Fatigue behavior of modified aluminum alloys for casts used in e-mobility applications based on different casting processes and the use of recycled material

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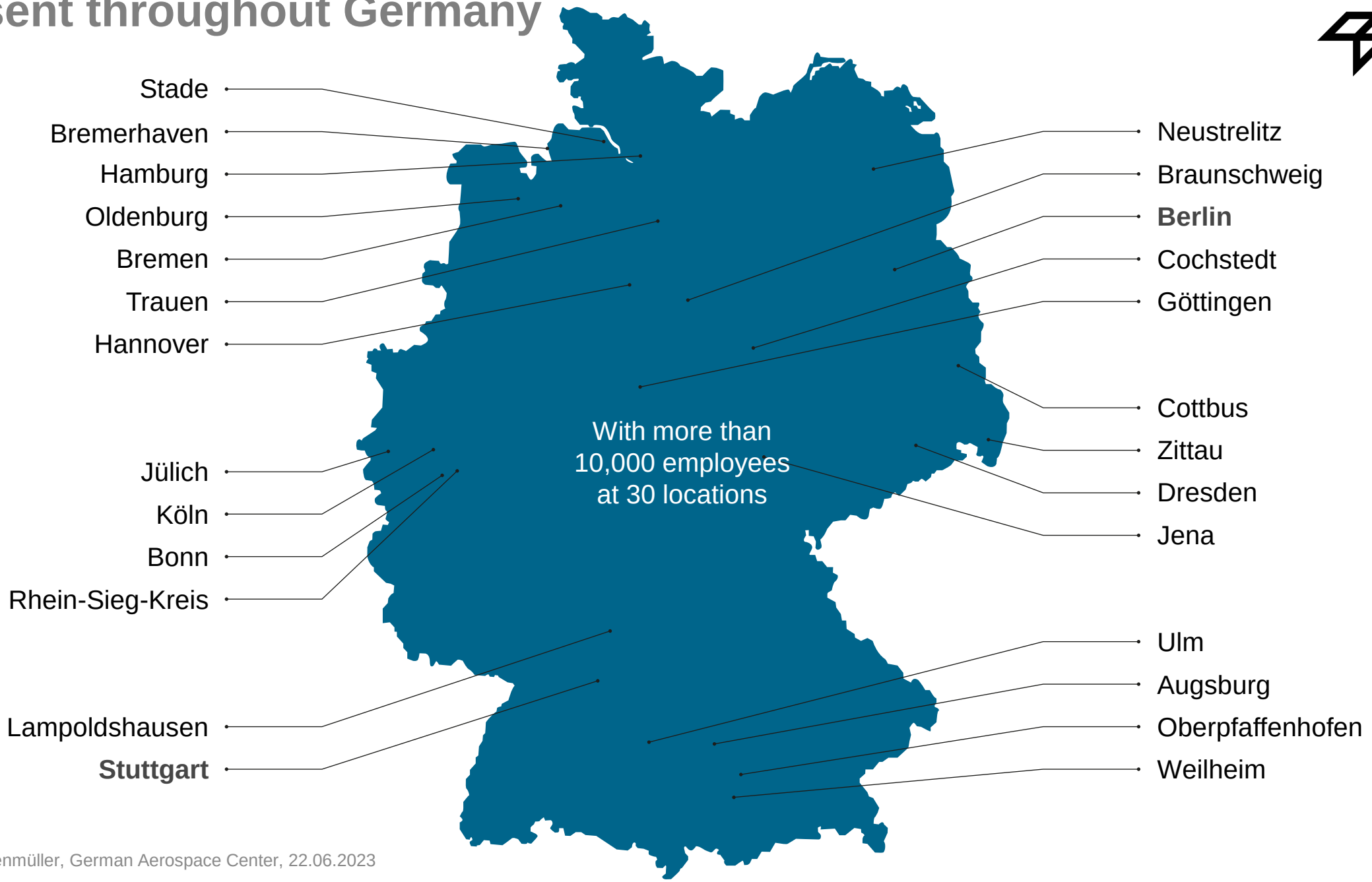
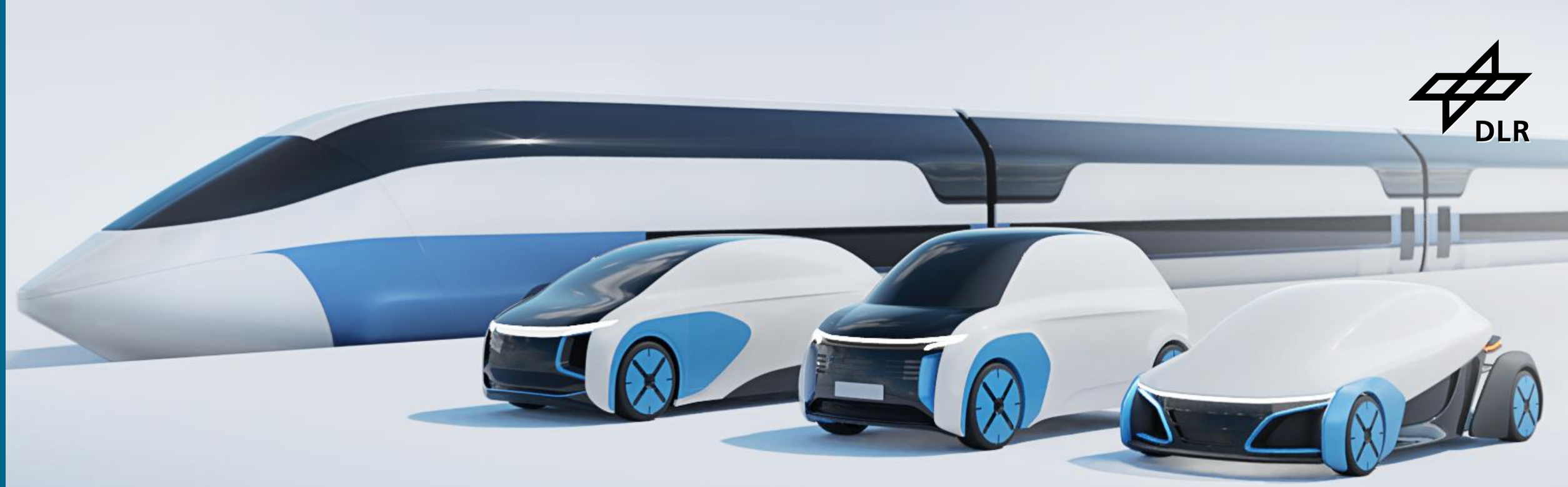
Agenda

