GREEN-LOOP

Wood Composites for Plain Bearings

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External Workshop on Wood Composites and their use for bearings, June 5th 2025

Funded by the European Union

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Agenda

- Introduction, Goal
- Materials
- Tribological tests
- Lab-Scale Bearing Tests
- Conclusion and Outlook

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The Fraunhofer-Gesellschaft and Fraunhofer IWM

Applied research with a focus on key future-relevant technologies and the commercialization of findings in business and industry. A trailblazer and trendsetter in innovative developments.

> 30,000 employees

76 institutes and research units

IWM: Fraunhofer Institute for Mechanics of Materials

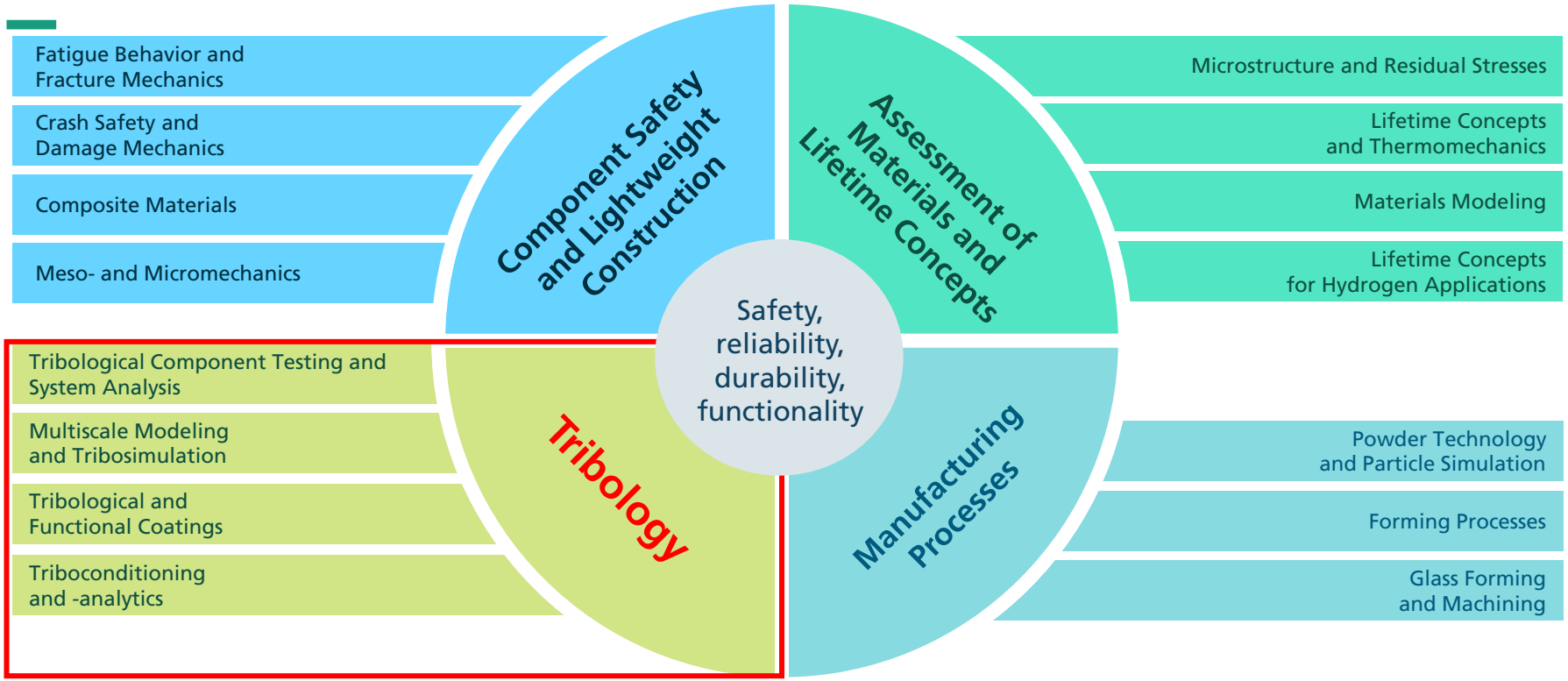
Freiburg

320 Employees, 30% Industrial revenues (2023)

Fraunhofer IWM

Fraunhofer Institute for Mechanics of Materials

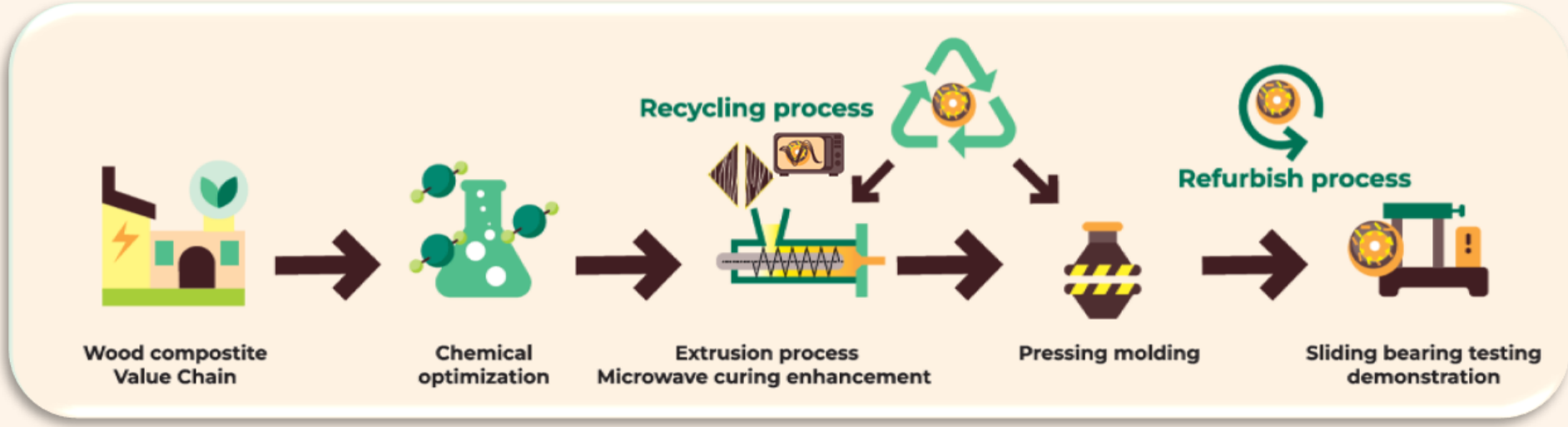
Business Units and Groups



Fraunhofer IWM

Wood composites material production

Flow Chart



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Involved partners in the Horizon Project, who were directly involved in this work field

