WEAR BEHAVIOUR OF CO-BASED ALLOYS FOR HIGH-TEMPERATURE APPLICATIONS

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N. Kind, P. Beau, S. Reh

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DLR

DLR – Institute of Test and Simulation for Gas Turbines
Overview

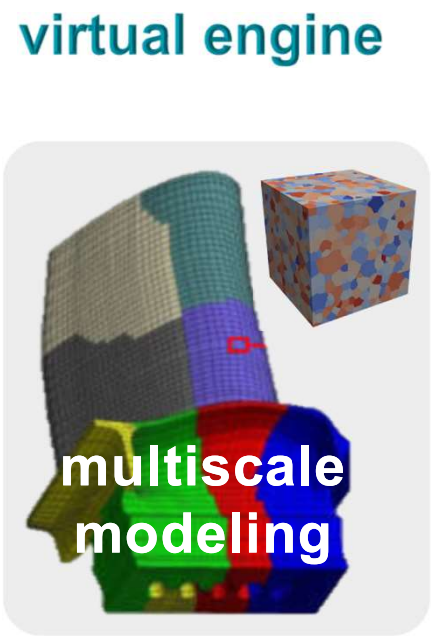
DLR

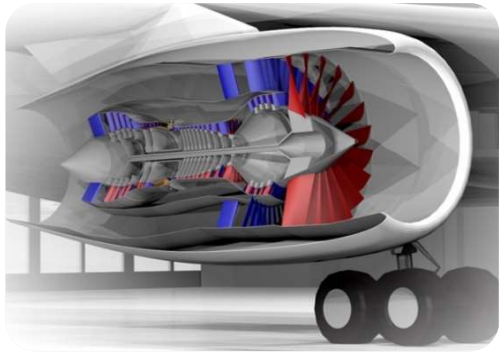
- German Federal Research Center for Aeronautics and Space
- R&D: aeronautics, space, energy, transport, security and digitalisation
- 54 institutes at 30 sites
- ~ 10.000 employees

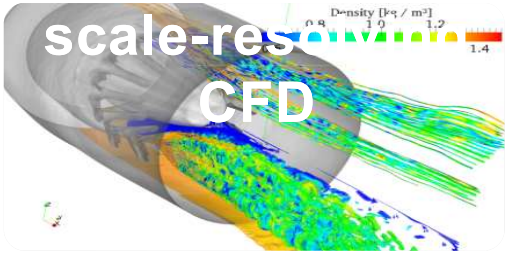
DLR – Institute of Test and Simulation for Gas Turbines
Research Topics