1. About Us
2. Project InDrutec-E
3. Approach and Setup
4. Results
5. Conclusion and Outlook

ABOUT US

Present throughout Germany





Material and Process Applications for Road and Rail Vehicles	Vehicle Architectures and Lightweight Design Concepts	Vehicle Energy Concepts	Alternative Energy Converters	Vehicle Systems and Technology Assessment

INSTITUTE OF VEHICLE CONCEPTS – OUR RESEARCH FIELDS

PROJECT INDRUTEC-E

InDrutec-E

The consortium

Industry partner

BOSCH

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Objectives and Measures

Objectives

Reduction of the component weight

Cost reduction

Reduction of the CO_2 footprint

Reduction of scrap rates

Measures

- Constructive optimization
- Alloys of higher strength
- Magnesium as a lightweight option

- Reduced material usage
- Improved manufacturing processes
- High recycled material content

- Optimized aluminum secondary alloys
- Lightweight construction

- Vacural® casting for magnesium as an improved production technology
- New mech. machining solutions

APPROACH AND SETUP

Approach

Parts for the electric drive unit

Requirements:
- Light weight
- Good fatigue strength
- Cheap
- Good castability

Standard die casting alloys

Properties:
- Cheap
- Well experienced for die casting applications
- Good castability
- Age-hardened

State of the art

Alternative?

