



RFCS-ProTuBend

Kick-Off Meeting

October 13th-14th, 2009
IUL, TU Dortmund



Introduction to the project

Flexible and cost-effective innovative manufacturing of complex 3D-bent tubes and profiles made of high-strength steels for automotive lightweight structures

- List of Participants
 - Agenda
 - Summary of the Project
 - State of the Art
 - 3D-Bending of Profiles (TSS-Bending)
 - Incremental Tube Forming
 - Work and Time Table
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List of Participants



P1. Institute of Forming Technology and Lightweight Construction (IUL), TU Dortmund (TU Dortmund), Germany

Prof. Dr.-Ing. A. E. Tekkaya, Dr.-Ing. Uwe Dirksen, Dr.-Ing. habil. Sami Chatti, Matthias Hermes, Daniel Staupendahl, Christoph Becker

P2. TECOS Slovenian Tool and Die Development Center, Slovenia

Dr. Gašper Gantar

P3. ASCAMM Technology Centre, Spain

Benjamin Cavallini , Fernando Porcel

P4. Spanish Rapid Manufacturing Association (ASERM), Spain

Felip Esteve Oró

P5. Centro Ricerche Fiat S.C.p.A. (CRF), Italy

Dr. Massimo Tolazzi

P6. Forschungsvereinigung Stahlanwendung e. V. (FOSTA), Germany

Dr. Hans-Joachim Wieland

P7. Faurecia Sièges d'Automobile (FAURECIA), France

Dr. Hosen Sulaiman, Philippe Ducreuzot, Thomas Schulte

Agenda

Tuesday, October 13th



- 13:00 – 13:30 welcome and snack
- 13:30 – 15:00 project introduction, overview of WP1 – WP6
introduction of the project partners (10 min each)
- 15:00 – 15:45 discussion of the grant agreement
- 15:45 – 16:00 coffee break
- 16:00 – 17:00 guided tour of the IUL Laboratory, presentation of the bending processes used in the ProTuBend project
- 17:00 – 18:30 discussion of WP1, definition of the technological requirements and the demonstrator
- 18:30 transportation to the Mercure Hotel in Dortmund
- 20:00 dinner

Location: Room 219 of the GBIV, TU Dortmund,
Baroper Str. 301, 44227 Dortmund, Germany

- 08:30 pick up from Mercure Hotel, transportation to the IUL
- 09:00 – 09:15 summary of the results of the WP1 discussion
- 09:15 – 10:45 discussion of WP2 tasks 2.1 – 2.3
- 10:45 – 11:00 coffee break
- 11:00 – 12:00 discussion of WP2 tasks 2.4 – 2.7
- 12:00 – 13:00 further proceeding
- 13:00 lunch

- Profiles and tubes from new steel grades are important for the realization of ultra-light component structures with contour complexity in automotive industry.
- An unsolved problem so far is the cost-effective and reliable manufacturing of these components.
- The aim of the project is to advance two new forming processes for an industrial use capable of forming and bending load-optimised 3D-tubes and profiles made of high- and ultra-high-strength steel.
- These processes (3D-profile bending and incremental tube forming) offer the opportunity of a free selection and reliable manufacturing of the bending contour.
- The superposition of stresses increases the process stability and predictability by minimization of springback.

- Different machine concepts available in industry.
- Stretch bending is the most suitable procedure to bent profiles three-dimensionally. Mainly used in automotive industry for mass production

Advantages:

- The material is completely plasticized during stretch bending by means of a tensile device stretching the profile in the longitudinal direction
- This stress superposition leads to reduced cross-sectional deformation and springback
- high shape and measurement accuracy as well as high reproducibility

Disadvantages:

- Low flexibility (for each profile, a new tool is necessary)
- Variations in material properties and cross-section must be low
- Very expensive tools and machines
- Increasing costs when bending long profiles and large cross sections

