Structural Durability of MTH Welds

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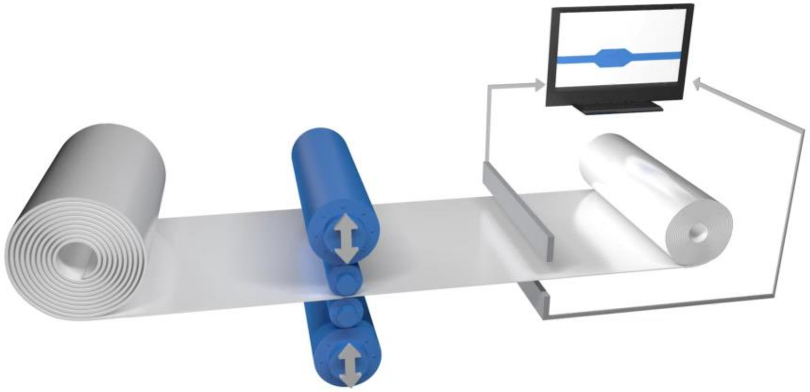
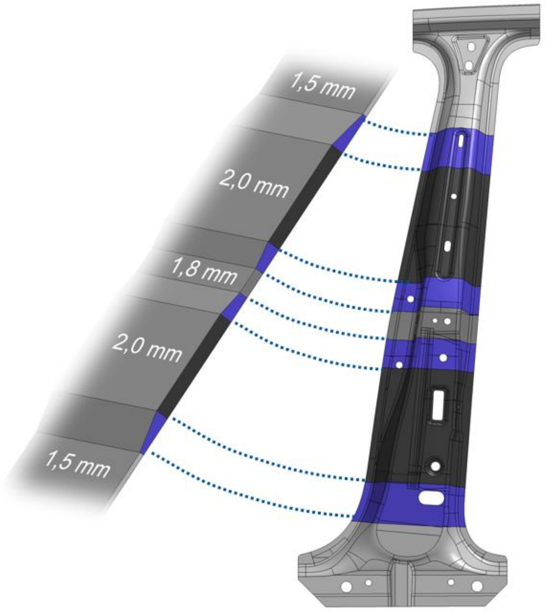
GREAT DESIGNS IN STEEL™

TRB – Tailor Rolled Blank (Flex Cold-Rolling)





Concept

- Cost efficient lightweight parts with load and function-optimized material usage

Implementation

- Flexible Cold-Rolling Process
- Flat material with repeated, varying thickness runs and harmonious transition zones
- Thickness run optimization drives the cost efficiency

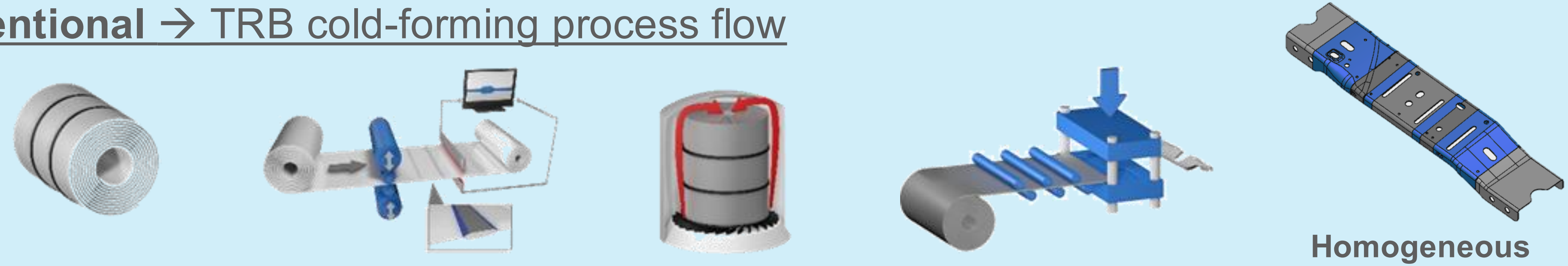
Targets / Benefits

- Part Integration / Design Simplification / Cost Optimization
- Weight Reduction
- Functional Improvement (Performance, Manufacturing, Quality)

Established Technology with over 20 years in Mass Production partnered with Several Renowned Global OEMs!

Mat. Innovation – Mubea TailorHardened (MTH)

Conventional → TRB cold-forming process flow



Raw Material (ex. HR420LA) | Flex Rolling | Batch Annealing | Part Production | Homogeneous mechanical properties “CR300 LA TRB“