High recycling content

Special casting process

Structural casting alloys

Properties:
- Special alloying composition
- Special production methods
- More expensive
- Self-hardening

Materials and Processes

Standard die casting alloy

One reference alloy:

- AlSi10Mg(Fe)

Structural casting alloys

Three different structural casting alloys:

- High Magnesium and Iron alloy
- High Magnesium and Zinc alloy
- High Magnesium and Silicon alloy

Three casting processes:

- Conventional die casting
- Vacuum supported die casting
- Vacural® die casting

High recycling content

Material Comparison

Reference alloy (AlSi10Mg(Fe))

- Basic, widely known casting alloy
- Heat treatable
- Good fatigue strength compared to other casting alloys
- Cheaper

Mechanical properties (F):

$R_{p0.2}$	=	140 – 200 MPa	(T6: +20%)
R_m	=	220 – 300 MPa	(T6: +6%)
A	=	1 – 3 %	(T6: +400 %)

Structural casting alloy (SCA)

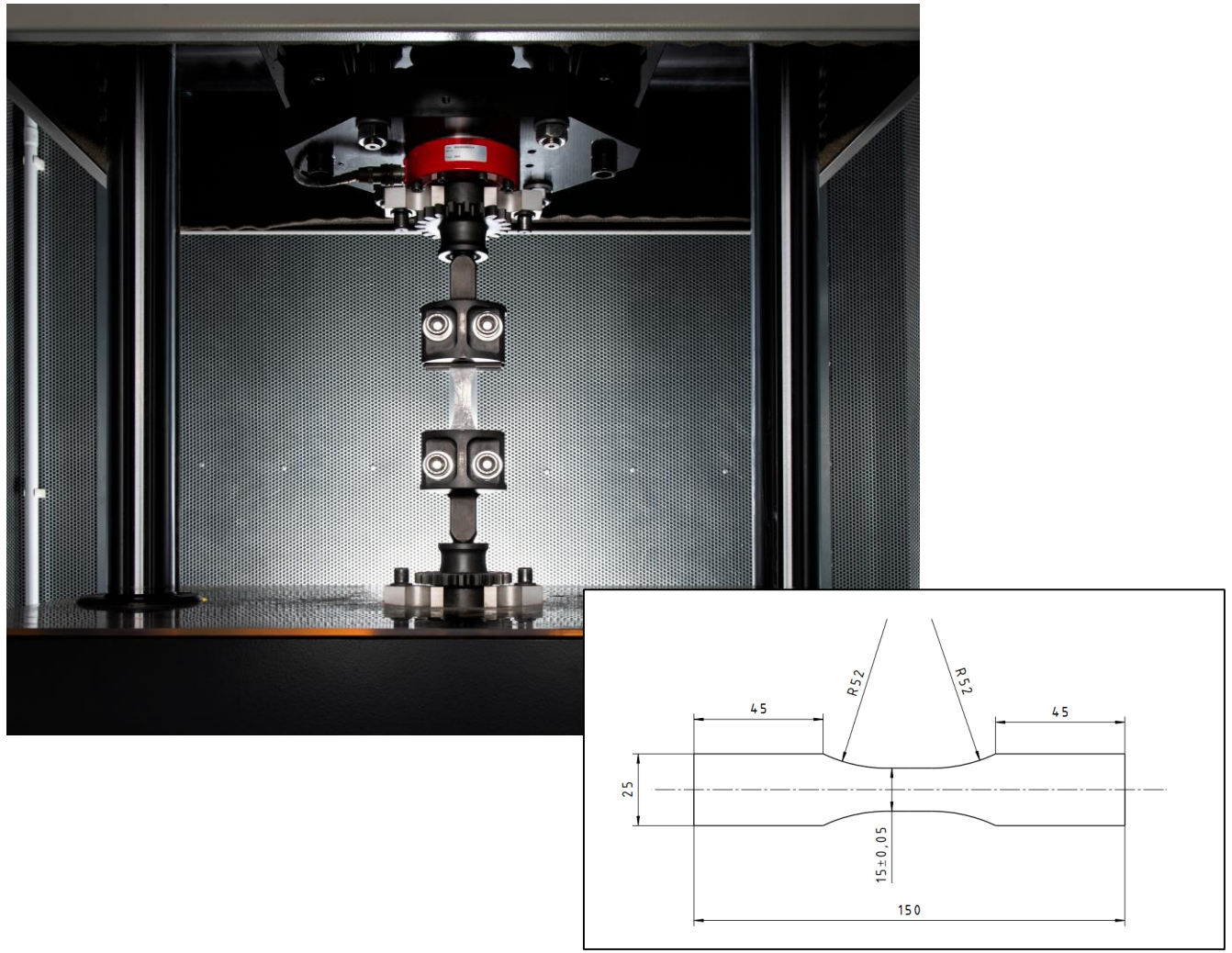
- High Magnesium and Silicon
- Special inert gas treatment during production necessary
- Rare earth metals
- Mostly used for light-weight structural parts
- Self-hardening

