11TH EASA Rotorcraft Symposium

Cologne, 5-6 December 2017

Loss of Lubrication in Rotorcraft Transmissions: Improvement and Simulation

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Institut für Konstruktionswissenschaften und Technische Logistik

Loss of Lubrication in Rotorcraft Transmissions:

Improvement and Simulation

Overview

1. Transmissions for Aviation and Tribology at TU Wien
2. Improvement: Lubrication and Loss of Lubrication
3. Improvement: Simulation and Calculation
4. Notice of Proposed Amendment 2017-07

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Classes / Courses 307 - 3 for Bachelor and Special Focus Design for Master										
Date: 27.11.2017										
Semester	BACHELOR 1	BACHELOR 2	BACHELOR 3	BACHELOR 4	BACHELOR 5	BACHELOR 6	MASTER 1	MASTER 2	MASTER 3	MASTER 4
	Techn. Drawings CAD	***Basics of Design***	**Machine Elements**	**Machine Elements KU in 4. or 5. Sem.**		**Bachelor Thesis**	**Machine Elements - Advanced -**	**Machine Elements - Advanced -**	**Machine Elements - Advanced -**	**Master Thesis**
	VU 2/307-1	*VO 2/307-1*	VO 3	UE 3 (KU)			VO 2	UE 4 (KU)	PA 4	
	307.426 (2)	*307.428 (3)*	307.451 (4)	307.453 / 307.452 (3)		307.418 (5/10)	307.454 (3)	307.455 (4)	307.482 (5)	(30)
		Techn. Drawings CAD		**Machine Elements** -Applications -					**Transmissions Selected Chapters**	**Transmissions Selected Chapters**
		UE 3/307-1		VU 2					UE 5	VO 2
		307.427 (3)		307.448 (3)					307.474 (5)	307.473 (3)
				Machine Elements - Applications - RU in 4. or 5. Semester				**Trans-missions for Aviation**	**Trans-missions for Aviation**	**Tribology of Machine Elements**
				UE 2 (RU)				VO 2	SE 2	VO 2
				307.449 (2)				307.459 (3)	307.461 (3)	307.483 (3)
Institut für Konstruktionswissenschaften und Technische Logistik TU WIEN Forschungsbereich Maschinenelemente und Rehabilitationstechnik				**Methods of 3D - CAD**				**Trans-missions for Aviation**	**Trans-missions for Aviation**	**Lubricated Contacts**
				VU 2/307-5				UE 3 (LU)	PA 4	VO 2
				307.450 (2)				307.460 (3)	307.085 (5)	307.485 (3)
								Special Maschine Elements	**Special Maschine Elements**	
	ECTS credits are shown in brackets							VO 2	UE 4 (KU)	
								307.456 (3)	307.457 (4)	
Semester	BACHELOR 1	BACHELOR 2	BACHELOR 3	BACHELOR 4	BACHELOR 5	BACHELOR 6	MASTER 1	MASTER 2	MASTER 3	MASTER 4

Courses about Transmissions for Aviation and Tribology

FVA
Forschungsvereinigung Antriebstechnik e.V.

DGLR
Deutsche Gesellschaft für Luft- und Raumfahrt Lilienthal-Oberth e.V.

AGMA
American Gear Manufacturers Association

AHS INTERNATIONAL
THE VERTICAL FLIGHT SOCIETY

TU WIEN VGR
Vienna Gear²ing

IFAR | INTERNATIONAL FORUM FOR AVIATION RESEARCH

AAI - Austrian Aeronautics Industries Group
Interessensgemeinschaft der Österreichischen Luftfahrtzulieferindustrie

AIRMED PRAHA 2008

AIRMED 24-27 MAY WORLD CONGRESS BRIGHTON 2011

WiGeP

TU WIEN
TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Institut für Konstruktionswissenschaften und Technische Logistik