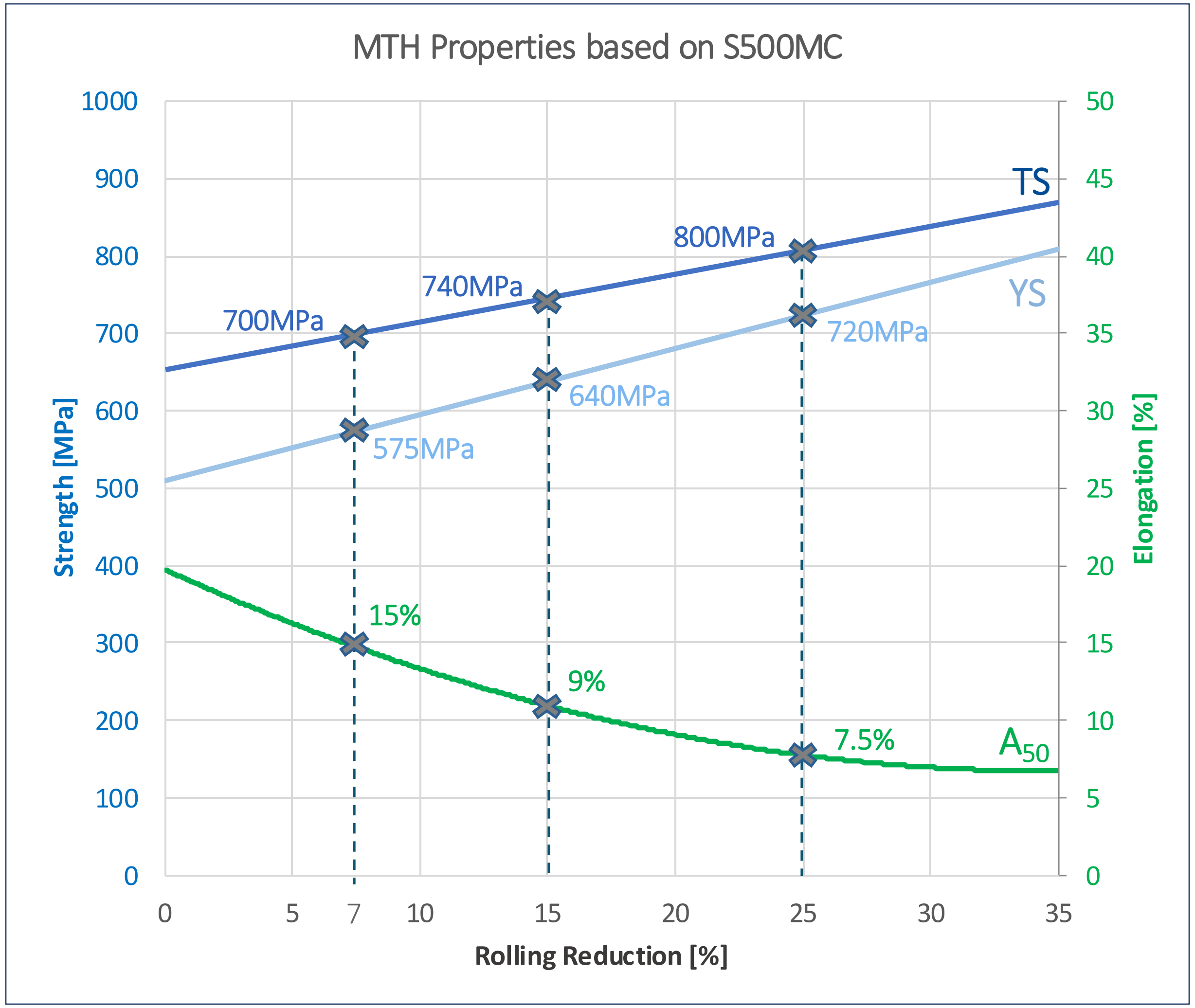
MTH → cost effective process flow

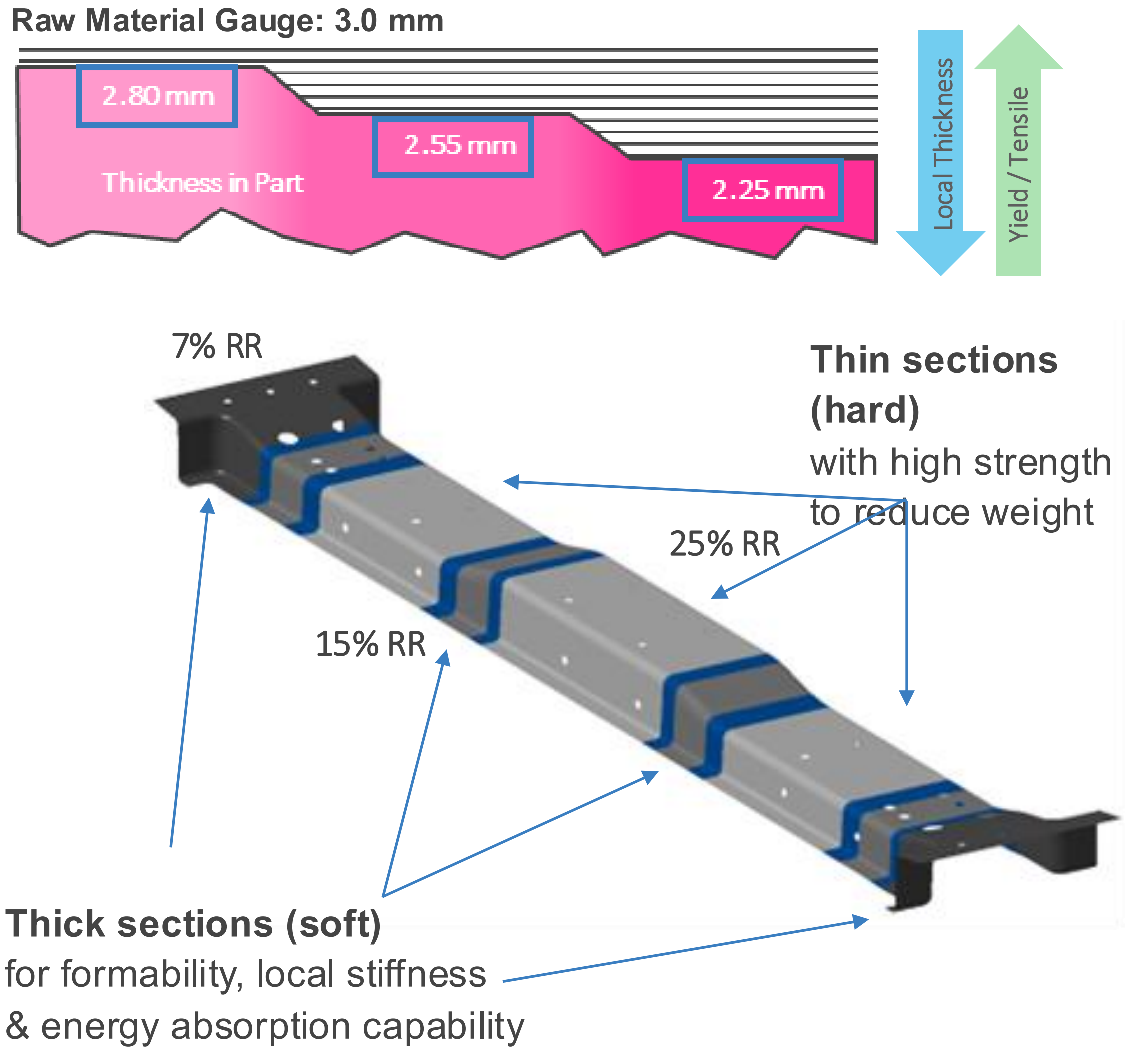
Raw Material (ex. DD13) | Flex Rolling | Batch Annealing | Part Production | TailorHardened mechanical properties ex. “MTH 300Y/370Y TRB“

Manufacturing Cost Reduction & Shorter Process Flow through Innovative Material Solution!

MTH – Mechanical Properties Behavior

Example: MTH575Y/720Y from HR500LA





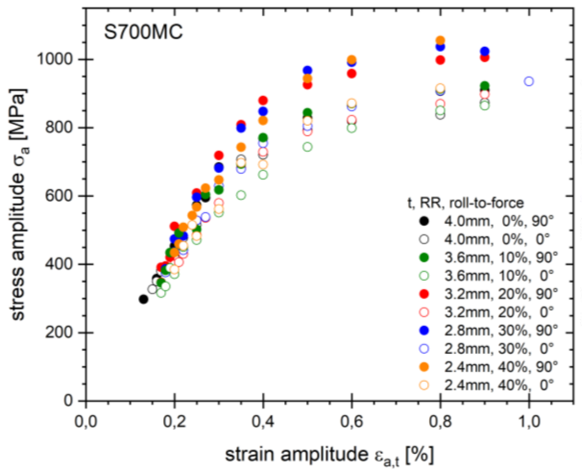
Cost Efficient Component Design & Manufacturing with Local Tailored Properties!