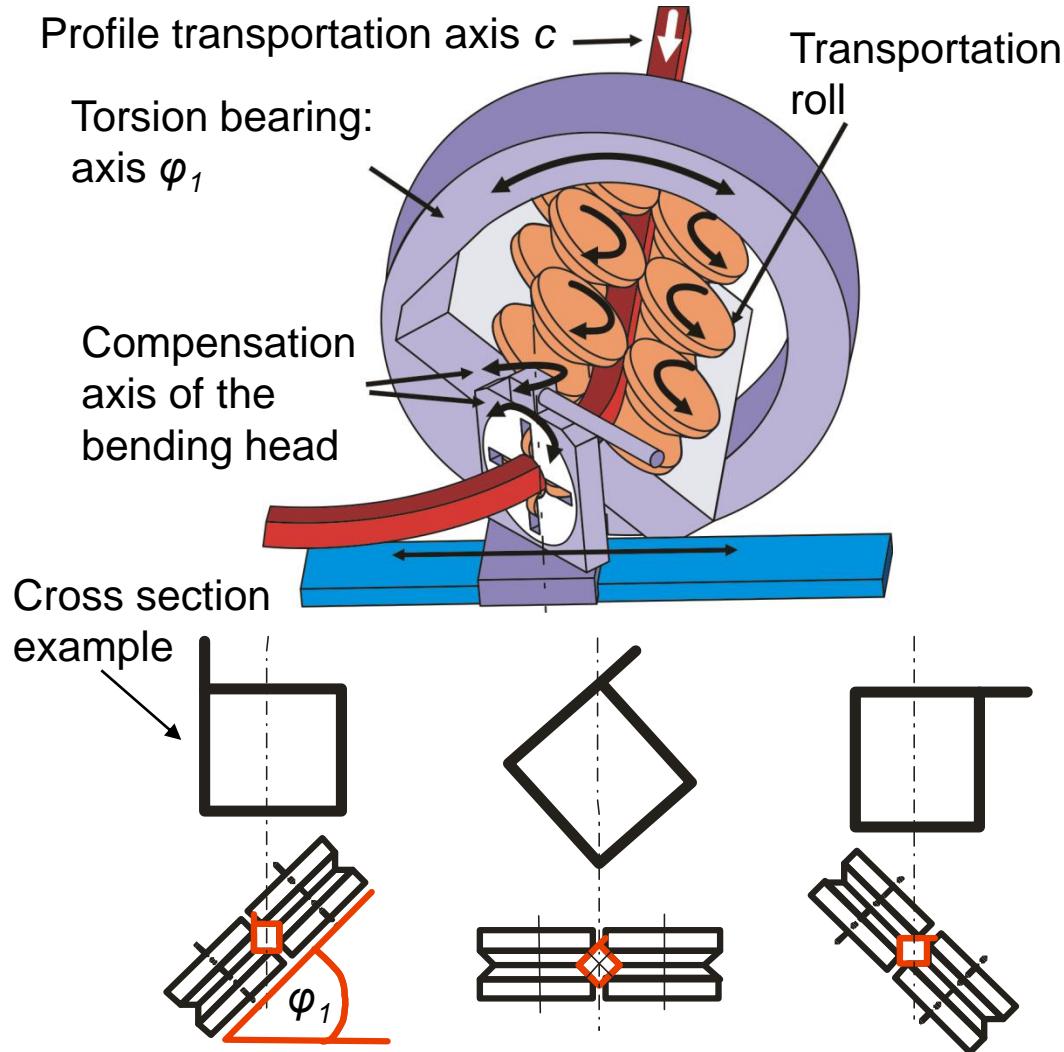
- Different machines based on a similar principle of kinematic shaping
- The tube is pushed by means of a pusher through a fixed bending tool and through a movable die and bent by a given motion of the die at a simultaneous feed-in motion of the longitudinal tube axis
- Well known machines: Hexabend, Nissin, MiiC, and TKS-MEWAG

Advantage:

- A tool change is not necessary when changing the bending contour

Disadvantages:

- Relatively high forming forces
- Cross-sectional deformations and friction problems at the deflecting dies
- Problem of predicting the tube bending contour, low process reliability
- Only bending of tubes with constant diameter is possible
- Use of high- and ultra-high-strength steel is problematic
- No targeted adjustment of variable material characteristics over the tube longitudinal axis