TU WIEN

Forschungsbereich
Maschinenelemente
und Rehabilitationstechnik

AC²T research

Austrian Excellence Center for Tribology

Mechanical Engineering - Laboratory: General View after Re-Opening

Mechanical Engineering – Laboratory: Tail drive shaft testing

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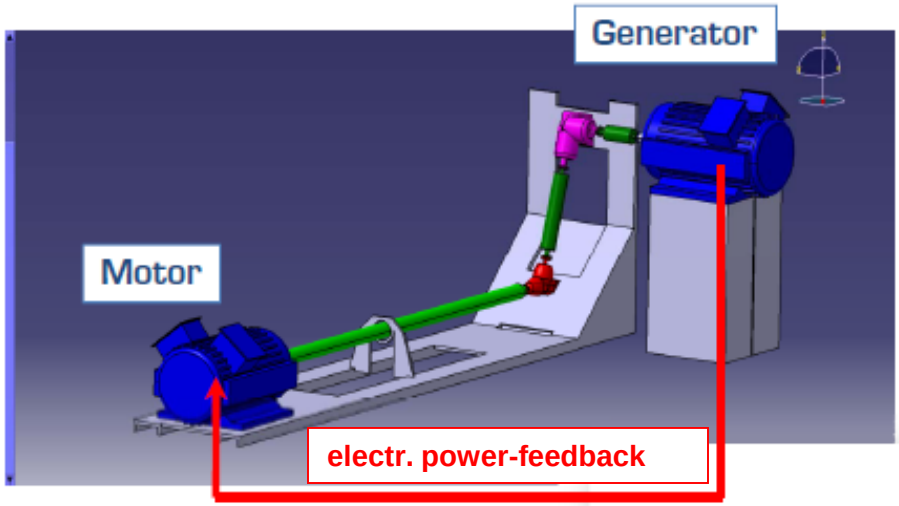
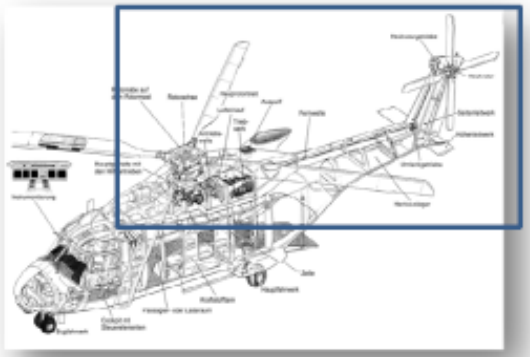
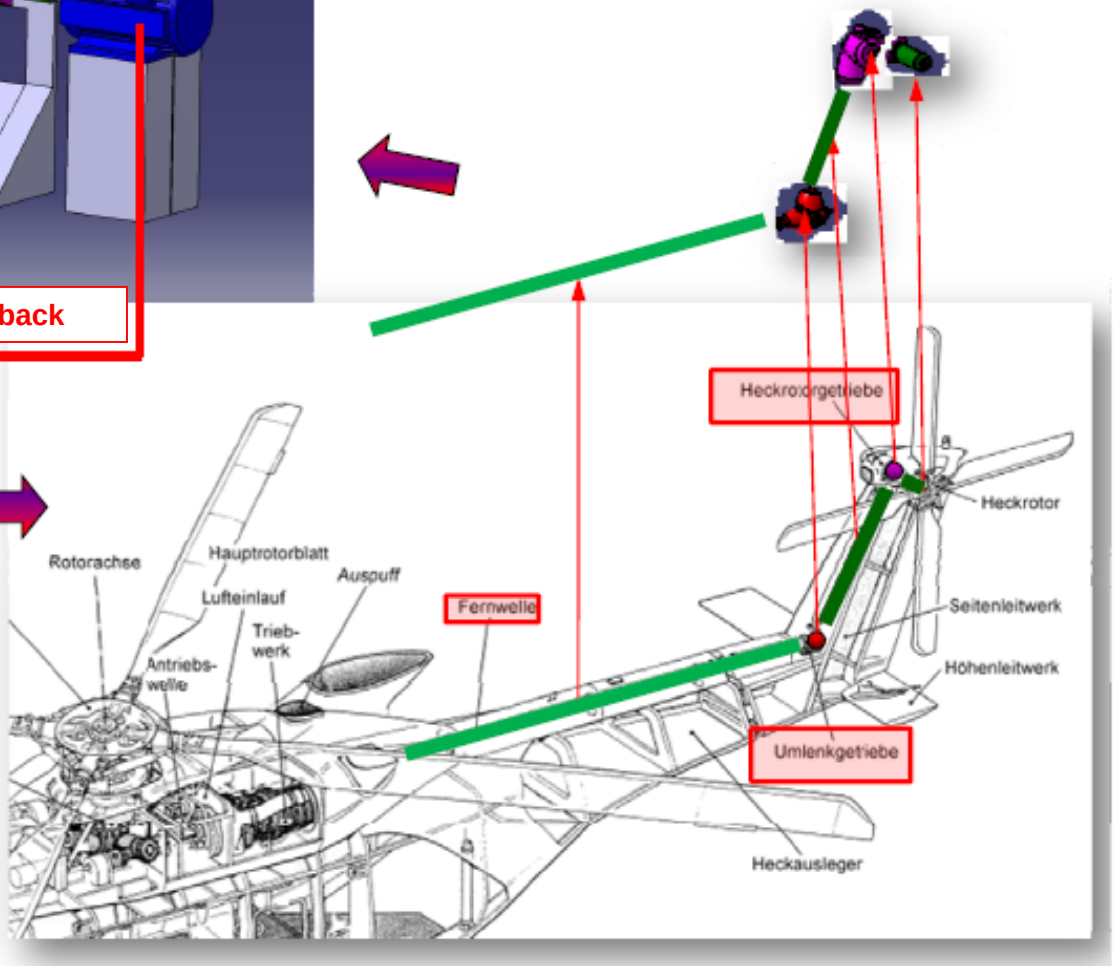
Forschungsbereich
Maschinenelemente
und Rehabilitationstechnik