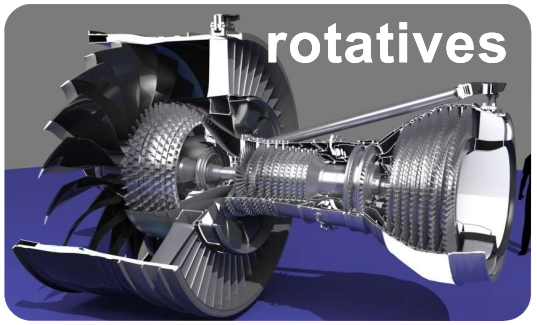
Virtual engine

Lifetime assessment & harsh conditions

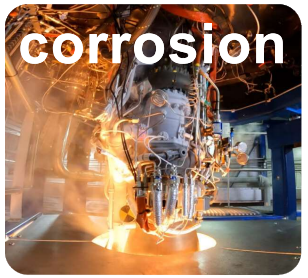


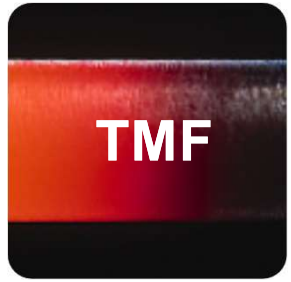






Lifetime assessment & harsh conditions





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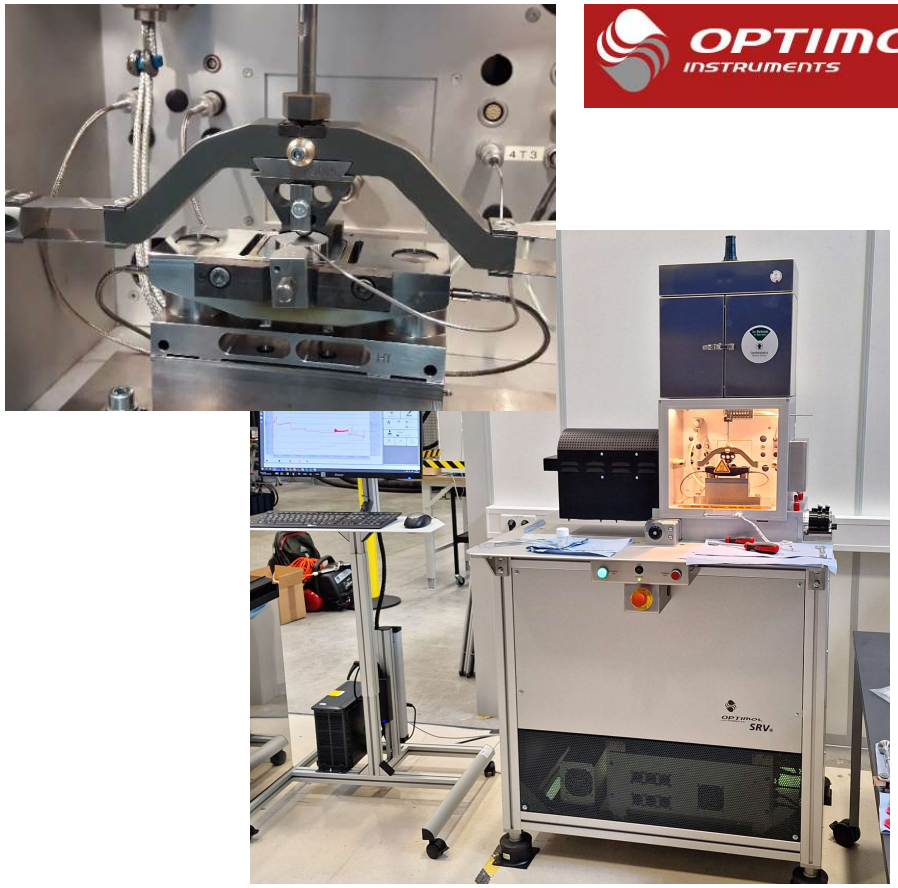
Tribology

Tribology under harsh conditions

- SRV5 by Optimol Instruments
- fretting and wear up to 1000 °C
- simultaneous application of synthetic combustion gas: O_2, SO_2, NO_x, H_2O-vapour

Applications

- HT-materials relevant for gas turbines (Ni-alloys, SiC/SiC)
- materials employed in adjacent components (coatings)



test stand SRV5® at DLR Augsburg

Content

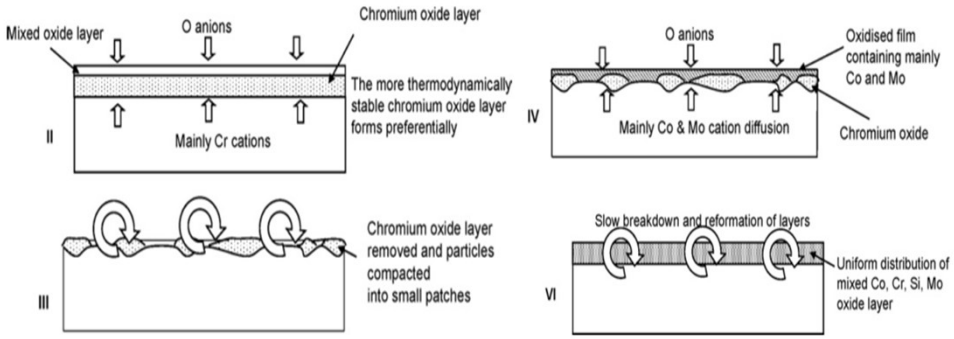
Wear behaviour of Co-based alloys for high-temperature applications

1) Co-alloys
2) Experimental methods
3) Results
   - Temperature effect
   - Influence of manufacturing process
   - Composite wear law
4) Summary & Outlook