- Fraunhofer Gesellschaft zur Angewandten Forschung e.V.
- Idener Research & Development
- NCC - National Composites Center, Bristol
- University of Bristol
- ISQ - Institudo de Soldatura e Qualidade
- Guala Closures S.R.L.
- IRIS Technology and Solutions

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Goal: Assess Suitability for Plain Bearings

Requirements for Tribological Applications

Product	Wood Composites	
Mechanical Properties	**Value**	**Units**
Compressive strength	> 70	MPa
Tribological Properties	**Value**	**Units**
Wear Coefficient	**< 10^{-5}**	**$mm^3/(Nm)$**
Friction coefficient	**< 0.3 under dry sliding**	**--**
pv-value	**> 0.3**	**MPa · m/s**
Working conditions	**Value**	**Units**
Temperature	0 - 100	°C

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Materials Overview

- Biopolymer Mix
- Wood Fibers size < 1 mm
- Fillers (Fibers)/ additives

Batch 1	Batch 2	Batch 3
12 Materials	7 Materials	12 Materials
Biopolymer Mix 1	Biopolymer Mix 2	Biopolymer Mix 2
+ Graphite	+ Wood Fibres	+ Wood Fibres
	+ Recycled Glass Fibres	+ Recycled Glass Fibres
	+ Lignin	+ Lignin

