Image" /></td>
</tr>
<tr>
<td>840 J/cm $P_L = 700$ W</td>
<td><img src="image7.jpg" alt="Image" /></td>
<td><img src="image8.jpg" alt="Image" /></td>
</tr>
<tr>
<td>720 J/cm $P_L = 600$ W</td>
<td><img src="image9.jpg" alt="Image" /></td>
<td><img src="image10.jpg" alt="Image" /></td>
</tr>
</tbody>
</table>
the non-destructive desoldering of car-body parts is basically possible with the technology that has been developed

to increase the process speed, further process optimization are required

a promising approach is the use of a high-speed thermal camera, which is used for example for laser hardening

further optimizations of the process are not possible within the scope of the project
Remanufacturing of metal components: RFID Data Storage

Markus Maibaum, M. Sc. | Fraunhofer IWU

Roberto Seyfert, M. Eng. | Fraunhofer IWU

December 9th 2020
Agenda

- Research of data storage hardware
- Testing data storage hardware
- Selection, documentation for a fitting data storage concept
RFID tags can be sorted by frequency, transmission speed, capacity and of course prize.

- **Ultra high frequency (UHF)**
  - Frequency: 433 MHz or 860 MHz to 960 MHz
  - Capacity low cost: 100 to 500 bytes
  - Capacity high cost: 4000 to 8000 bytes
  - Costs: (20 to 30€)
  - Speed: Fast

- **High frequency (HF)**
  - Frequency: 13,56 MHz (known as near field communication (NFC))
  - Used in products like smart cards or mobile payment
  - Costs: round about 1€
  - Capacity: 4000 to 8000 bytes
  - Speed: Middle
Testing data storage hardware

- Write data on RFID data storage chip
- Put the written Chip on a fitting place on a chosen part or assembly
- Read data from the RFID data storage chip

<table>
<thead>
<tr>
<th>Type</th>
<th>Parameter</th>
<th>Mandatory / optional</th>
<th>Derived from</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>general</td>
<td>Vehicle name</td>
<td>mandatory</td>
<td>OEM</td>
<td>car name depending on OEM</td>
</tr>
<tr>
<td>general</td>
<td>Part ID</td>
<td>mandatory</td>
<td>OEM</td>
<td>unique part ID</td>
</tr>
<tr>
<td>general</td>
<td>Year of manufacture</td>
<td>mandatory</td>
<td>OEM</td>
<td>YYYY(MM.DD)</td>
</tr>
<tr>
<td>general</td>
<td>Part type</td>
<td>mandatory</td>
<td>OEM</td>
<td>profile, structural part, deep drawn part, etc.</td>
</tr>
<tr>
<td>general</td>
<td>Material class</td>
<td>mandatory</td>
<td>OEM</td>
<td>e.g. steel</td>
</tr>
<tr>
<td>general</td>
<td>Material ident number</td>
<td>mandatory</td>
<td>OEM</td>
<td>e.g. 1.0922</td>
</tr>
<tr>
<td>general</td>
<td>Material norm</td>
<td>mandatory</td>
<td>OEM</td>
<td>e.g. DIN EN 10268</td>
</tr>
<tr>
<td>general</td>
<td>Material name</td>
<td>mandatory</td>
<td>OEM</td>
<td>e.g. HC180Y+ZE</td>
</tr>
<tr>
<td>general</td>
<td>Surface status</td>
<td>mandatory</td>
<td>OEM</td>
<td>e.g. +AZ 150</td>
</tr>
</tbody>
</table>

- Possible number of material data which is useful for the remanufacturing process.
Smart and low cost solution for getting all required data through the live cycle of parts and assemblies from OEM to remanufacturing companies

- 8 kbit RFID Chip
- Android Open source software (write and read)