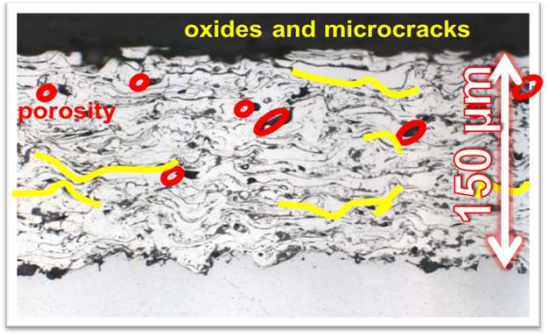
Co-based alloys
Motivation

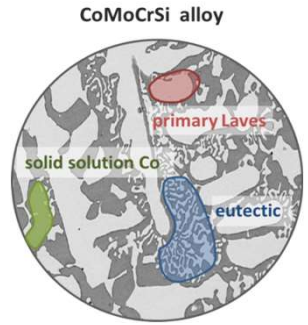
Behavior at high temperature

- superior resistance to wear above ~ 400 °C
- Formation of compacted oxide (glaze) layer
  - (1) formation of Cr-oxide layer
  - (2) removal of oxide and compaction of debris
  - (3) diffusion of Co and Mo to surface
  - (4) breakdown and formation of oxide films and further diffusion → uniform distribution of elements in compacted oxide film



Formation of compacted oxide layer (glaze layer) of T-800 [Wood et al.]





Does the manufacturing process have an influence on the wear behaviour?

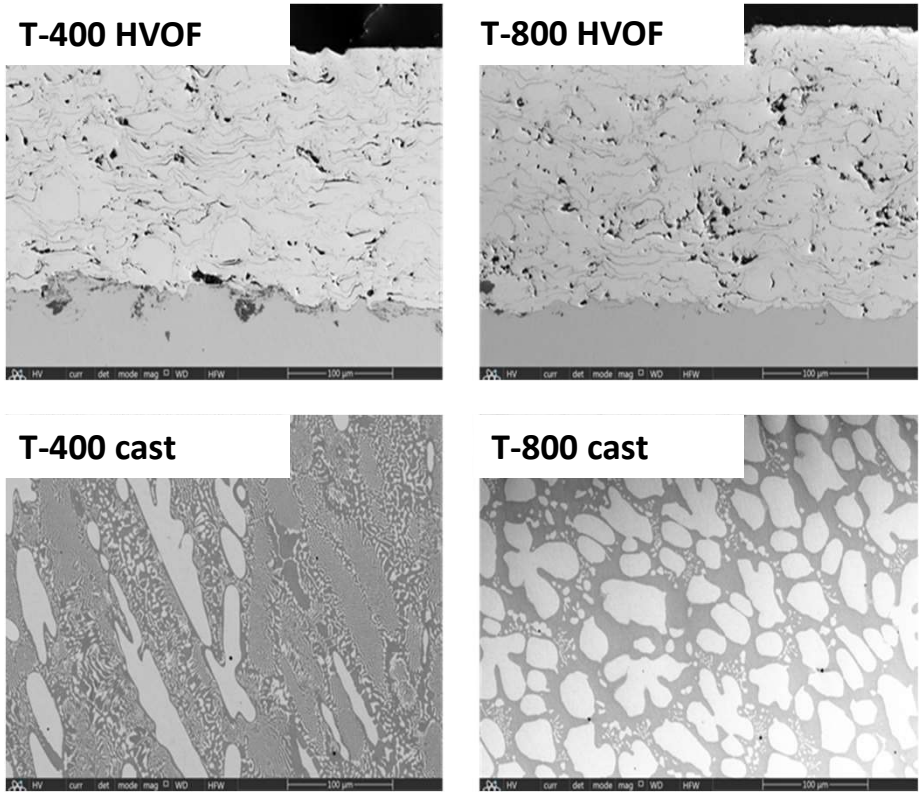
Experimental methods

Materials

- T800 & T400

alloy	type	Co [wt%]
T800	CoMoCrSi	51-53
T400	CoMoCrSi	61-63

- HVOF-sprayed & cast
- cylinder / flat contact



Cross-sections of T-800 and T-400 [P.Beau]