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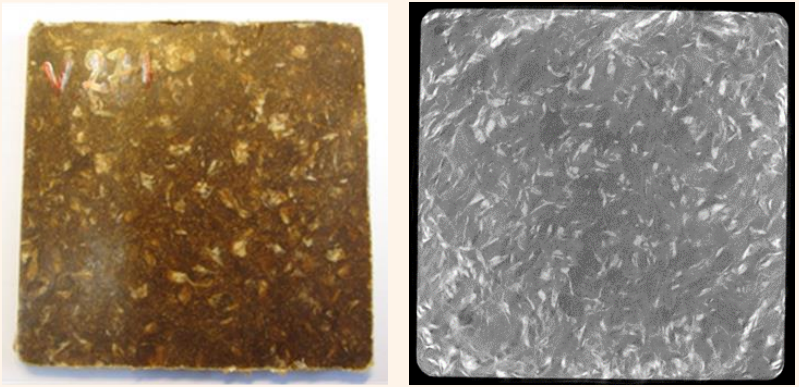
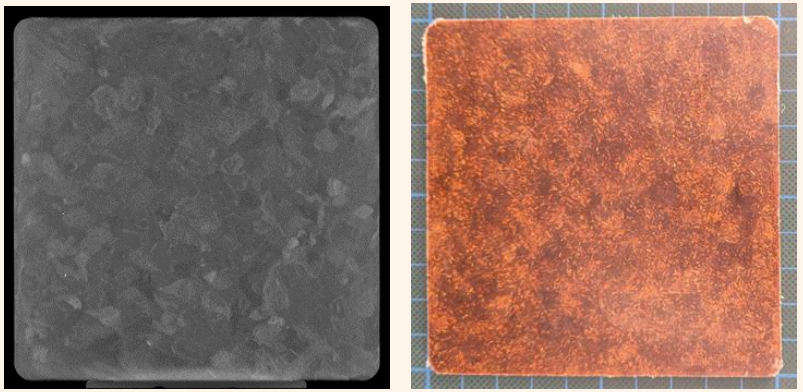
Materials Processing

- Successful implementation of microwave enhancement → improved homogeneity and material properties → reduced energy consumption

conventional processing



microwave heating



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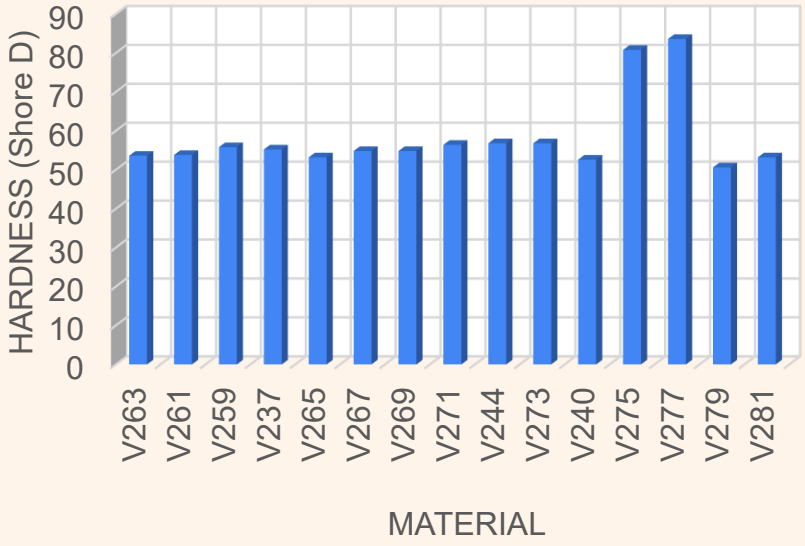
Properties

Properties

- Hardness values: > 50 Shore D
- Density: ca. 1.2 g/cm³
- Compressive strength: > 60 MPa
- Compressive strength with MW enh.: 82 MPa
- Thermal stability: 120 °C (DTA)
- Tensile Strength: average 8 MPa
- Tensile Strain: average 2 %