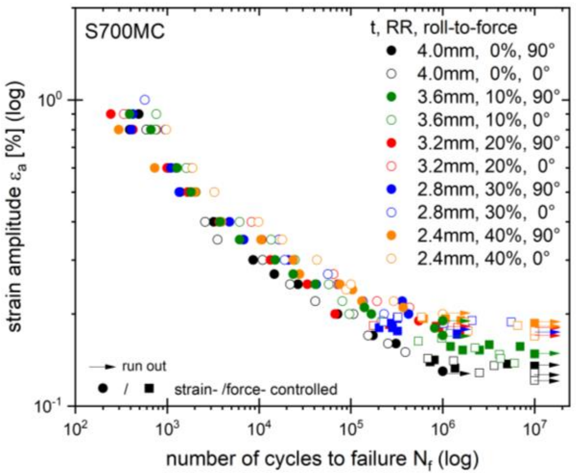
Fatigue Strength of MTH Steel / Recap of GDIS 2025

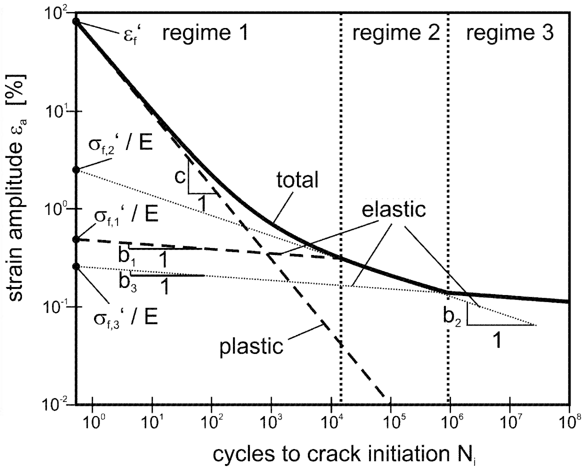
- MTH has a positive influence on the structural durability by increasing rolling reduction leading to:
  - Increase in fatigue life (reduced strain amplitude at same stress level)
  - Increase in fatigue strength (higher stress level for same strain amplitude)

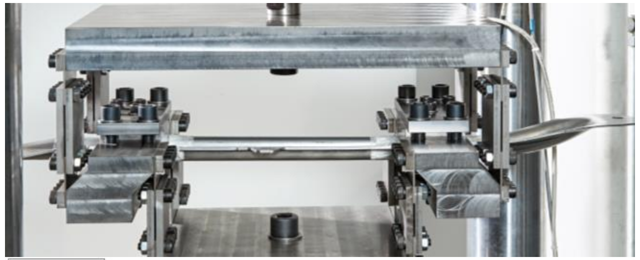
- The Fatigue-Life Curve provides much more accuracy compared to the traditional approaches (Basquin-Coffin-Manson-Morrow and Ramberg-Osgood)

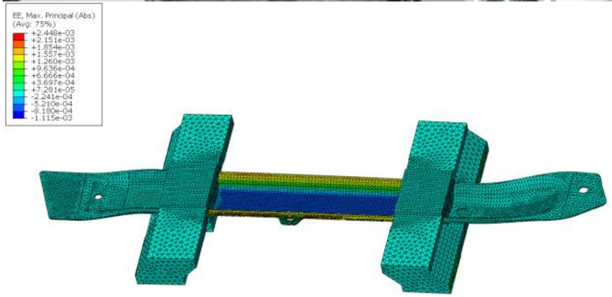
- Validation (Fatigue-Life Curve vs. experimental results) using automotive component shows satisfactory correlation





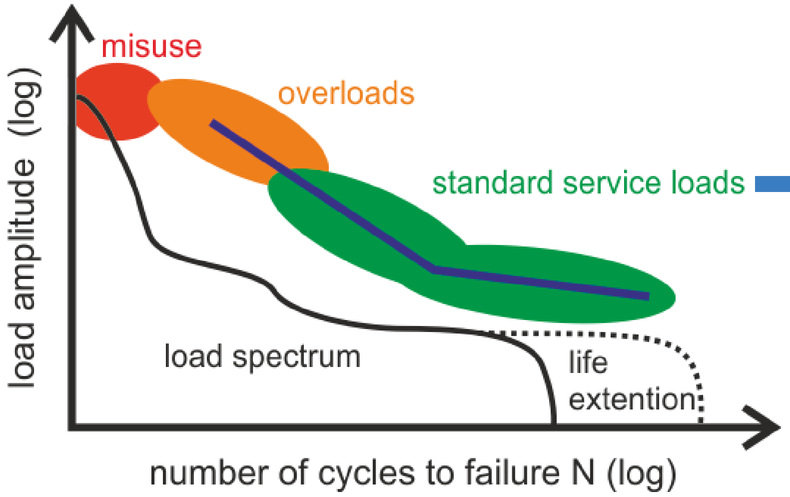


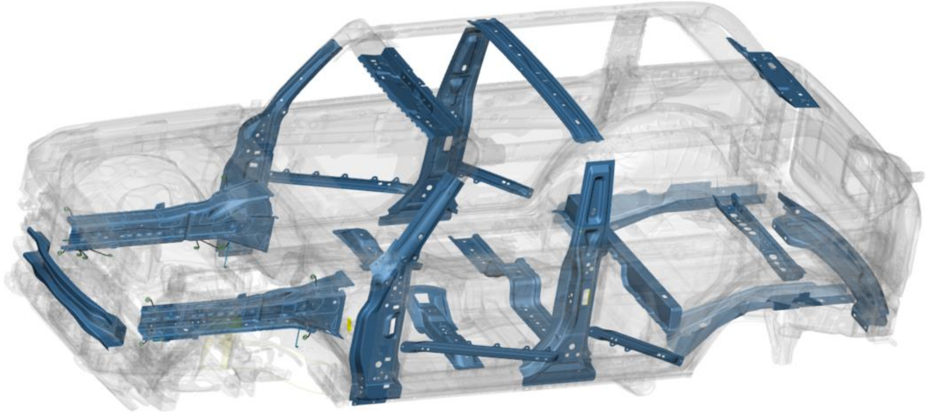




Motivation – Fatigue Approach

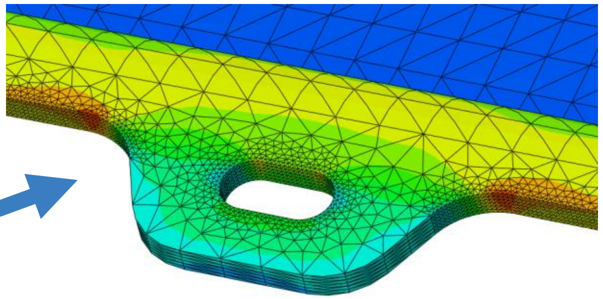
Service loading conditions



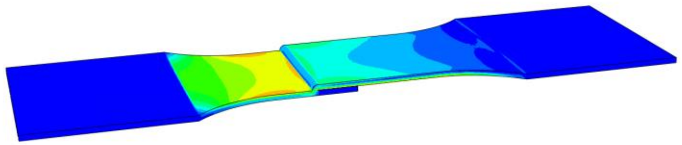


Component Design using MTH material

Deriving of material properties for CAE application



Investigation of fatigue performance of MTH welds compared to conventional grades