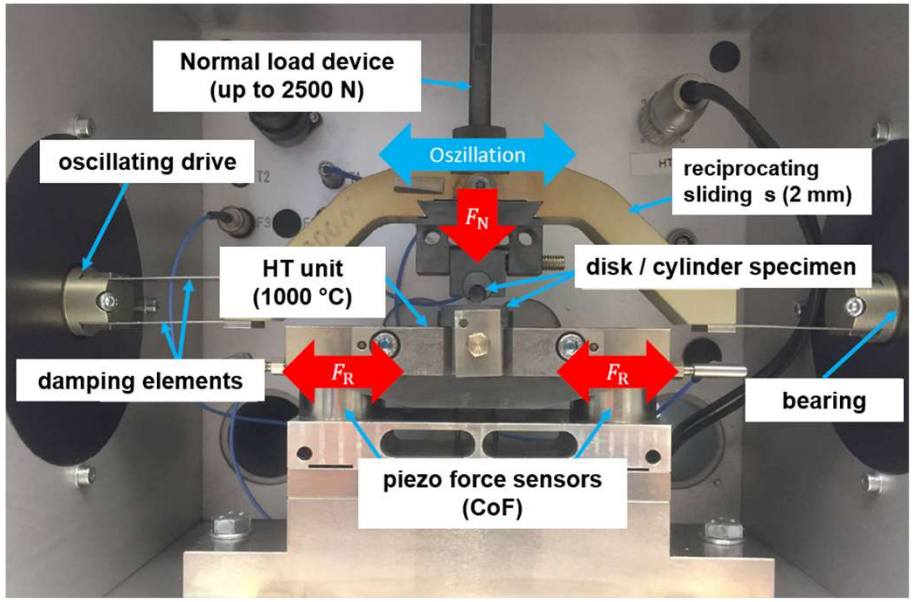
Experimental methods

Wear tests - SRV4

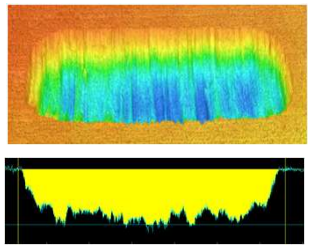
- normal load: 20 - 100 N
- test frequency: 5 Hz
- sliding distance: 2 mm
- test duration: 1 - 18 h
- temperature: 25 - 800 °C

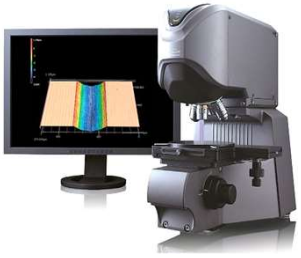
Characterisation

- measurement of wear volume
- SEM, EDX



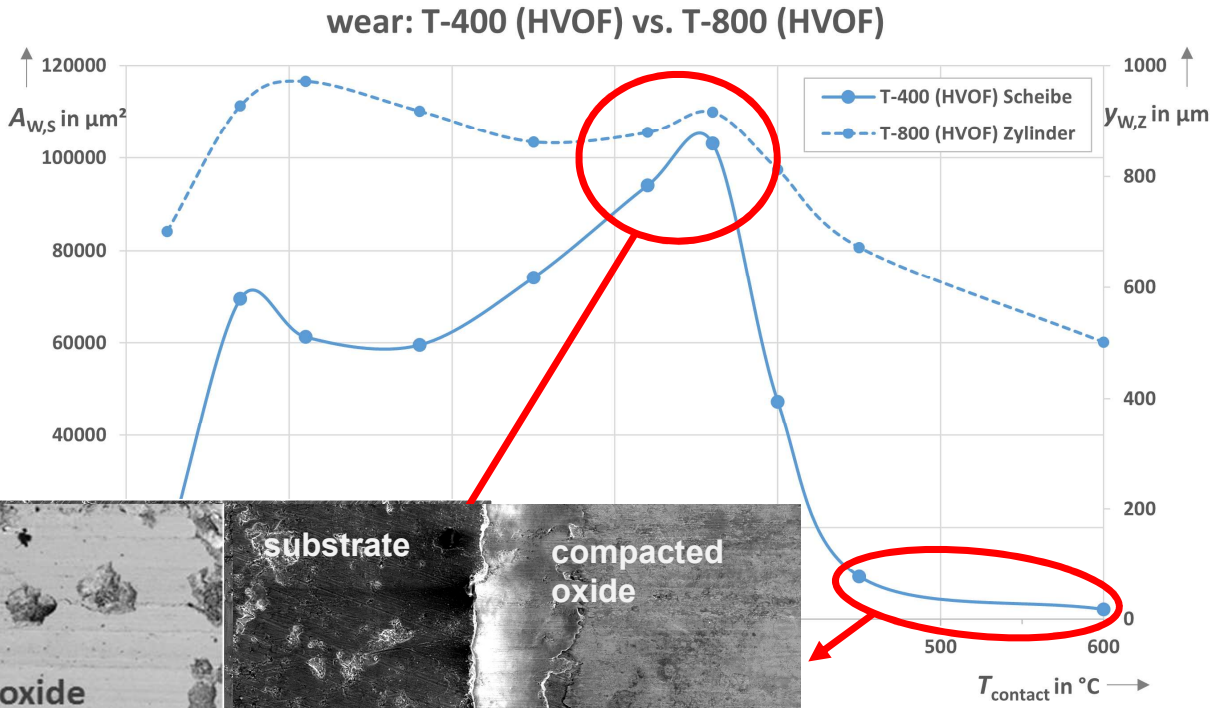
SRV4 wear test [P.Beau]