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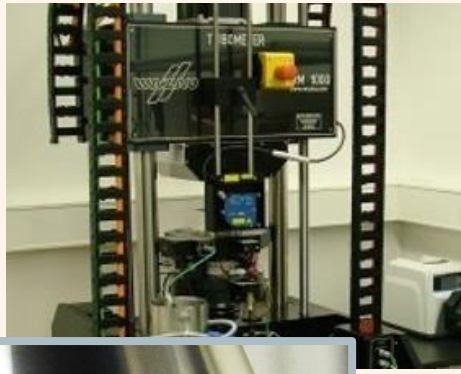
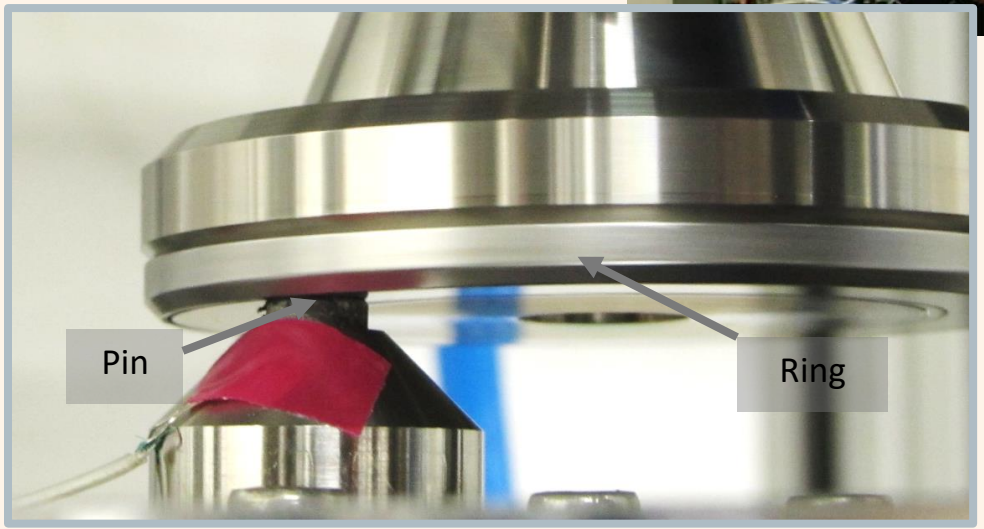
Tribological Testing (Model Scale)



Test parameters :

- Normal force: 85 N ≙ 3 MPa
- Velocity: 0,1 m/s
- PV: 0,3 MPa * m/s
- Test duration: ca. 6 h
- Test media: dry, Air at RT
- Samples: Pins diam 6 mm, height >3mm



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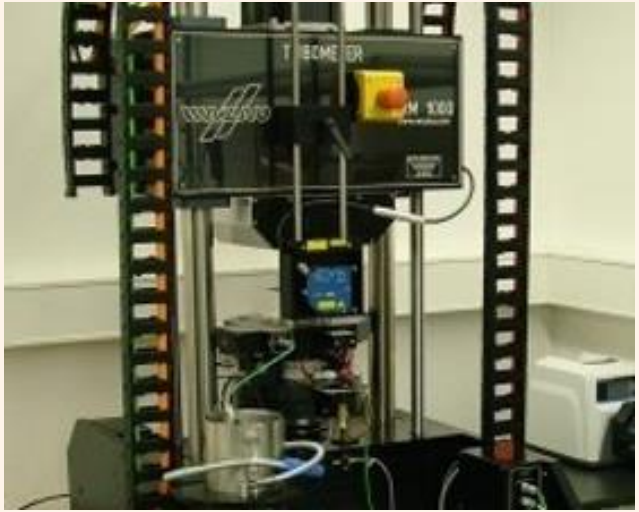
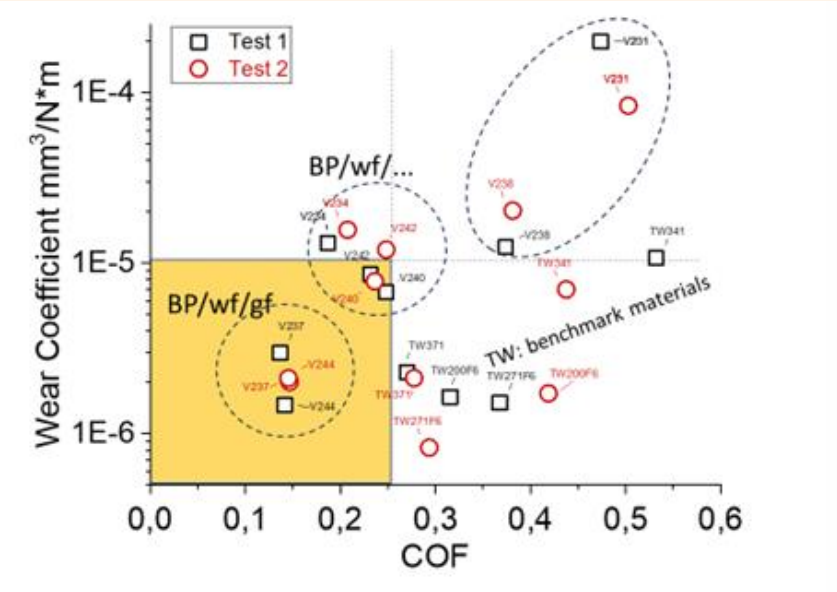
Results of Model Tests