Universal Test Stand
- in realisation -

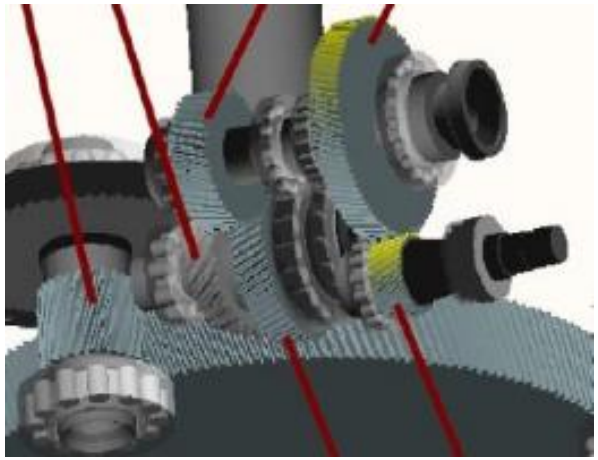
power: $P \approx 300$ kW
speed: $n_{an} \approx 6500$ min $^{-1}$







Maschinenelemente-Labor: Universal - Prüfstand 300kW



ZOERKLER
the spirit of precision

TU WIEN
TECHNISCHE UNIVERSITÄT WIEN
Vienna University of Technology

Drivetrain Development

TECHNISCHE UNIVERSITÄT MÜNCHEN

ZOERKLER
the spirit of precision

TECHNISCHE UNIVERSITÄT WIEN

VARI-SPEED

Variable Speed Rotorcraft Drive System

LEHRSTUHL FÜR HUBSCHRAUBERTECHNOLOGIE

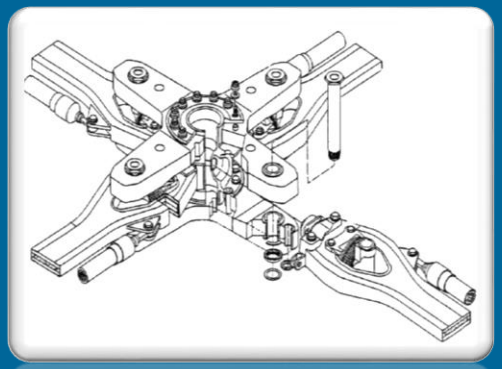
Forschungsbereich Maschinenelemente und Rehabilitationstechnik

FFG

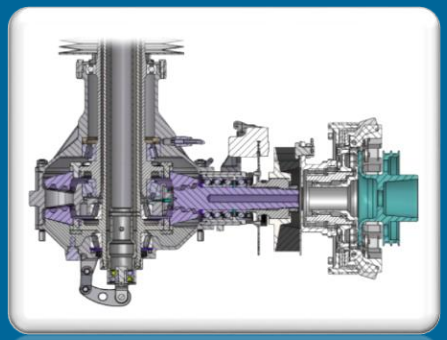
bmvit
Bundesministerium für Verkehr, Innovation und Technologie