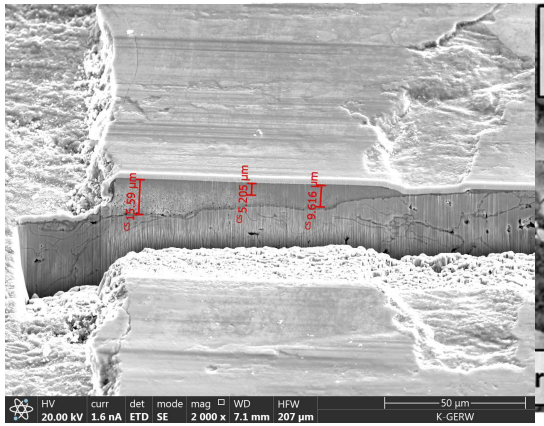


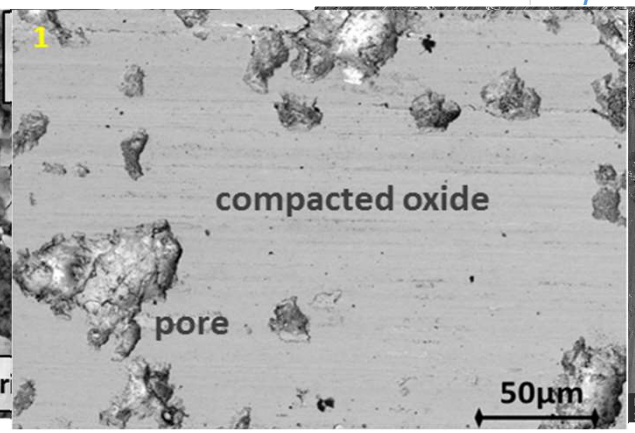


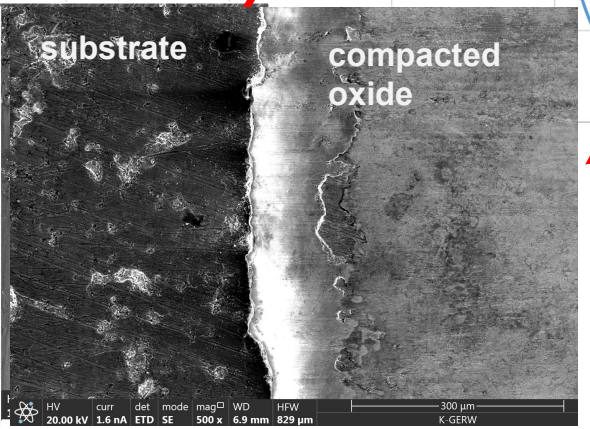
Results
Temperature effects

- low / zero wear if $T_{contact}$ > 450 °C
- reason: formation of glaze layer
- measure $T_{contact}$