➔ *Very good results: Low friction & wear in unlubricated sliding*



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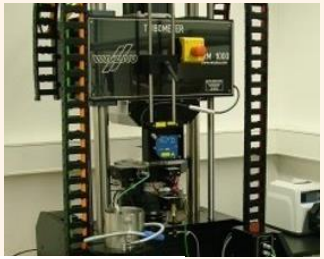
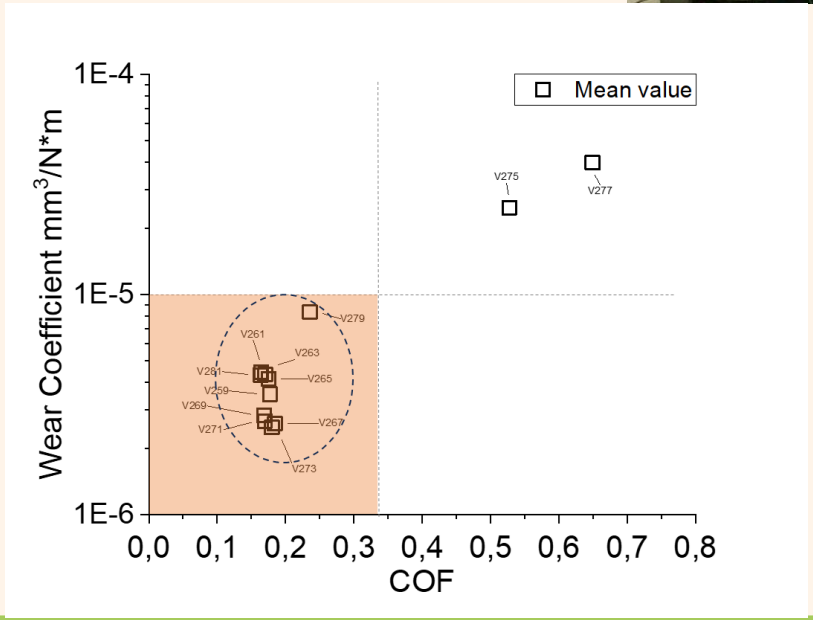


Variation of filler content

➔ *Very good wear properties confirmed and materials selected*



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Bearing Designs and Testing

Tests with real bearing configurations

- load (radial force): 10 - 650 N
- rotational speed: 0 - 3000 rpm
- temperature: RT - 100 °C
- size: 2 - 16 mm ($Ø_{innen}$)
- lubrication: unlubricated, grease, oil

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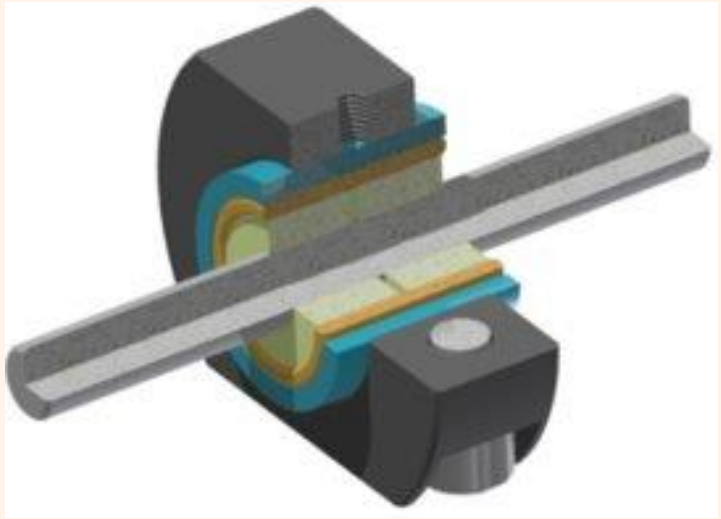
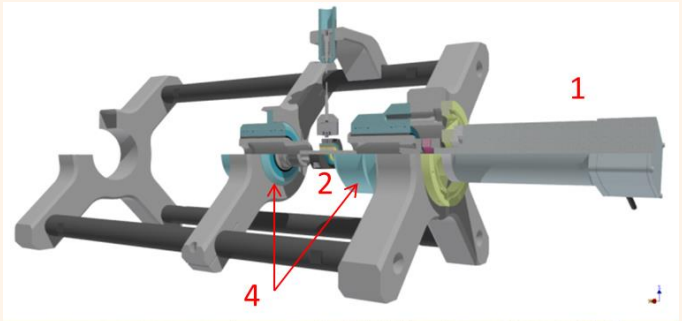
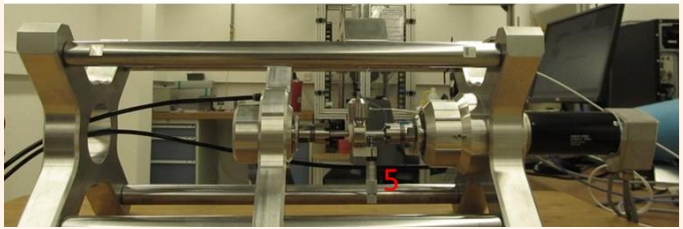
Bearing Designs and Testing