Luftfahrtforschungs-programm (LuFo V)

Bundesministerium für Wirtschaft und Energie



Rotor for variable Rotor Speed



Transmissions for variable Rotor Speed with constant Turbine Speed

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ZOERKLER the spirit of precision

TECHNISCHE UNIVERSITÄT WIEN

VARI-SPEED

IFAR Initiative „Vertical Lift“

International Level

Continental Level

National Level

Harmonized Activities

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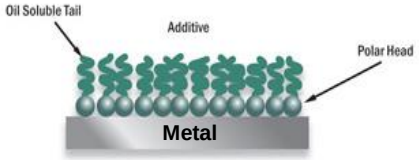
Loss of Lubrication – Lubricants



Base Oil

- Prevent metal-metal contact
- Cleaning and suspending
- Transfer heat from metal surfaces

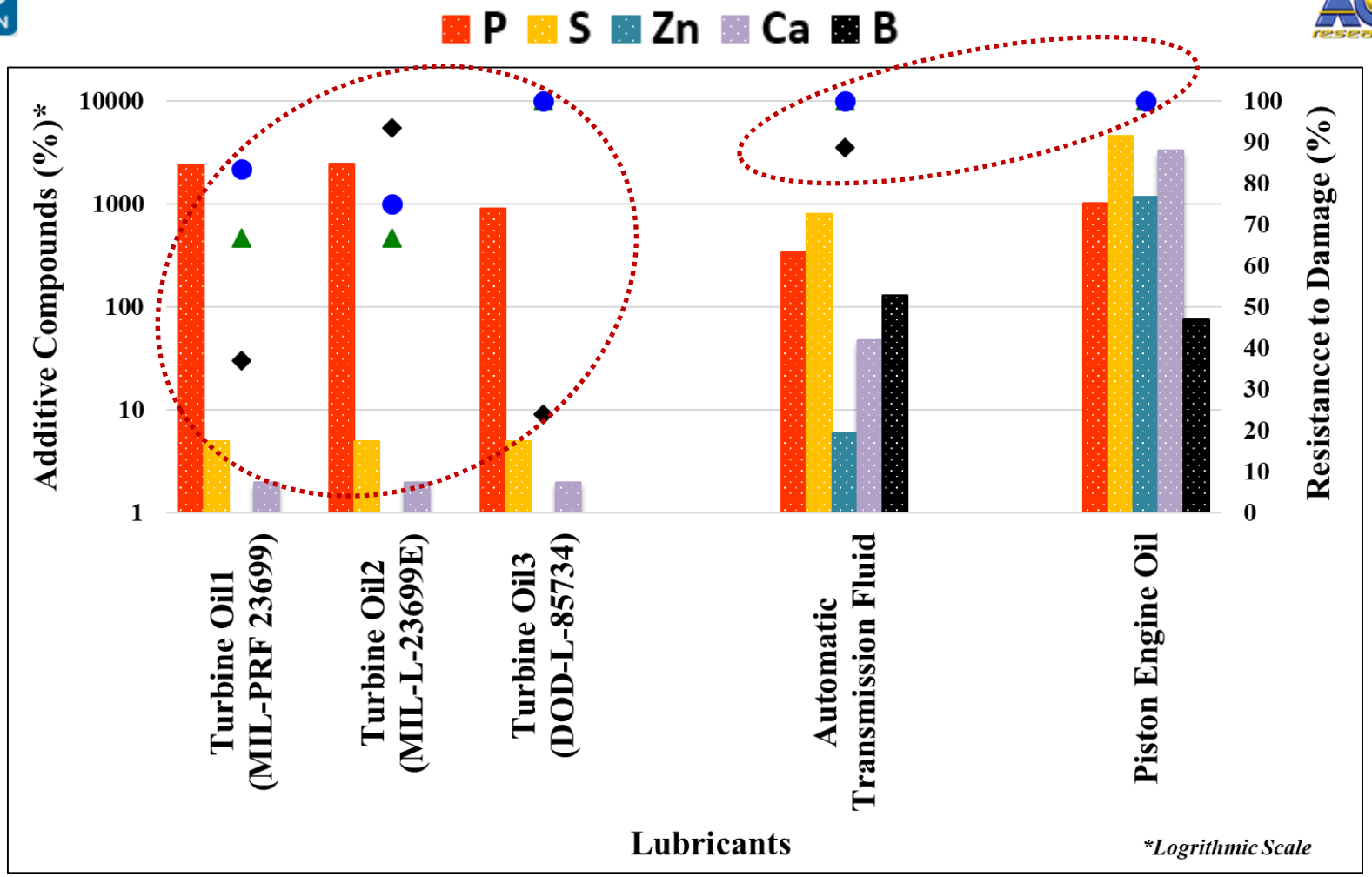
Additives

- Enhance an existing property
- Add a new property
- Suppress undesirable property

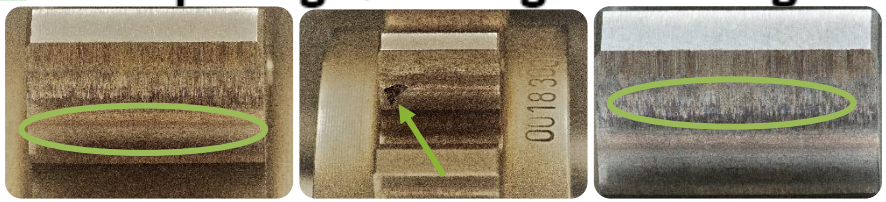
Additives	Engine Oils	ATF	General R&O Oil	AW Hydraulic	Industrial Gear Oil	Automotive Gear Oil	Grease
Detergents	✔	✔					
Dispersants	✔	✔					
Anti-Oxidants	✔	✔	✔	✔	✔	✔	✔
Rust Inhibitors	✔	✔	✔	✔	✔	✔	✔
Anti-Wear	✔	✔		✔	✔	✔	✔
Extreme Pressure Agents					✔	✔	✔
VI Improvers	✔	✔		**High VI**	**Some**	**Some**	
Pour Point Depressants	✔	✔	✔	✔	✔	✔	
Anti-Foam	✔	✔	✔	✔	✔	✔	
Friction Modifiers	✔	✔					