Next Step: Fatigue Performance of MTH Welds

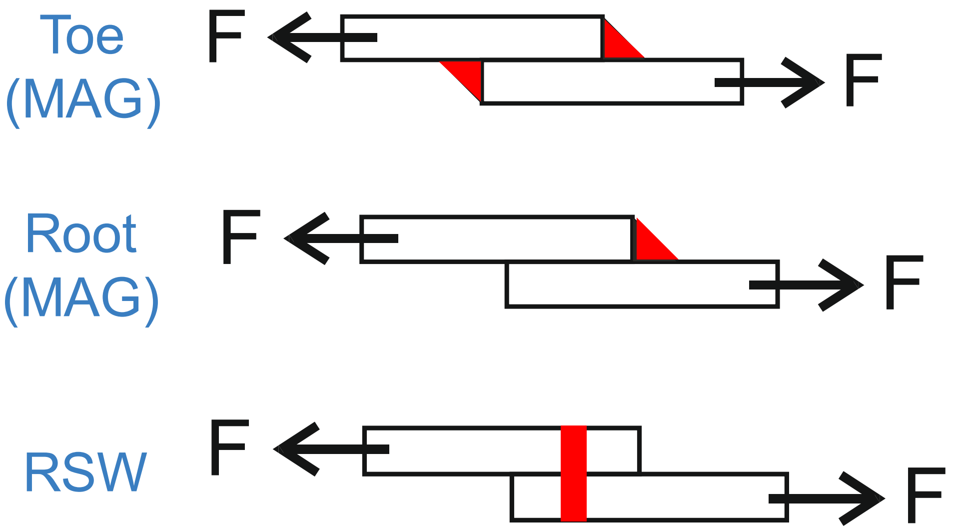
Test Campaign

- **Fatigue performance comparison of MTH vs. conventional, hot rolled grade**
- **3 different welding geometries (toe, root and spot)**
- Sample manufacturing according to SEP1220
- Force-controlled fatigue tests according to ISO 12107, DIN 50100
- Total length of all specimens 225 mm, free clamping length 120 mm

For each geometry:

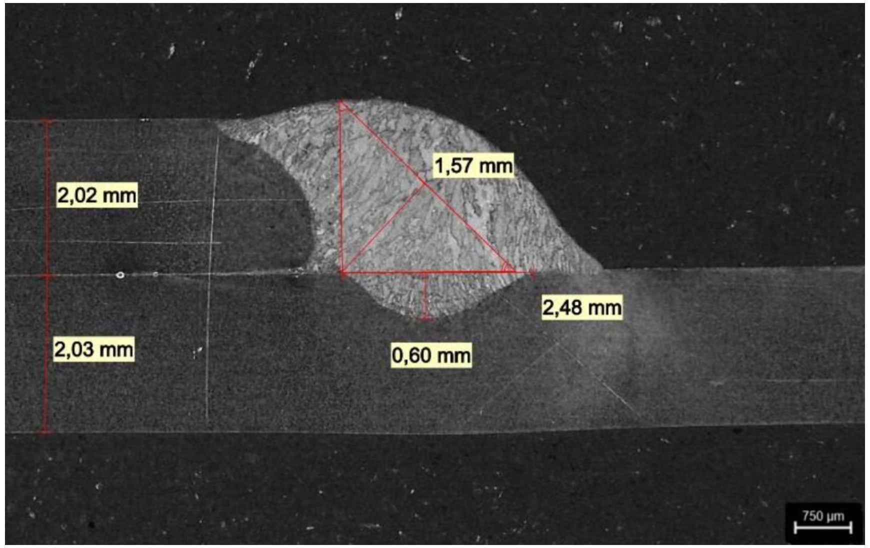
Material	Rolling Reduction	Condition
DD13	RR= 0%	Hot rolled
DD13	RR= 40%	MTH
S420MC	RR= 0%	Hot rolled

Weld concepts and loading application

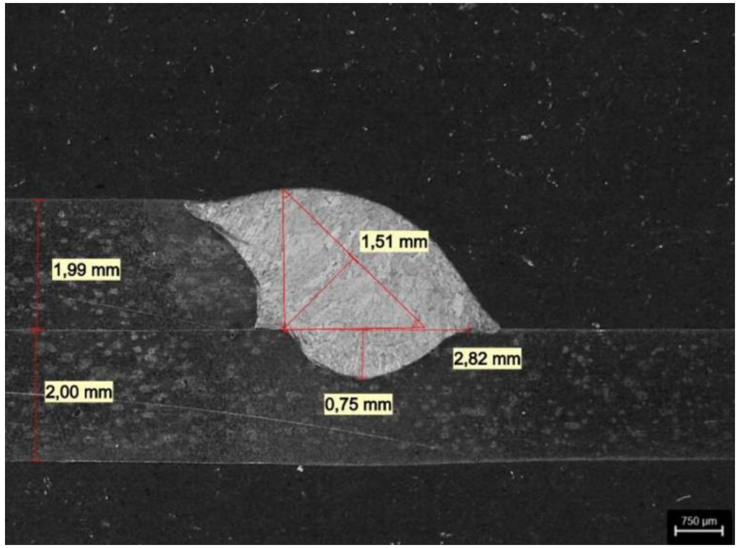


Toe/Root Welding Parameters and Micrographs

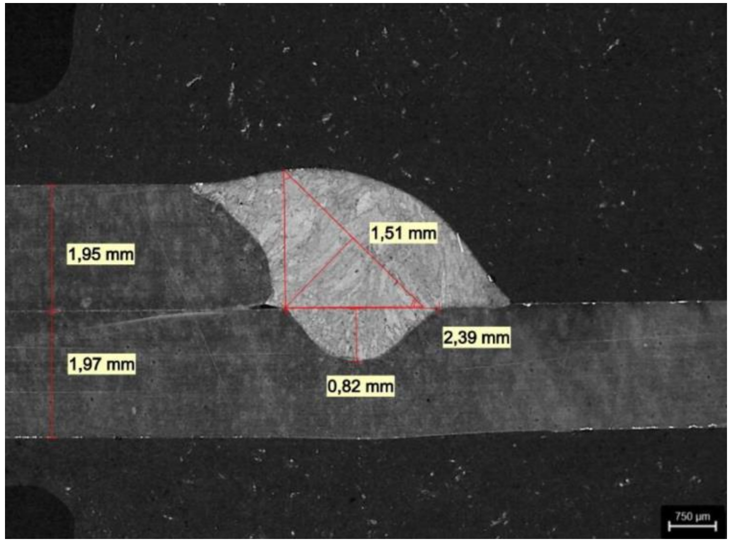
DD13 RR=0%



DD13 RR=40%



S420MC RR=0%



Welding parameters:

Welding filler material:	G3Si1
Wire diameter d_D:	1.00 mm
Welding speed v_D:	3.7 m/min
Nominal sheet thickness:	2.00 mm

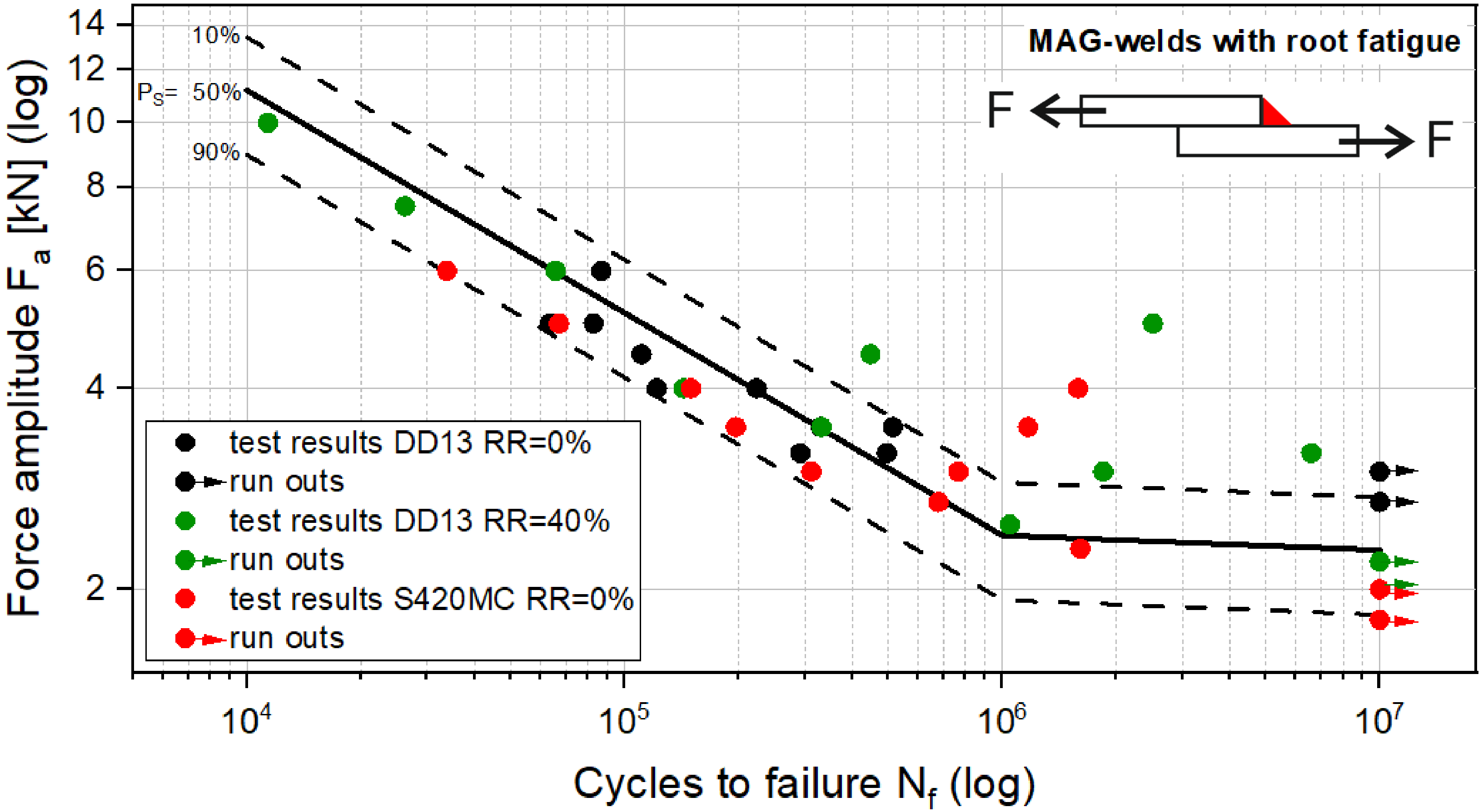
The same parameters were used for all materials.

The weld geometries meet the requirement according to SEP1220.

Micrograph details:

Magnification:	20:1
Cutting:	Transverse
Etching:	3% Nitral
Position:	In the middle of the seam