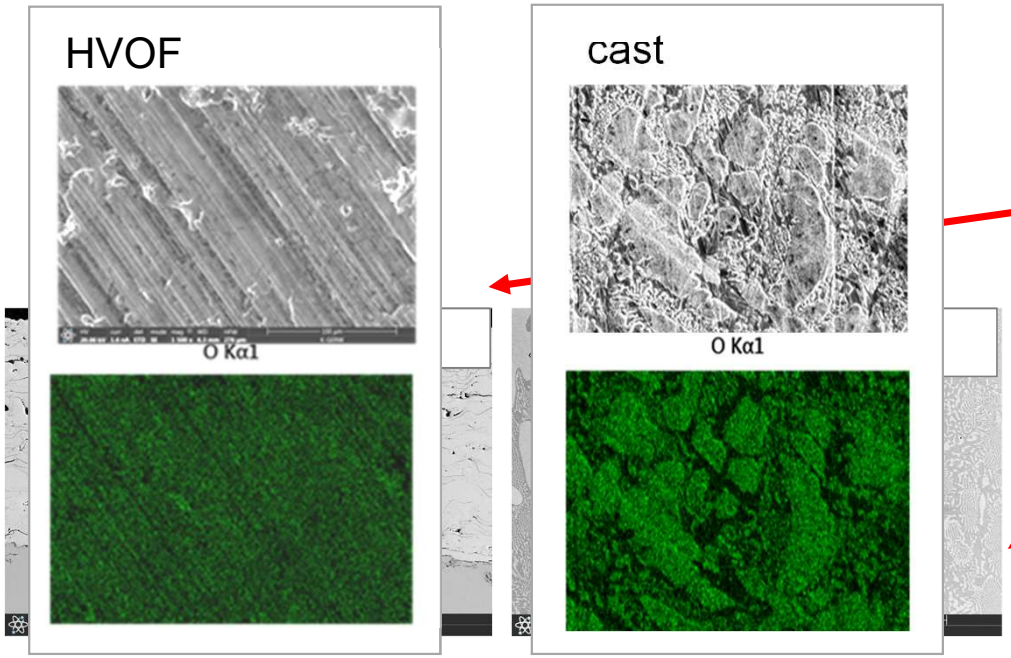


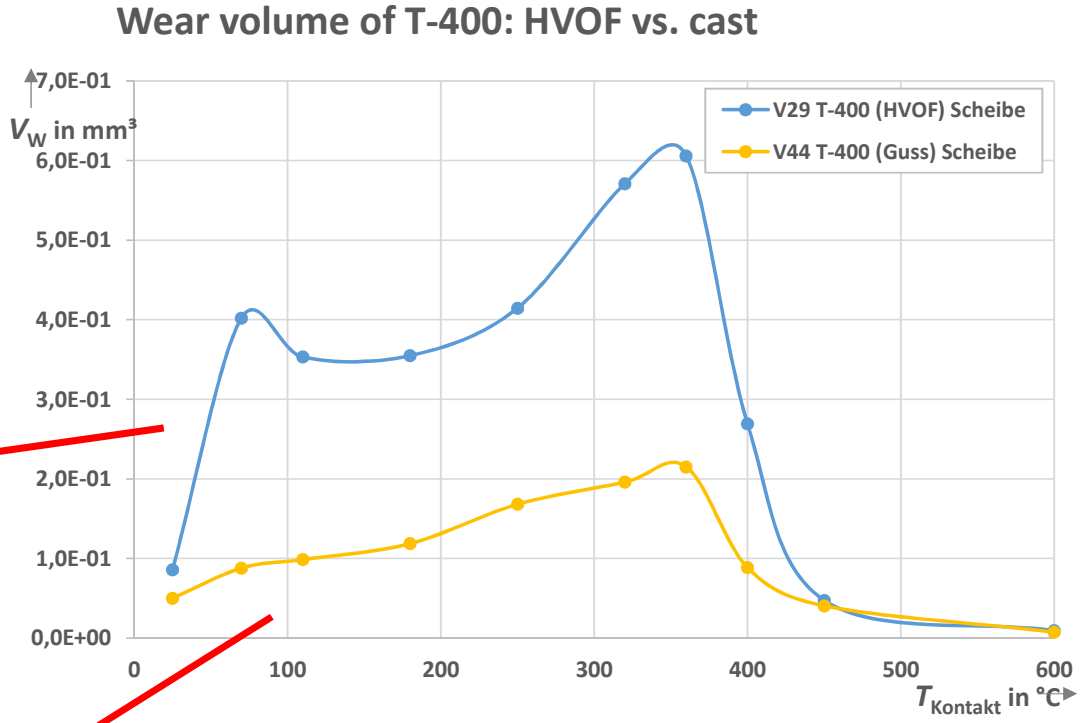




Results
Manufacturing process

- Soft matrix, hard dendrites in Laves phase
- dendrites promotes localized oxidation (islands of zero wear, self-healing)