Source: Petro Canada

Loss of Lubrication – Additive compounds Vs Spur gear testing

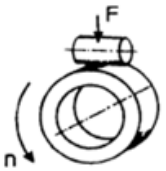


▲ Micropitting ◆ Pitting ● Fretting

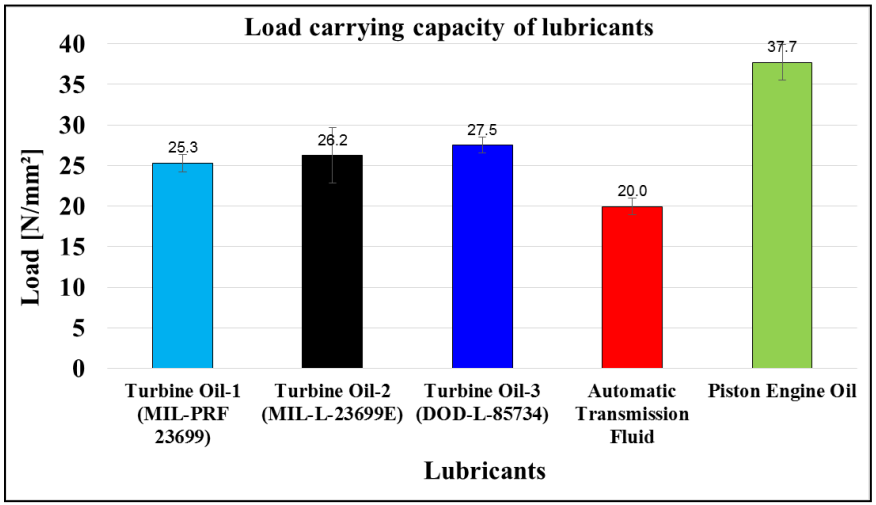