Mechanical properties (F):

$R_{p0.2}$	=	200 – 220 MPa
R_m	=	340 – 360 MPa
A	=	9 – 12 %

Specimens and Testing Setup

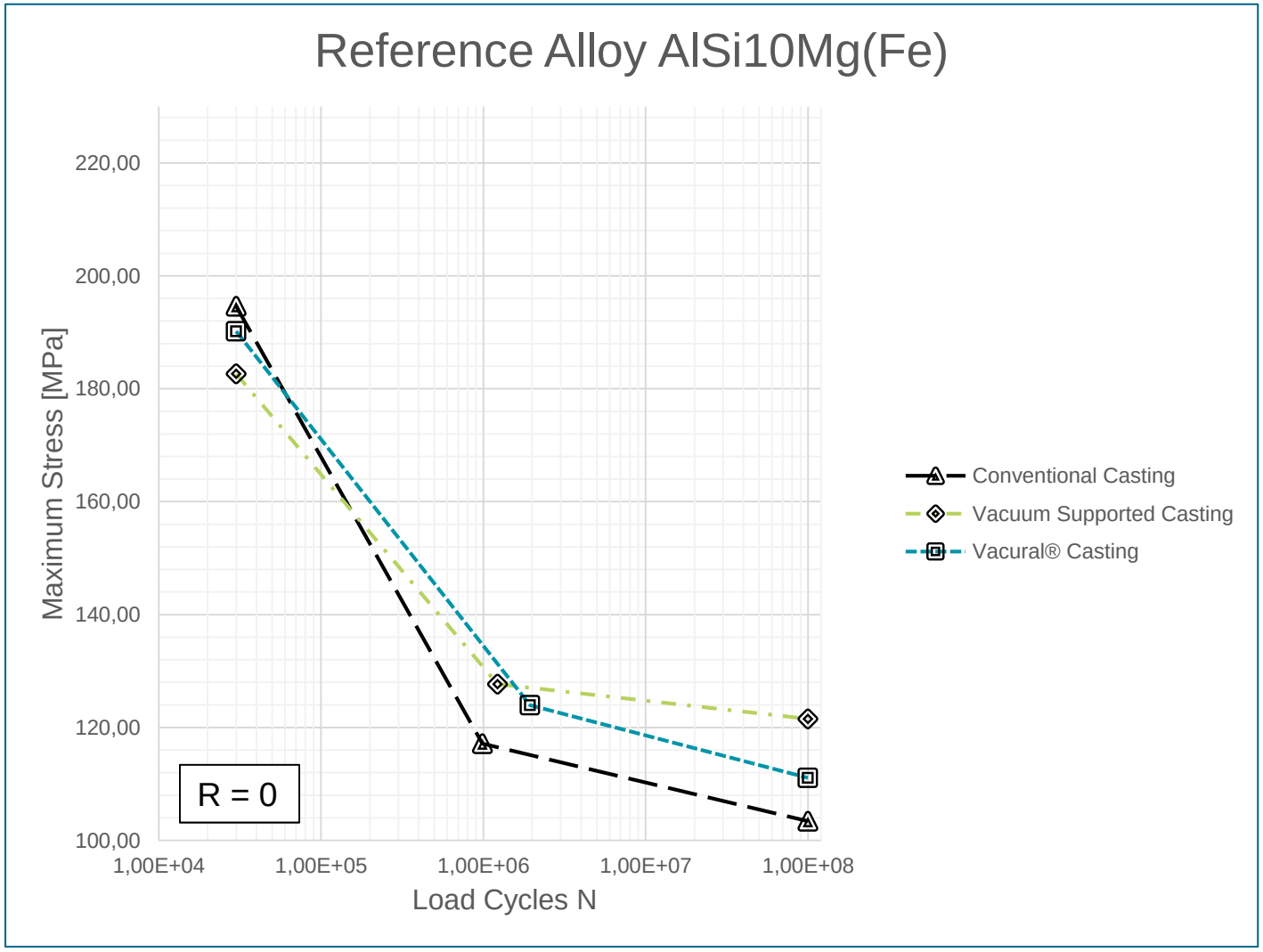
- Specimens
  - Good surface quality
  - Wide transition radius
- Testing setup
  - Amsler 30 HFP
    - Electromagnetic pulsation
    - Testing at resonance frequency
    - Low energy consumption
    - Force up to 30 kN
  - Testing frequency: 90 – 105 Hz