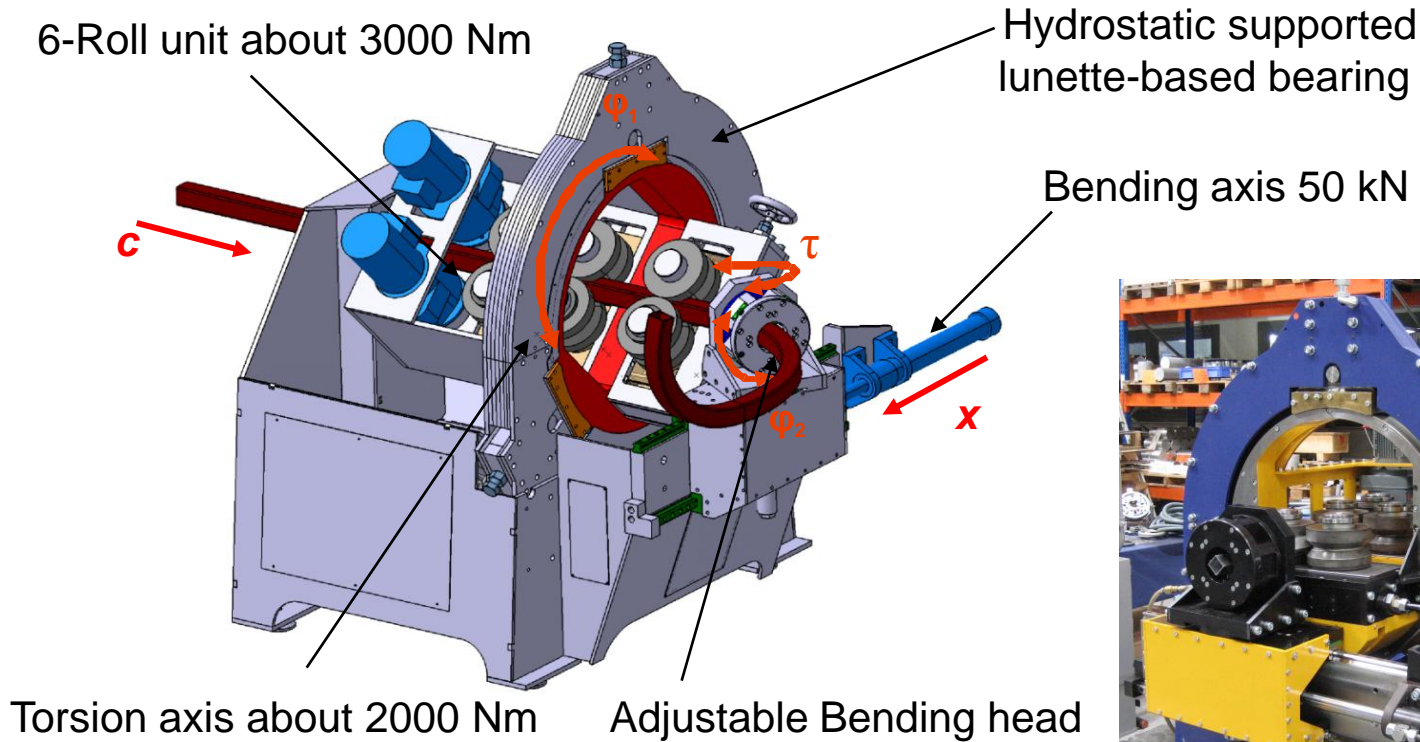
Potentials of the new process

- 3D-bending operations are possible
- Evolutions of roll bending, so no pusher system is needed
- Low cost tooling
- Profile leaves the process always in the same plane, so online measurement is possible
- Unsymmetrical cross sections can be bent because of defined superposition of torsion moments with the forming zone

Adjustment of the bending plane by superposed torsion moment

International patented

New Machine Set-Up (TSS-Bending)



- Bending moment about 21000 Nm
- Roll-based drive allows appliance at the end of continuous production processes, e.g. at the end of a roll forming mill.
- Torsion stress superposition by induced difference between φ_1 and φ_2 .