Loss of Lubrication – Tribometry tests

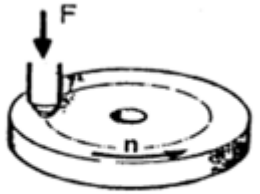
1. Load capacity



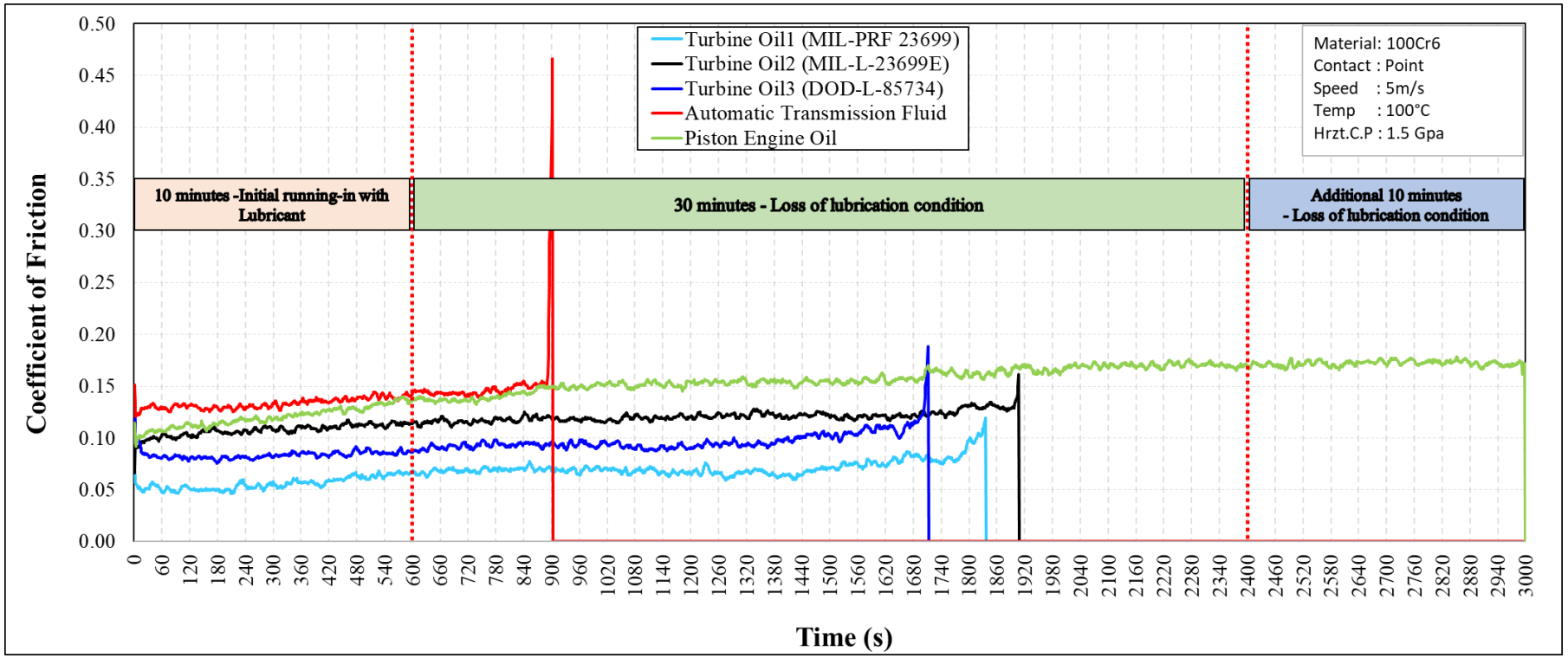
Reichert-frictional wear rig