Test Results for MAG-Welds with Root Fatigue

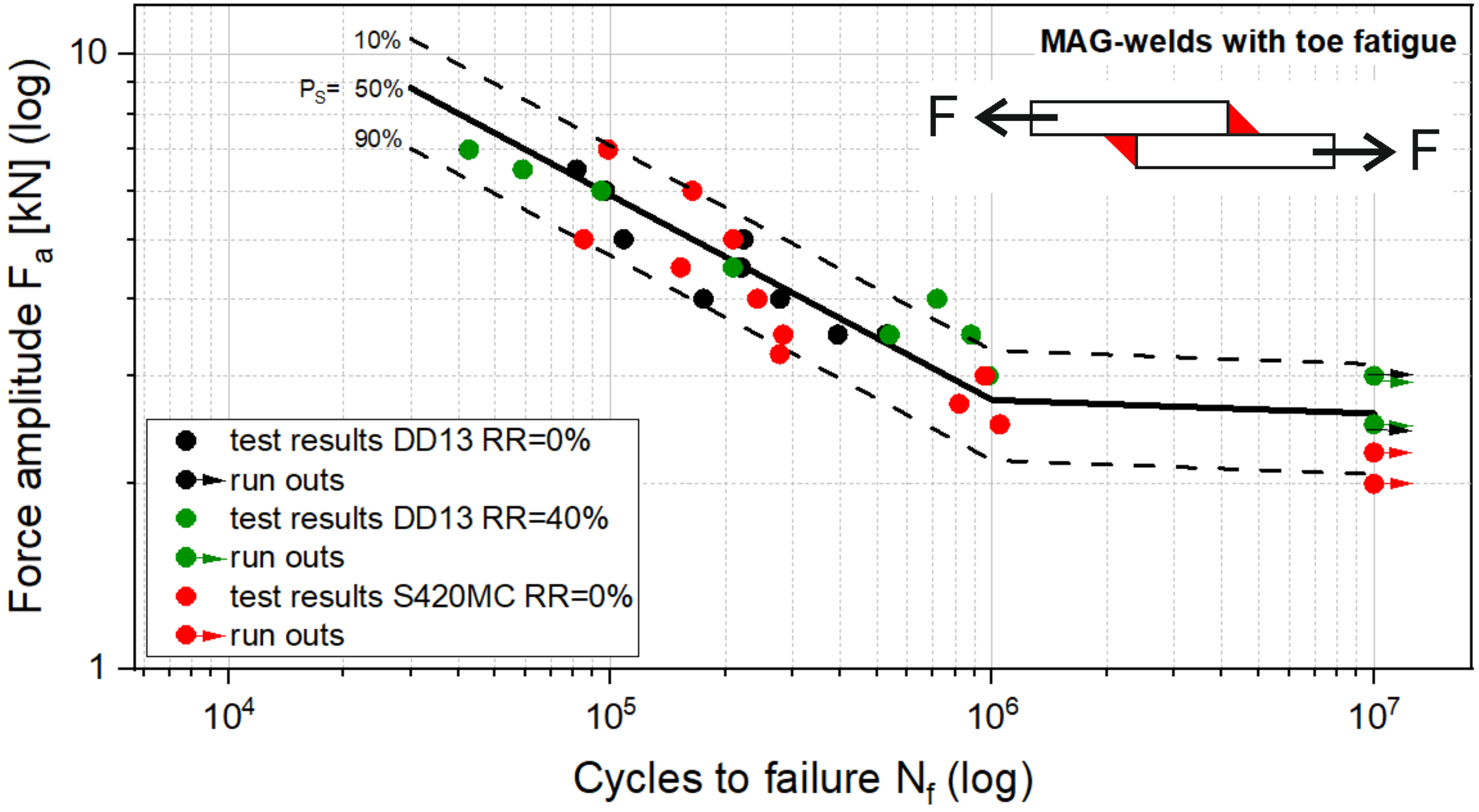


- Statistical evaluation was done considering all results of all three steel grades.
- All steel grades investigated with the root MAG-welding concepts show comparable fatigue strength.
- Results are within the scatter band evaluated and documented in the literature accepted by the industry for fatigue investigations of welded joints. [1,2]

[1] Forschungskuratorium Maschinenbau. Rechnerischer Festigkeitsnachweis für Maschinenbauteile. 7. Aufl. Frankfurt: Forschungskuratorium Maschinenbau, 2020.

[2] Hobbacher, A. F.; Baumgartner, J.: Recommendations for Fatigue Design of Welded Joints and Components. Third Edition, Springer International Publishing, 2024. DOI: 10.1007/978-3-031-57667-6

Test Results for MAG-Welds with Toe Fatigue

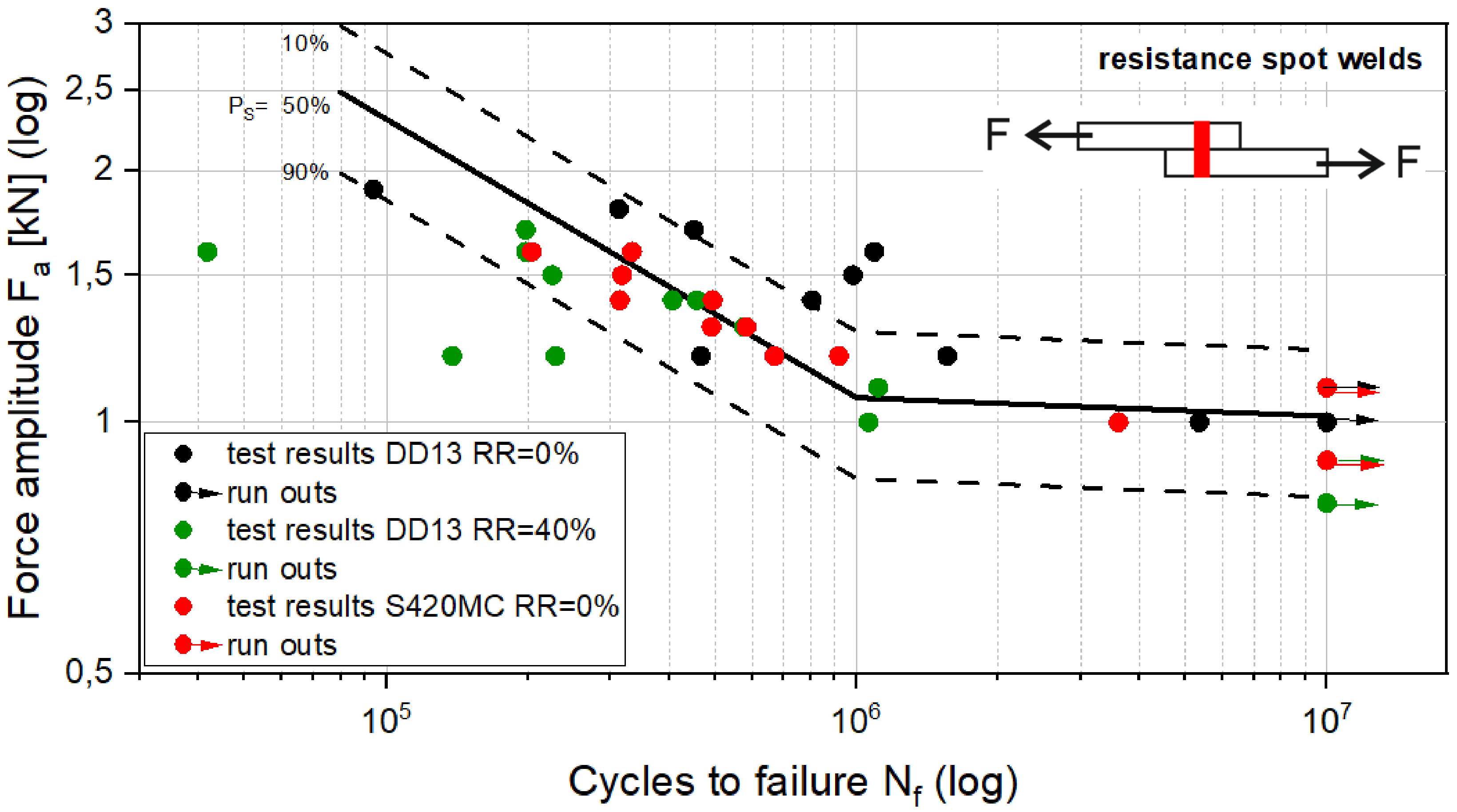


- Statistical evaluation was done considering all results of all three steel grades.
- All steel grades investigated with the toe MAG-welding concepts show comparable fatigue strength.
- Results are within the scatter band evaluated and documented in the literature accepted by the industry for fatigue investigations of welded joints. [1,2]

[1] Forschungskuratorium Maschinenbau. Rechnerischer Festigkeitsnachweis für Maschinenbauteile. 7. Aufl. Frankfurt: Forschungskuratorium Maschinenbau, 2020.