Tests with real bearing configurations







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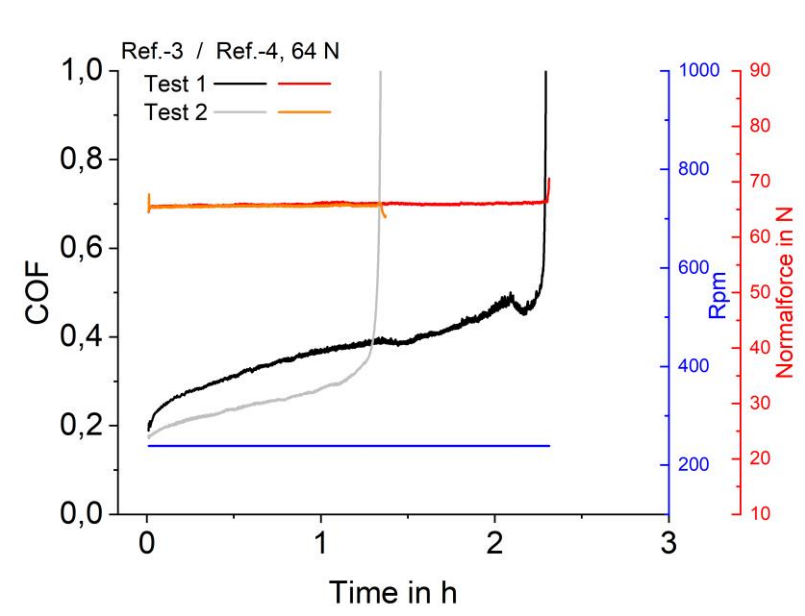
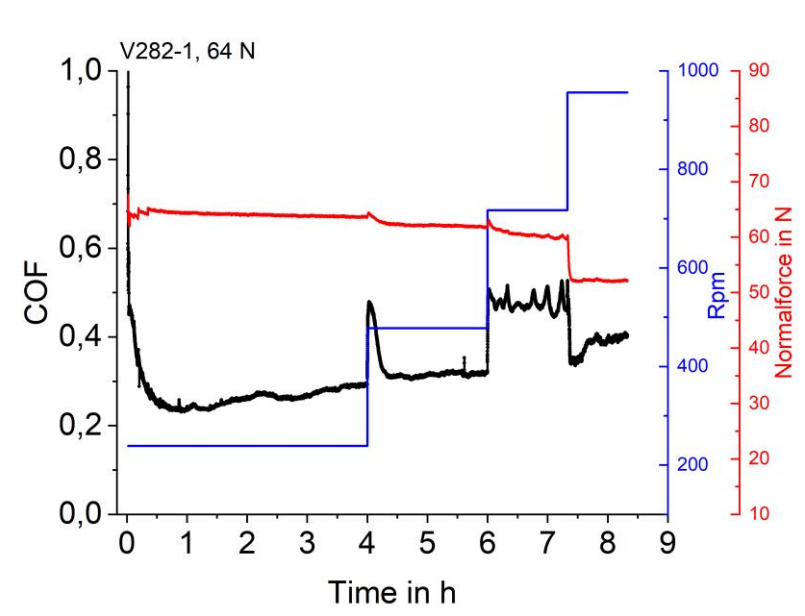
Results

