Flexible Rolling of Tailor Rolled Blanks
- innovative light weight design in steel -

Dr.-Ing. Michael Rehse
Muhr und Bender KG
During the past 5 years, lightweight construction potential, feasibility, competitiveness and volume production capability of Flexible Rolling have been verified.

- Tailor Rolled Blanks -

- a light weight design opportunity -

- Flexible Rolling is a continuous rolling process with periodically varying thickness.

- Mubea developed the complete process chain for a steel component made of TRB

- The adoption of TRB in the automotive industry offers great potential for the optimization of weight, function, cost and complexity.

- Verification of competitiveness: supply orders with Audi, BMW, DCX, GM & Skoda (Σ 31 parts)

- Ongoing launches in Europe and North America

- Serial production of Tailor Rolled Tubes with an annual capacity of 1 million tubes

- Application studies for multiple car and truck bodies

- Verification of volume production capability: 16,500 to / 5.75 million blanks up to now

During the past 5 years, lightweight construction potential, feasibility, competitiveness and volume production capability of Flexible Rolling have been verified.
Mubea – as a lightweight design specialist – supplies automotive OEM’s worldwide with steel based products. Using Mubea lightweight innovations, a weight reduction of 20 kg per vehicle can be achieved.
Over 4,200 employees @ 15 production sites enable us to serve the customers worldwide.
Mubea strives for a continuous growth in the coming years.
Mubea has a long experience in cold rolling.

- Many years of experience in the cold rolling area
- Annual production of 30,000 t/year
- Core competence in the following materials
  - Spring steels
  - Mild and higher-tensile steels
- Expansion of the cold rolling mill in two steps
  - Flexible rolling facility I: 10,000 t/year
  - Flexible rolling facility II: 60,000 t/year
- Materials:
  - Deep-draw grades
  - Micro-alloyed steels
  - Higher-tensile steels
Mubea is convinced that lasting success can only be achieved in partnerships.

Principle of Flexible Rolling

- Defined sheet metal thickness contours
- Uniform thickness transition areas
- High efficiency as strip rolling process
- Can be applied to all rollable metals
Flexible Rolling allows to produce components with almost all thinkable thickness changes.

- Varying sheet metal thickness with smooth transitions
- 50% max. thickness reduction
- Slope between 1/3000 up to 1/100
- Thickness tolerances ± 50µm
- Optimized sheet thickness dependent upon the load
- The cost of the component does not depend on number of thickness steps
- Reduction of sheet and component weight
Flexible Rolling allows to produce components with almost all thinkable thickness changes.

- Varying sheet metal thickness with smooth transitions
- 50% max. thickness reduction
- Slope between 1/3000 up to 1/100
- Thickness tolerances ± 50µm
- Optimized sheet thickness dependent upon the load
- The cost of the component does not depend on number of thickness steps
- Reduction of sheet and component weight
Mubea has developed the complete process chain for a steel component made of Flexibly Rolled Parts.
Cold Rolling Plant in Attendorn

- Start of construction work: Ma `03
- Completion of building: Jan `04
- Start of equipment installation: Feb `04
- First Coil: Aug `04
- Capacity: 60,000 t/year
Mubea developed the complete process chain for a steel component made of Flexible Rolled Blanks.
Production Technology TRB Pressed Parts

- Mechanical press, Press force: 1.100 tonnes
- Max. length pressed parts: 1450mm
- Max. length developed blanks: 2500mm
- Fully automated part / developed blank production from coil
- Fully automated blank orientation (lengthwise or across the rolling direction), independent of die
- In-house processing of Tailor Rolled Blanks

Mubea Press Shop

Application Example: Steering Link

Process Chain

- Short processing time: raw material coil to the finished, flexibly rolled component in one plant.
- Cost reduction due to omittance of storing and one production step (stackling of blanks).
Properties of TRB

- Continuous transition
- Harmonic tension distribution throughout the thickness transition area
- Homogeneous surface
- No disturbed fibre pattern
- No notch effect
- No detrimental effects on microstructure caused by welding
- Can be modelled for simulation
- Forming properties are comparable to conventionally rolled metal

The material and forming properties of Tailor Rolled Blanks are comparable to conventionally rolled metal.
The flexible rolling process enables non-tool-related production.