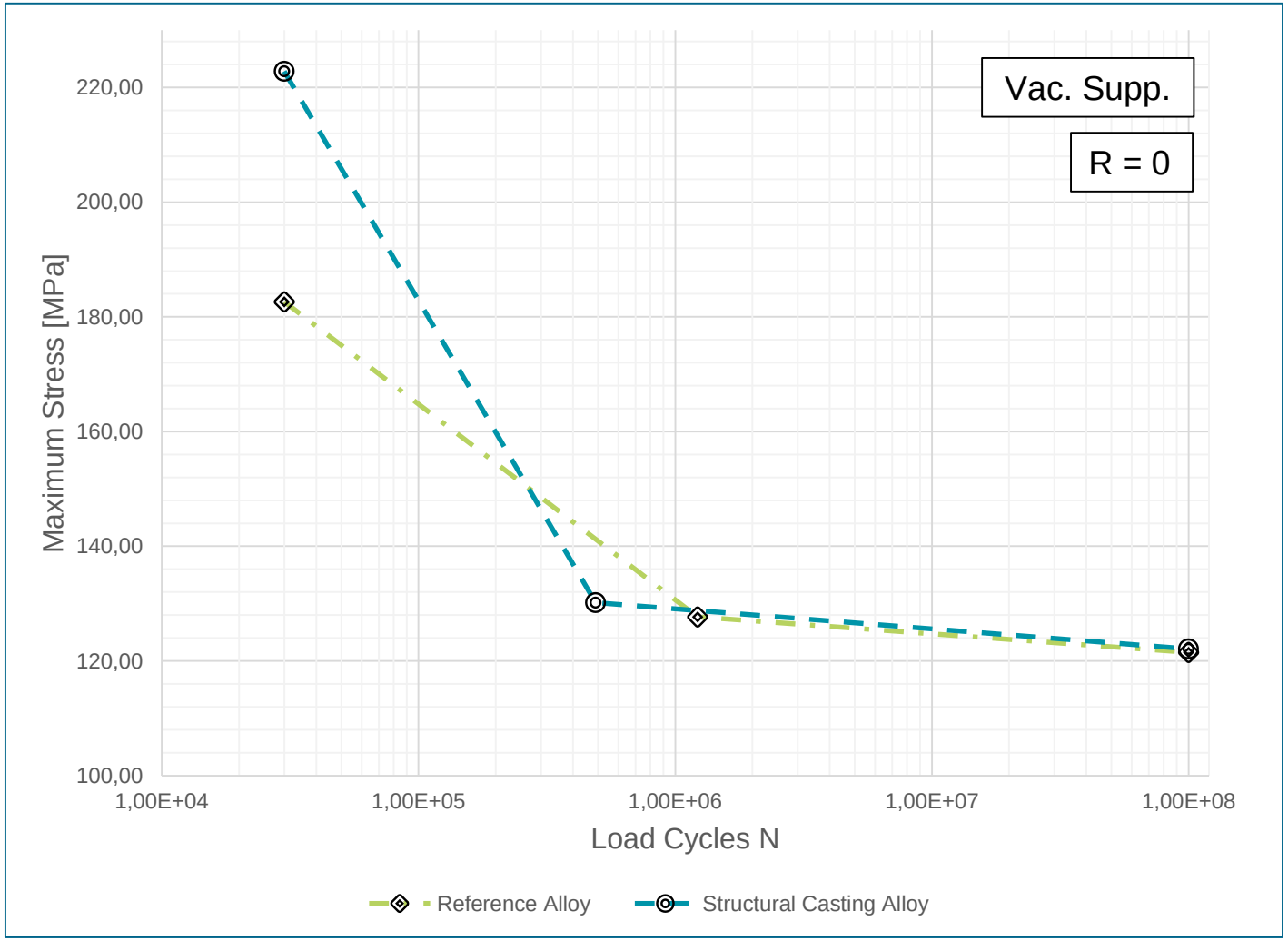
RESULTS

Different Casting Processes

- Low-cycle fatigue strength (LCFS) independent of casting process
- Conventional casting provides least high cycle fatigue strength (HCFS)
- Vacuum supported casting seams most suitable for high cycle fatigue loaded parts
- Vacural® casting provides excellent results for static properties
- No full potential of Vacural® casting due to focus on research



Reference Alloy compared to SCA



- No recycling content in SCA
- Slightly earlier break point for SCA
- Significant higher LCFS for SCA
- HCFS (at $N = 1*10^6$) for both alloys similar