reference material



wood composite



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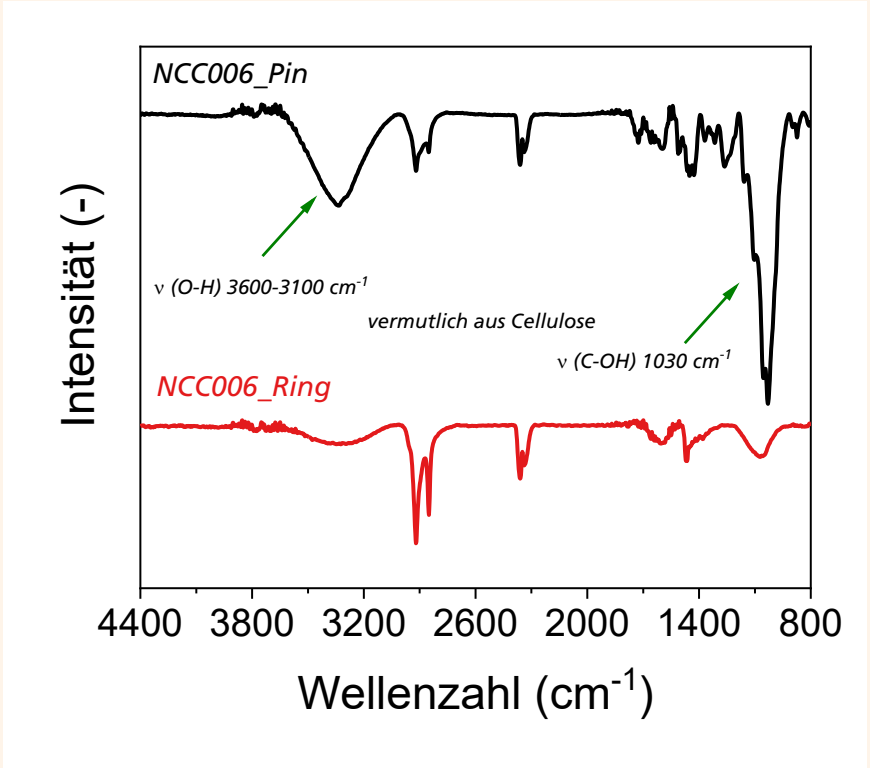
FTIR Analysis



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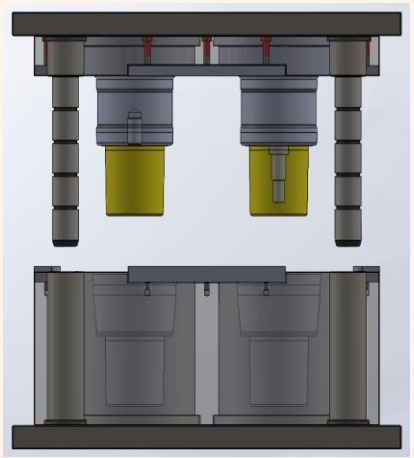
Bearing Designs and Testing

- Bearing design finalised – bearing within a conveyor roller
- Flat panels produced for use in tribological testing
- Tooling produced for final bearing production
- Final demonstration by end of July 2025



Tooling

Bearing blank

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Conclusions

- The specifications were suitable and a guideline for materials development and tribological assessment
- Very promising results are regarded as a success:
    - Suitable mechanical material properties
    - Very low friction coefficients without the use of liquid lubricants
    - Acceptably low wear rates.
    - **All important materials specifications have been fulfilled.**
- Outlook: Finish the evaluation of the tribological performance of the WC materials on a model scale and prepare for component testing with real bearing geometries to demonstrate their feasibility for technical use.

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SWOT

S: Promising Materials, suitable mechanical properties, promising friction and wear behaviour.
S: Low PCF in synthesis and production, low energy consumption in use.
W: Concerns due to scatter of material quality and low tensile strength
W: No experience in practical use
T: Validity of design rules unclear
T: Higher costs – can the be reduced to the same level as polymer bearings?
O: Representation of sustainability
O: Good chances on market once proof of concept will be shown for the whole product life cycle

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Thanks for your attention!

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