[2] Hobbacher, A. F.; Baumgartner, J.: Recommendations for Fatigue Design of Welded Joints and Components. Third Edition, Springer International Publishing, 2024. DOI: 10.1007/978-3-031-57667-6

Test Results for Resistance Spot Welds



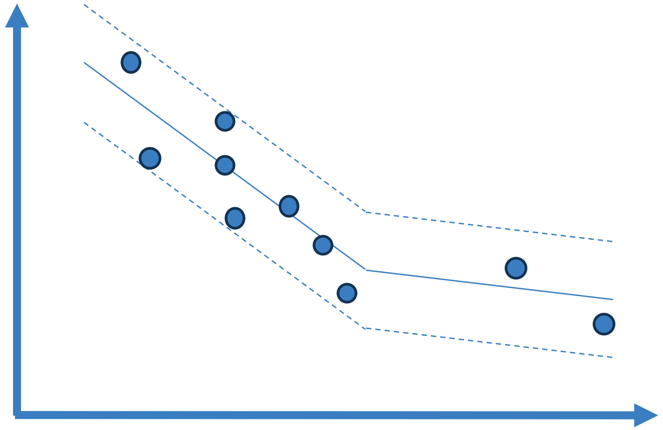
- Statistical evaluation was done considering all results of all three steel grades.
- All steel grades investigated with the resistance spot welding concepts show comparable fatigue strength.
- Results are within the scatter band evaluated and documented in the literature accepted by the industry for fatigue investigations of welded joints. [1,2]

[1] Forschungskuratorium Maschinenbau. Rechnerischer Festigkeitsnachweis für Maschinenbauteile. 7. Aufl. Frankfurt: Forschungskuratorium Maschinenbau, 2020.

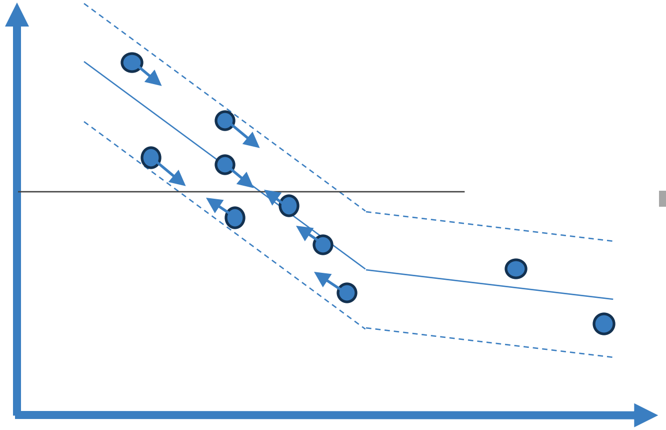
[2] Hobbacher, A. F.; Baumgartner, J.: Recommendations for Fatigue Design of Welded Joints and Components. Third Edition, Springer International Publishing, 2024. DOI: 10.1007/978-3-031-57667-6

Statistics

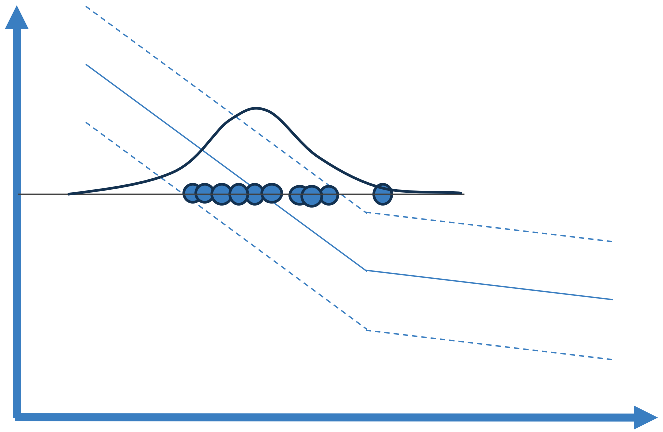
Normal Scores According to Rossow



Start: Woehler curve

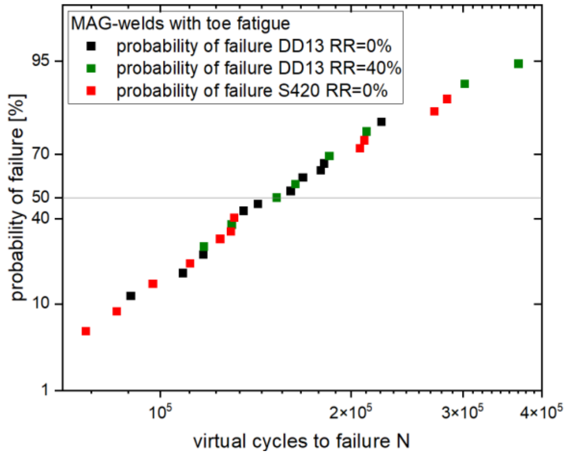


First step: Move the datapoints up onto one Force amplitude level parallel to the slope of the Woehler curve (k=3 here)

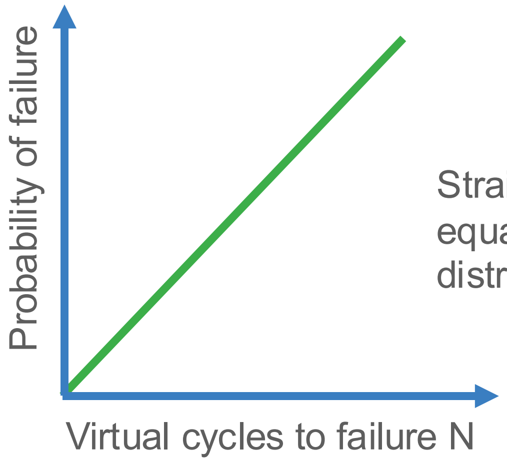


Second step: Assume normal distribution and assign a probability of survival to each data point