$\sigma_{Ref} = 130.2$ MPa

$\sigma_{SCA} = 129.1$ MPa

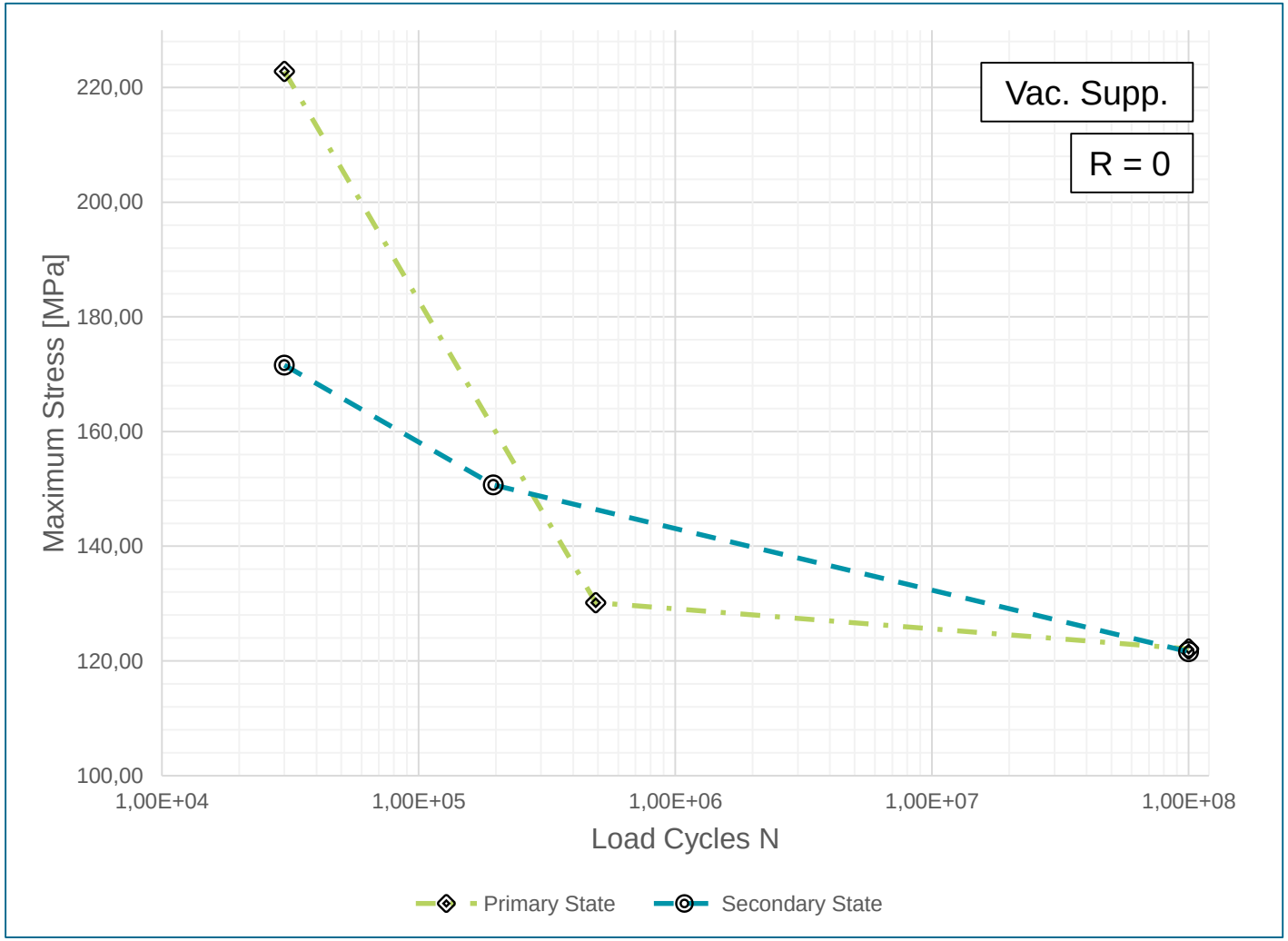
Recycling Content in SCA

- Secondary state has increased recycling content
- Significant higher LCFS for primary state