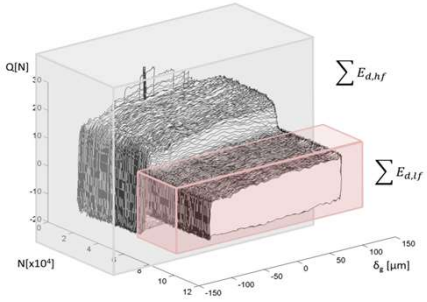
Results
Composite wear law

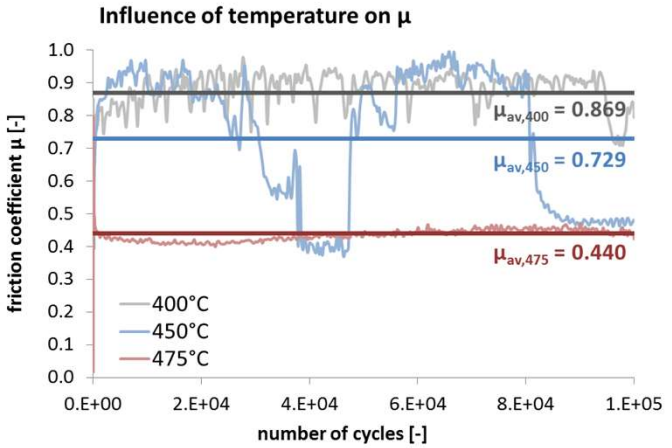
Friction coefficient

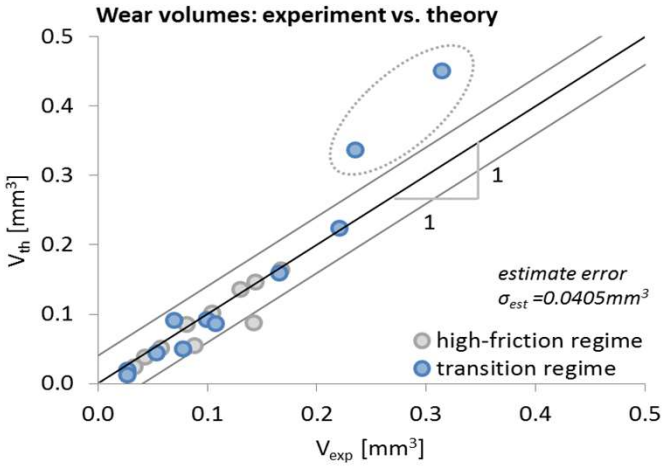
- modified Archard approach
- assumption: upon formation of compacted oxide, dissipated energy no longer contributes to wear process
- wear volume predicted for both high-friction and transition domain

$$E_d(i) = \begin{cases} E_d(i) \; if \; \mu > 0.6 \\ 0 \; if \; \mu < 0.6 \end{cases}$$

$$V = \alpha \cdot \sum_{i=1}^{N} E_d = \alpha \cdot \sum_{i=1}^{N} \int_{-\delta}^{\delta} Q_i(\delta) d\delta$$







Summary & Outlook

Summary

- significant influence of manufacturing process on wear behaviour of Co-based alloys

  → tailored solutions for industrial applications

- description of wear over entire temperature possible using an energetic approach

Outlook

- correlation to micro/macro hardness and elastic properties
- influence of corrosive medium

DLR-SG
Nora Kind
Am Technologiezentrum 5
86159 Augsburg (GER)
nora.kind@dlr.de

Beau Engineering Services
Patrick Beau
info@go-getting.de
+49 91113057540

THANK YOU FOR YOUR ATTENTION

Impressum

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Datum:	2024-05-07
Autor:	Nora Kind, Patrick Beau, Stefan Reh
Institut:	DLR-SG
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