International patented

The TSS-Bending Machine



Sponsored by the German Research Foundation (DFG)

- 3 CNC-Axes
- Extension to 5 CNC-Axes in work
- LabView-based PC-control
- Manuel and software-controlled use

Performance data

Feed: 2 asynchronous motors 2950 Nm

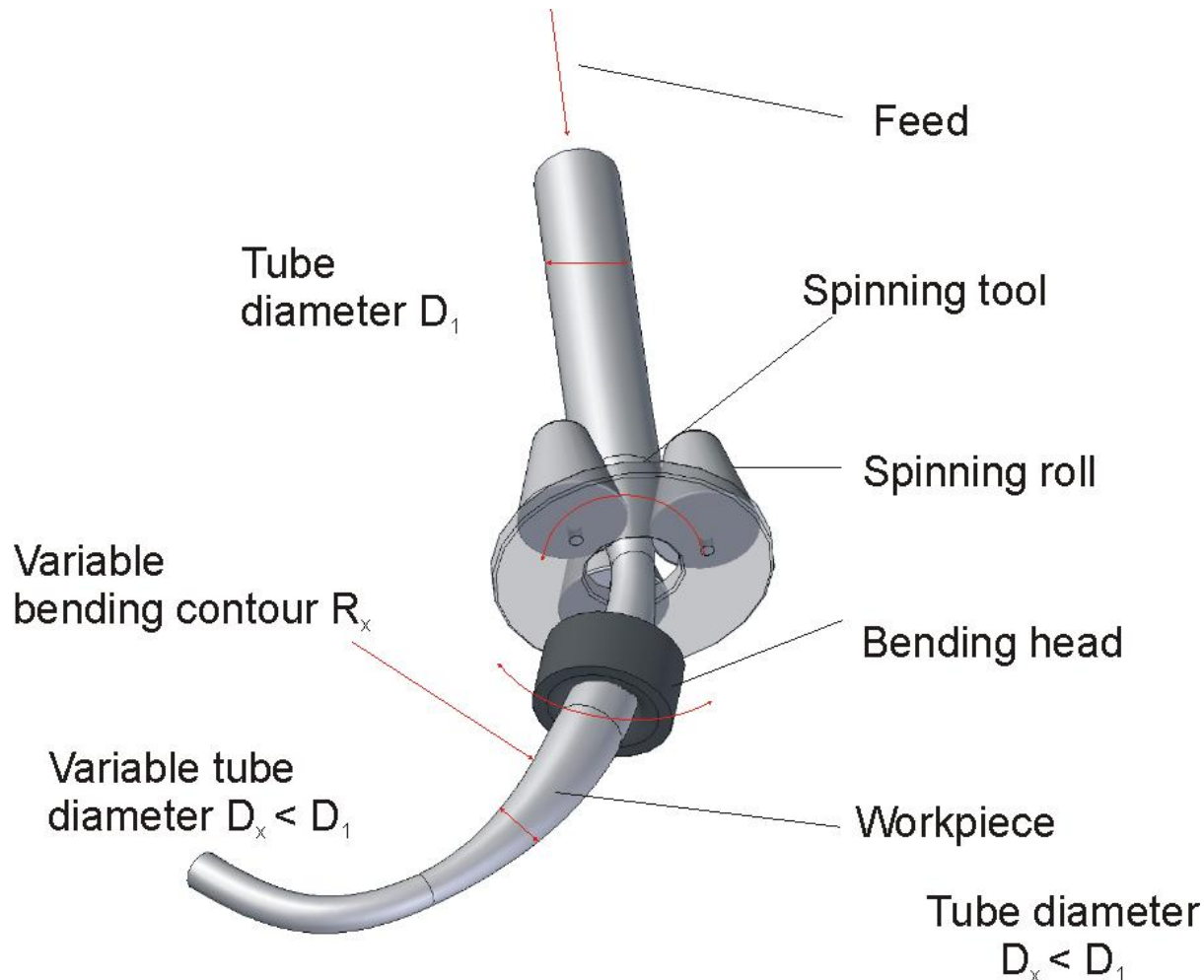
Swivel axis: Servo-motor 2000 Nm

Bending axis: symmetric 50 kN, max. 80 kN

Profile: 65 x 65 mm or $\varnothing 65$ mm (asymmetric Profile cross-section), unlimited length