2. Friction



pin-on-disk machine



Test method image: B.-R. Hoehn, P. Oster, T. Tobie, K. Michaelis

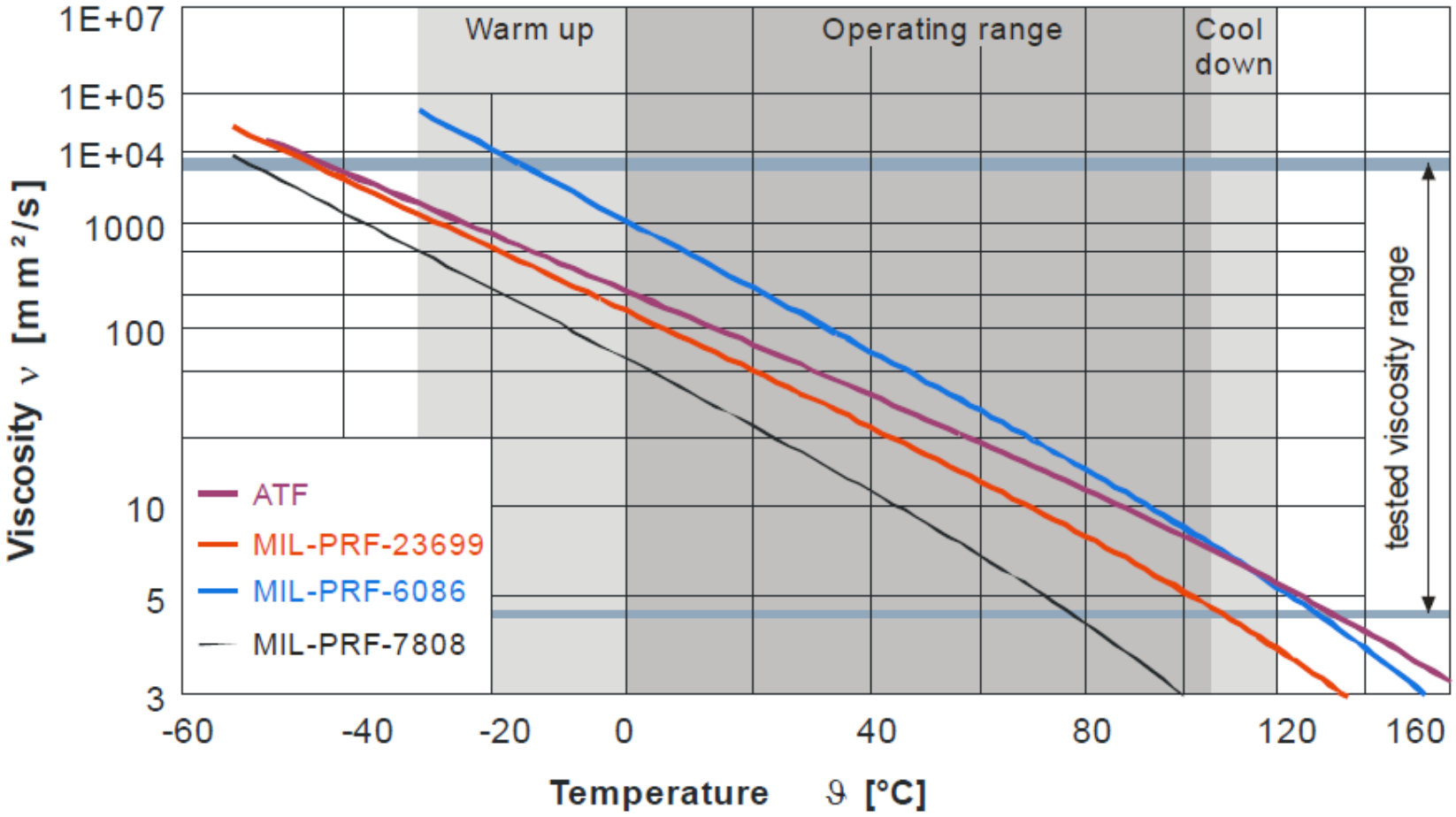
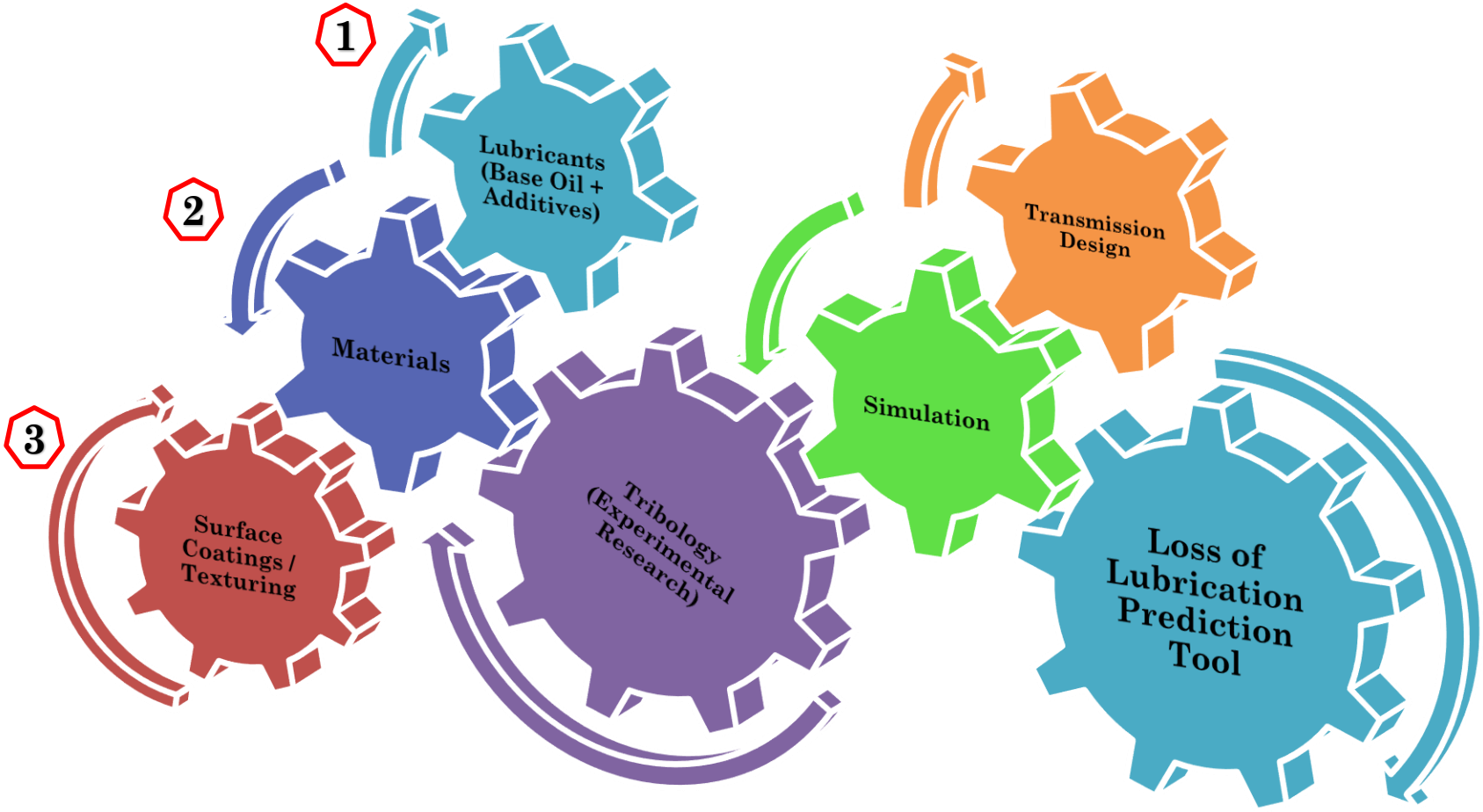