Amplitude	Cycles	Virtual cycles	Probability of survival
X	Y	Z	P
X	Y	Z	P
X	Y	Z	P



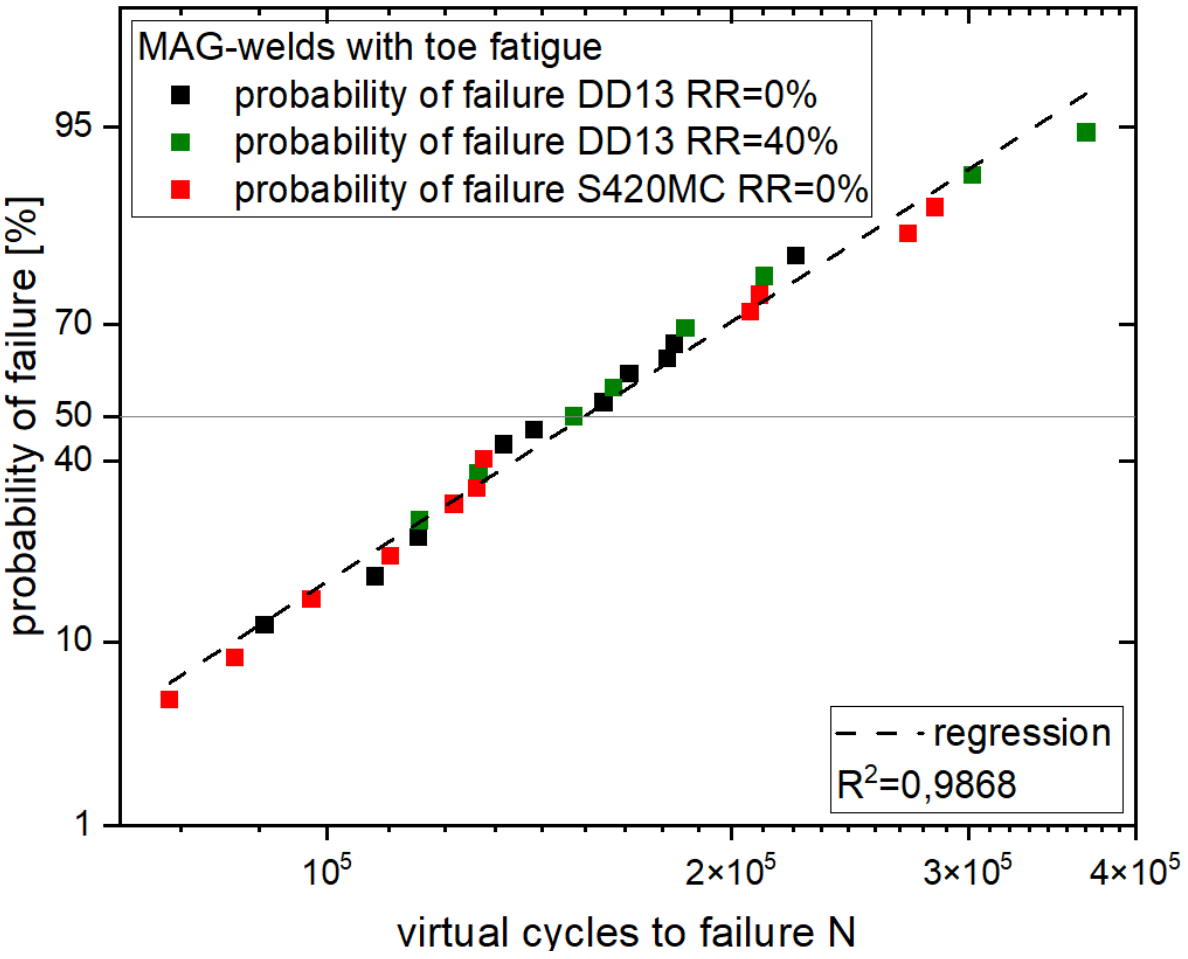
Third step: Visualization on probability graph paper

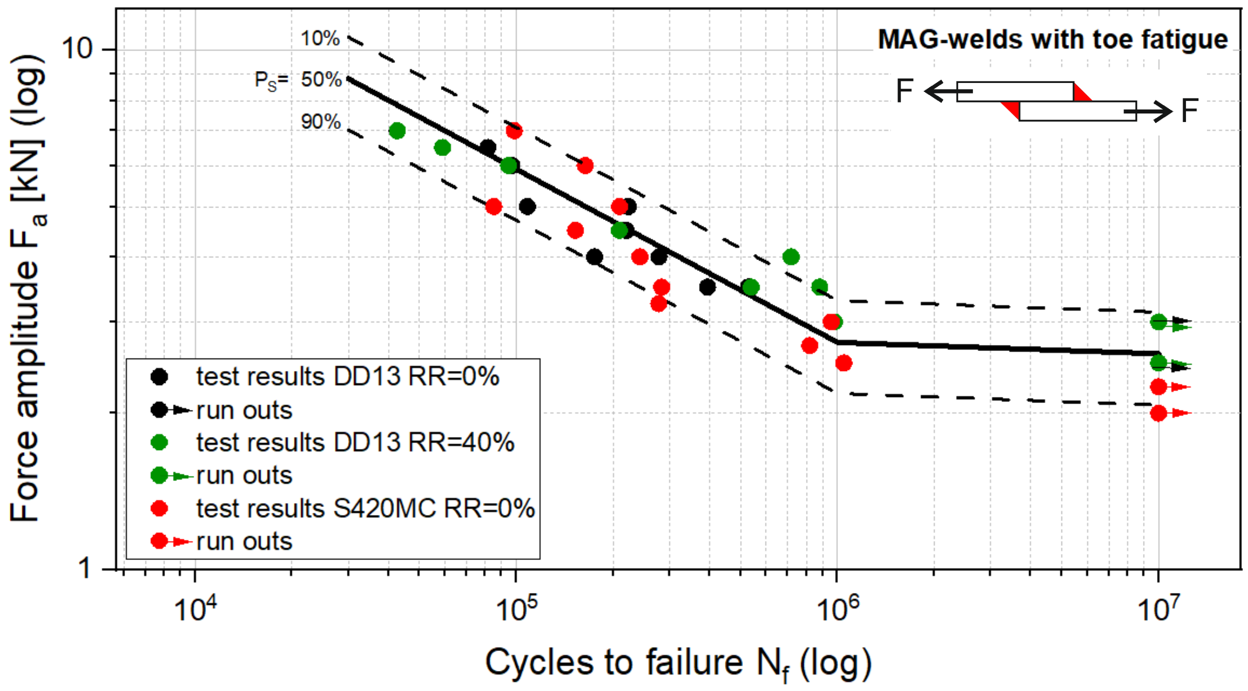


Straight line equals normal distribution

[3] Rossow, E.: Eine einfache Rechenschiebernäherung an die den normal scores entsprechenden Prozentpunkte, *In: Zeitschrift für wirtschaftliche Fertigung* 59 (12), Berlin, 1964.

Normal Scores According to Rossow





The fatigue results of all three material conditions lie on a normal distribution reflecting similar fatigue performance. This has been also observed for the resistance spot welds and the root concept.

Summary

Steel Sheets – GDIS 2025 (recap)

- MTH has a positive influence on the structural durability by increasing rolling reduction leading to:
  - Increase in fatigue life (reduced strain amplitude at same stress level)
  - Increase in fatigue strength (higher stress level for same strain amplitude)
- The Fatigue-Life Curve provides much more accuracy compared to the traditional approaches (Basquin-Coffin-Manson-Morrow and Ramberg-Osgood)
- Validation (Fatigue-Life Curve vs. experimental results) using automotive component shows satisfactory correlation

Welded joints – GDIS 2026

- MTH material shows similar fatigue performance on welded joints using the same welding concept/technology as conventional hot-rolled steel.
- Fatigue results on all three welding concepts follow a normal distribution
- Fatigue life/ survival probability of welded joints using MTH material can be estimated using standard approaches [3]

[3] Rossow, E.: Eine einfache Rechenschiebernäherung an die den normal scores entsprechenden Prozentpunkte, *In: Zeitschrift für wirtschaftliche Fertigung* 59 (12), Berlin, 1964.

Thank you for your attention!

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