Incremental Tube Forming: 3D-Bending of Tubes with Cross Section Adjustment

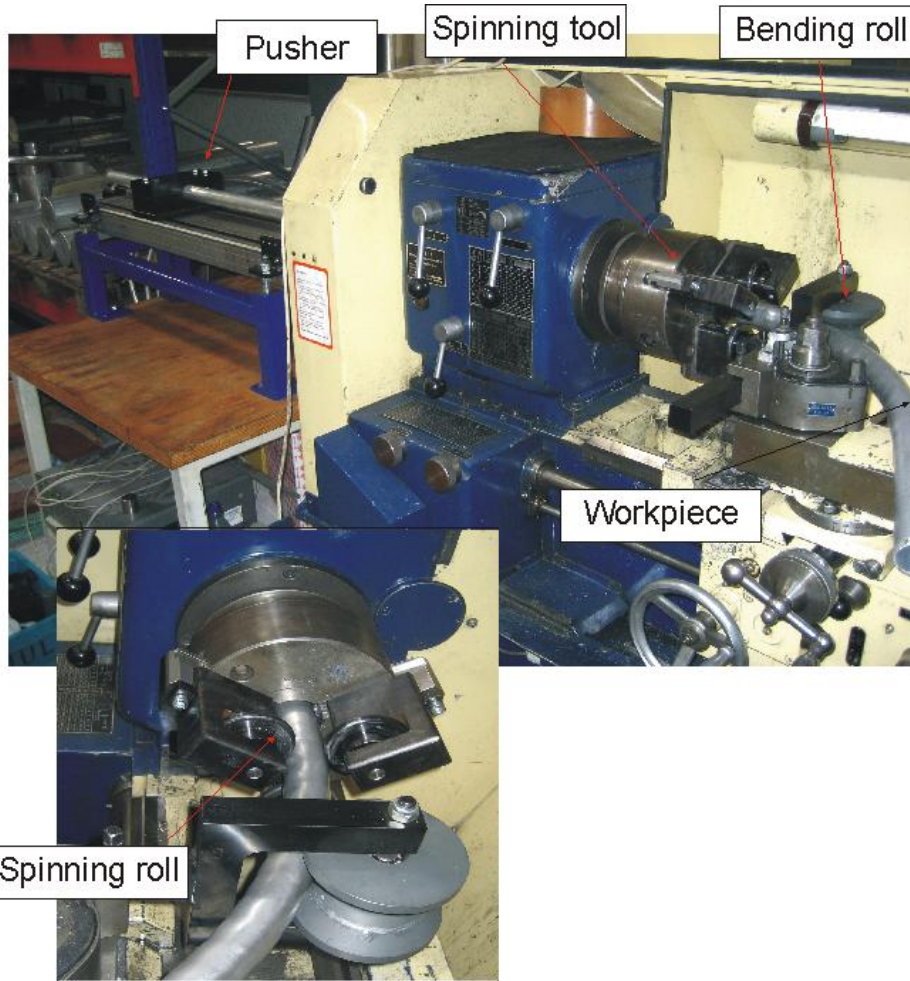
Incremental Tube Forming IRU



Potentials

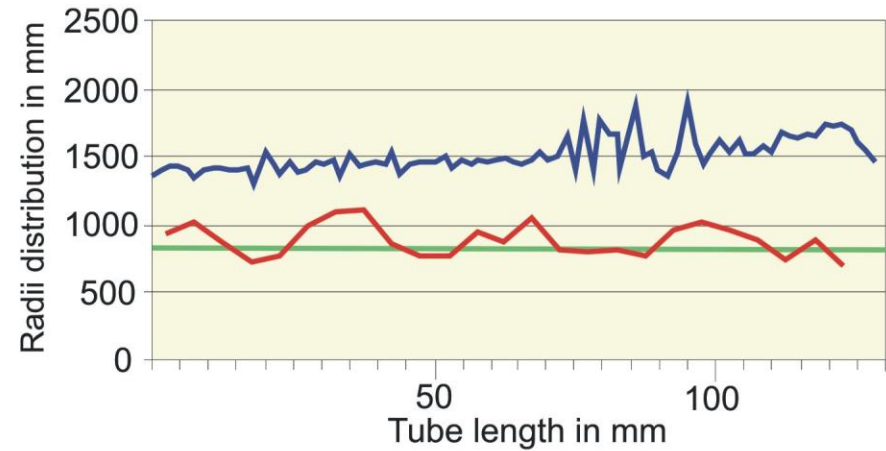
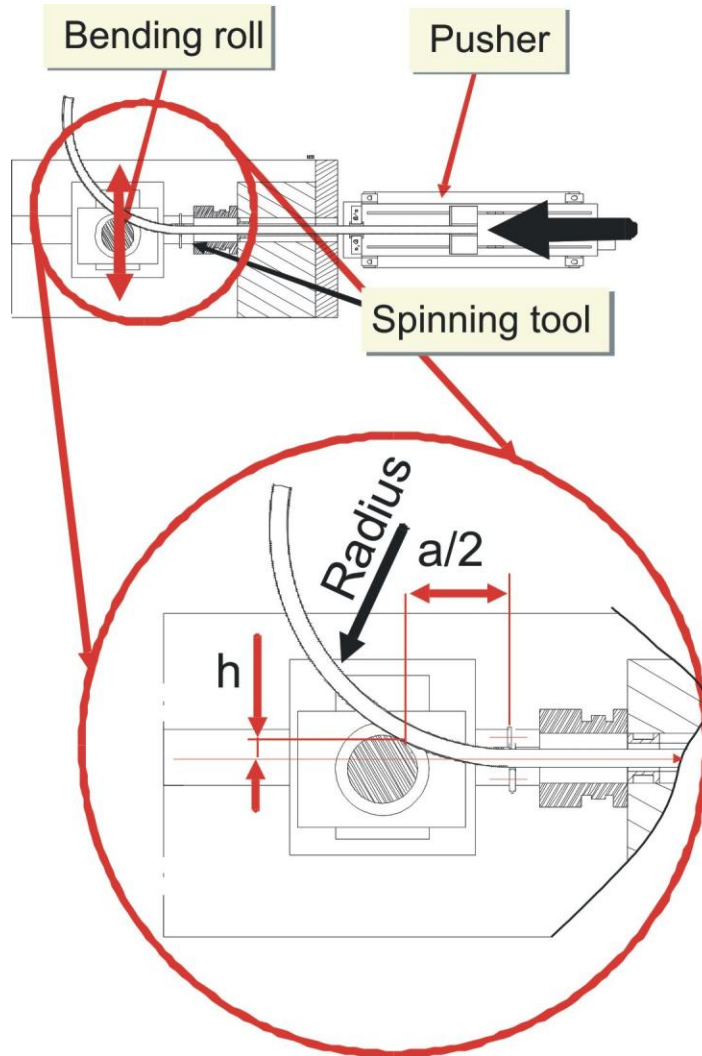
- Flexible bending of 2D- and 3D-contours
- Variable diameters along the longitudinal tube axis
- Springback reduction
- Bending of new materials like high strength steels
- Bending of tubes with small wall thickness
- Defined material hardening
- Enhancement of workpiece roundness

Experimental Set-Up and First Bent Tubes



First experiments are realised on a extended turning lathe

Reduction of Springback in Incremental Tube Forming



- $n = 350$ 1/min, $h = 11$,
spinning roll adjustment: $d = 0.5$
 - $R_{Sec} = 896$ mm, $h = 11$, $R_{Sec} = \frac{a^2}{8h} + \frac{h}{2}$
 - $n = 0$ 1/min, $h = 11$, spindle stands.
Bending only by pusher
- Material: Al Mg Si0.5 (A6060)
Tube: $\varnothing 40 \times 2$