Figure 11: Viscosity - Temperature Behaviour of Typical Helicopter Gear Box Oils

LUBRICATION

(Doleschel, A, Emmerling, St.:.:
"The EC135 Drive Train. Analysis and Improvement of Fatigue Strength".
ErF 2007

Loss of Lubrication – Tribological approach



Prediction tool at the early design phase

Helicopter Tail Rotor Drive

Bevel gears after chemically activated superfinishing

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Loss of Lubrication

Simulation and Calculation:

Realisation of a calculation method that enables to evaluate the loss-of-lubrication performance in early design stages.

Today this performance can only be evaluated during testing which is rather late in the development and makes it difficult to integrate eventual design improvements.

Started in October 2016 with first PhD student together within new professorship on tribology at TU Wien

(Prof. C. Gachot, Mr. Faruck)

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Notice of Proposed Amendment 2017 – 07 (RMT.0608)

NPA 2017 – 07 has the objective to improve the loss-of-lubrication situation in Rotorcraft Transmissions and reduce the level of risk associated with it.

- Improvement of the safety assessment of pressurized lubrication systems
- Include the lubrication system in the definition of the rotor drive system
  => Design assessment acc. to 29.917 (b)
- Additional material for AC 29-2C
- Revision of 29.927 (c) and the associated AMC
- TU Wien is willing to support these actions (a.o. contact to EHA)

NPA 2017 - 07

EASA
European Aviation Safety Agency

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Thanks for Your Attention !