- Increased HCFS (at N = $1*10^6$) for the secondary state

σ_{Pri}(N $1*10^6$) = 129.1 MPa

σ_{Sec}(N $1*10^6$) = 142.5 MPa



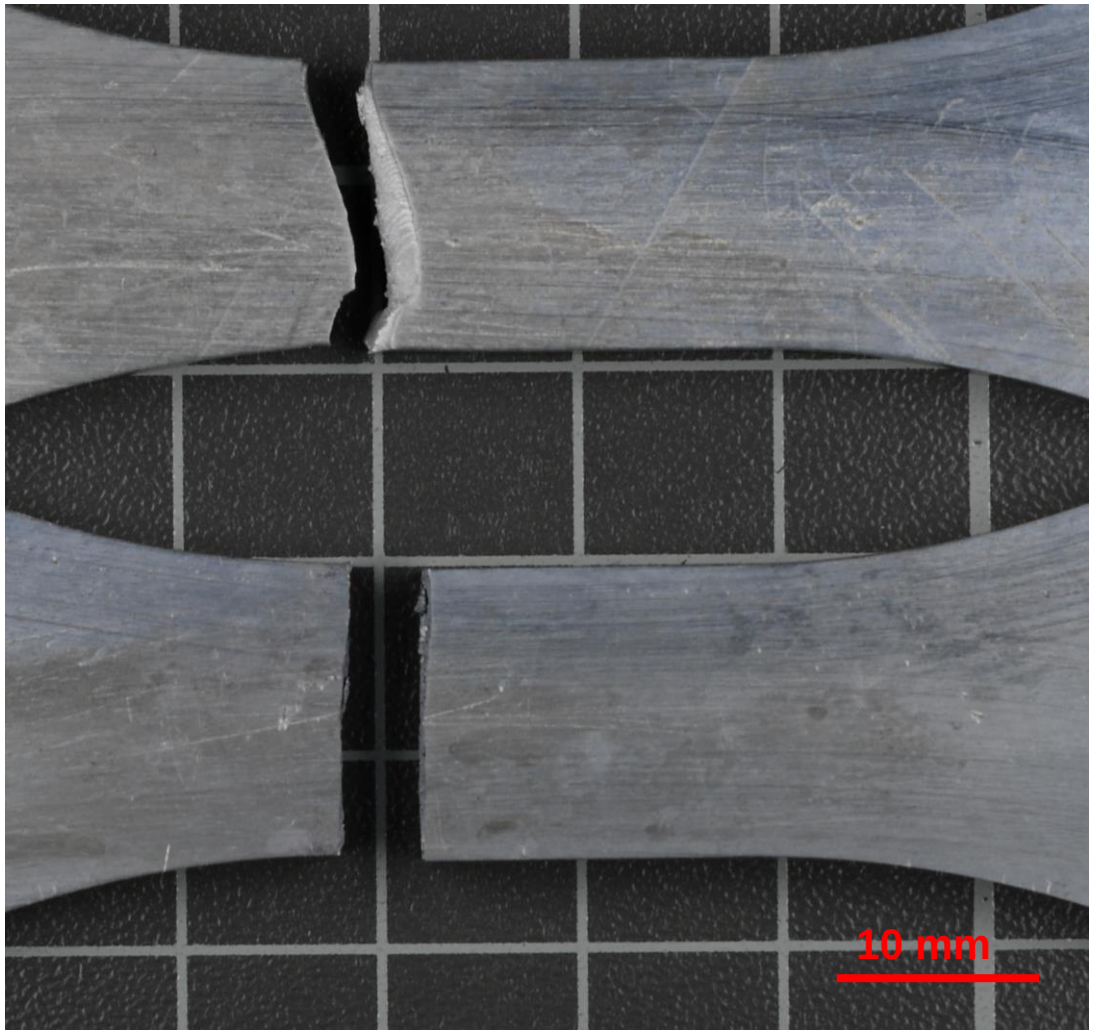
Recycling Content in self-hardening Casting Alloys

Primary State

- High strain (A = 9 – 12 %)
- Inert gas treatment during production necessary
- Rare earth metals used

Secondary State

- Decreased low cycle fatigue strength
- Significant lower maximum strain (A < 3 %)
- No more inert gas treatment and rare earth metals necessary
- Recycling content up to 90 %
- Increased HCFS



CONCLUSION AND OUTLOOK

Conclusion and Outlook

- ✓The substitution of basic casting materials with high strength structural casting alloys is possible
- ✓ Production effort, costs and CO_2-footprint of structural casting alloys are decreased through the use of recycled aluminum
- ✓ Low strain of secondary alloys is not relevant for the application in casts for electric motors
- ✓The choice of the casting process and parameters has a huge influence on the fatigue strength of parts

- ➢ Further investigation on the influence of casting process and recycling content on fatigue strength
- ➢ Comparison of aluminum and magnesium casting alloys for different casting processes

Thank you for your attention!

QUESTIONS, PROJECT IDEAS OR INTEREST AS A PROJECT PARTNER?
PLEASE CONTACT US!
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