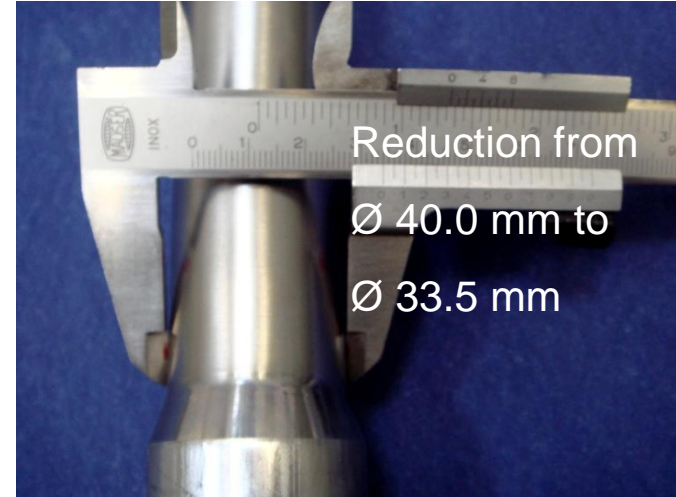
R_{Sec} = computed radius according to secant equation delivers a good accordance with radii distribution with superposed spinning process.

Obvious reduction of springback.

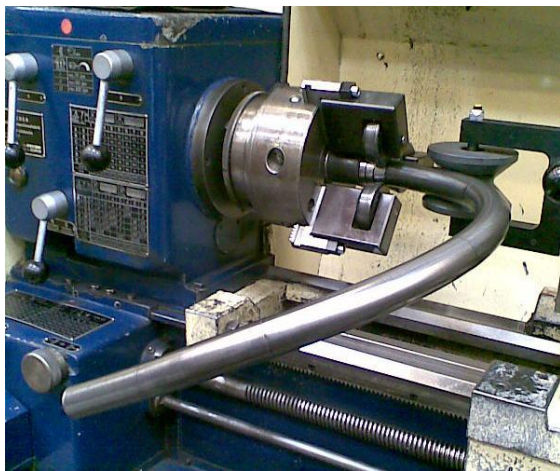
Components made by Incremental Tube Forming



Smallest Radius (well bent)



Largest diameter reduction



3D-Effect



Failure during reduction

Work and Time Table (1)



Work packages	Work packages' title	Leader	1st year				2nd year				3rd year					
			I	II	III	IV	I	II	III	IV	I	II	III	IV		
WP 1	Definition of specific requirements	CRF FAURECIA														
Task 1.1	Definition of technological requirements	CRF FAURECIA														
Task 1.2	Definition of demonstrators	CRF FAURECIA														
Milestones			M1.1													
WP 2	Investigation of the bending processes and process limits	TUDO														
Task 2.1	Exp. investigation of 3D-profile bending	TUDO														
Task 2.2	Num. investigation of 3D-profile bending	TECOS														
Task 2.3	Comparison of the analyses for 3D-PB	TUDO TECOS														
Task 2.4	Exp. investigation of inc. tube forming	TUDO														
Task 2.5	Num. investigation of inc. tube forming	ASCAMM														
Task 2.6	Comparison of the analyses for inc. TF	TUDO ASCAMM														
Task 2.7	Comparison of both processes	TUDO														
Milestones							M2.1	M2.2								

Work and Time Table (2)



Work packages	Work packages' title	Leaders	1st year				2nd year				3rd year						
			I	II	III	IV	I	II	III	IV	I	II	III	IV			
WP 3	Optimisation of the processes for new steel grades	TUDO															
Task 3.1	Establishment and selection of optimisation concepts	TUDO															
Task 3.2	FE-simulations for verification of the new tools	TECOS ASCAMM															
Task 3.3	Further development of tools and machines periphery	TUDO															
Milestones																	
WP 4	Improvement of the robustness of the production processes	TECOS															
Task 4.1	Selection of optimal optimisation strategy	TECOS															
Task 4.2	Development of optimisation system	TECOS															
Task 4.3	Optimisation of selected demonstrators	TECOS															
Milestones																	

Work and Time Table (3)



Work packages	Work packages' title	Leaders	1st year				2nd year				3rd year							
			I	II	III	IV	I	II	III	IV	I	II	III	IV				
WP 5	Test production and validation	TUDO																
Task 5.1	Manufacturing of demonstrators	TUDO																
Task 5.2	Parts re-design	CRF																
Milestones																		M5.1
WP 6	Project coordination and dissemination	TUDO																
Task 6.1	Dissemination	TUDO FOSTA																
Task 6.2	Project coordination	TUDO																
					M6.1													M6.3 M6.4