Simple software programming allows contour changes from one coil to the other.

Cost efficient manufacturing of derivates or product variants:
- Without set-up costs
- No additional body shop costs

Easy contour optimization due to the flexibility of the process.
• Part design requires increased thickness
• Optimized distribution of stiffness in outer areas by matching of sheet thickness (NVH)
• Front crash demands local up-gauging at load exposed front and below x-member
• Improvement of crash performance

With local sheet metal thickness adaptations to the load
Tailor Rolled Blanks provide best performance at minimum weight.
Integration of components

- Conventional design:
  1 component
  4 reinforcements $\Sigma 5$ parts

- TRB – design: $\Sigma 1$ part

Opportunities:
- production costs
- tool costs / investments
- assembly process
- logistic costs
- floor space required

- Potential savings up to 1 US$/unit exclusive of weight-increasing

Reduction of assembly groups by Tailor Rolled Blanks.
The technology offers high potentials for different components in the structure and chassis areas. Application criteria for optimum TRB applications have been identified.
Producing structure parts for the DC E-class and the BMW 5-series, we verified volume production capacity.

- Increased torsional stiffness
- Weight reduction of 1.2 kg vs. conventional part

**HSLA 300 / 350 TRB Z100**
flexible rolled 1.9 > 1.05 > 1.9 mm
Considering the technology advantages of TRB during the part development process results in maximal weight reduction and low costs.

- 30% weight reduction
- Narrowest part tolerances
- Cost-effective light weight construction
Mubea put the first production line for Tailor Rolled Tubes in stream.

**Layout tube production line**
- Discontinuous tube production
- High number of profile shapes by means of flexible forming techniques
- Connection by laser beam welding
- Integration of further process steps like bending and forming

- Tube with a constant outer diameter and invisible thickness transition run
- Tube with constant inner diameter and visible thickness transition run
- Tube with variable diameters and varying thicknesses

**Profile shapes**
Development of Tailor Rolled Tubes (TRT)

Tailor Rolled Tube with variable diameters

Manufacturing tubes with variable diameters and sheet metal thicknesses features maximum flexibility in weight optimization and design.

Diameter variation: 52%
Thickness variation: 43%
Weight reduction: 33%

- Different diameters along the whole tube
- Different thicknesses over the whole length of the tube
- Maximum weight savings
- High degree of design flexibility
- Cost efficient manufacturing of complex tube geometries (compared to hydro forming)
The combination of matched sheet metal thickness and extremely high material strengths allows a maximal weight reduction.
- 24% weight reduction
- Improved crash performance as a result of integration of components and adaptation of thickness

BTR 165 TRB
flexible rolled 1.0 > 1.9 > 1.6 > 1.3

<table>
<thead>
<tr>
<th>die hardened</th>
<th>Rp0.2 [N/mm²]</th>
<th>Rm [N/mm²]</th>
<th>A5 [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>min. 950</td>
<td>min. 1300</td>
<td>min. 6</td>
</tr>
</tbody>
</table>

Weight optimized B-pillar design through load adapted thicknesses.
Summary

- Flexible Rolling is designed as a continuous rolling process for metal sheets with periodically varying thickness.
- Mubea developed the complete process chain for a steel component made of Flexible Rolled Blanks.
- The adoption of Tailor Rolled Blanks in the automotive industry offers great potential for the optimization of weight, function, cost and complexity.
- The material and forming properties of Tailor Rolled Blanks are comparable to conventionally rolled metal.
- All conventional process steps for the production of metal parts are applicable for Tailor Rolled Blanks.
- The technology offers high potential for different components in the structure and chassis area.
- Mubea has put the first production line for Tailor Rolled Tubes in stream.
- World-wide, Mubea is leading in the production of Tailor Rolled Products.
THANK YOU VERY MUCH FOR YOUR ATTENTION!!!!