COST Action 532

Triboscience and Tribotechnology:

Superior friction and wear control in engines and transmissions

Workgroup 3

Tribochemistry

Co-ordinators: Sture Hogmark, Bojan Podgornik

COST - 532

Management Committee meeting

17.10.2004

Ghent

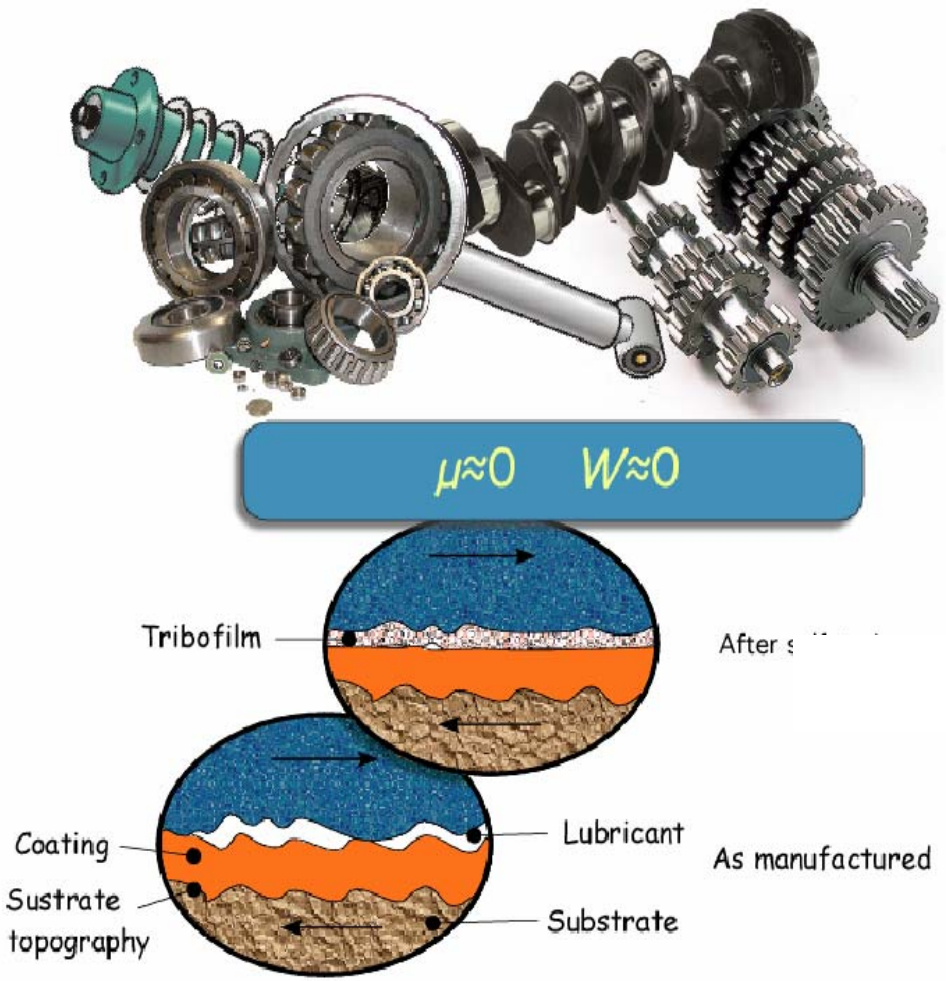
Aim

TRIBOCHEMISTRY

The field of tribology focussing on the chemical reactions occurring on surfaces under tribological stress. It is therefore central to the understanding and development of surfaces and/or lubricants

Central issue for all projects in this workgroup is research on physics and chemistry stimulated in tribological contacts.

Background



Tribofilms:

- Reaction products between surface materai and lubricants in tribological contact
- Control friction and wear in boundary and mixed lubrication

Steel/Steel ☑

Steel/Coated ?

Coated/Coated ☒

Goal of WG 3

The primary challenge or goal in this WG is to investigate if it is useful to coat lubricated surfaces, and if so, how to optimise the combination of coating material and lubricant additives to achieve tribofilms for low friction, long endurance life, environmental friendliness of coated/surface treated engine components at sufficiently low costs.

Projects Summary

October 2004:

Total number of projects:	11
No. of approved and started projects: (CH1 – CH10)	10
No. of approved but not yet funded projects: (M16)	1
New project proposals: (P17-P18)	2

Projects Summary I

APPROWED AND STARTED PROJECTS

	Title	Start	Realiz.	Funding PU/IN/OW	Publications Pap/Conf/Rep	Ind. Impr.	Comp.
CH1 POR	Development of self-lubricating coatings of the W-S-C/N system for mechanical applications	11/03	30%	40/0/60	2/0/0	-	2
CH2 PL	Interactions of lubricant additives and materials of rubbing elements	01/03	50%	60/0/40	5/0/1	-	0
CH3 SE	The influence of water contamination on endurance life	04/01	80%	60/40/0	0/2/3	-	1
CH4 PL	Oxidation stability of non-toxic greases	01/03	30%	60/0/40	0/2/1	-	0
CH5 SI	Interactions between hard coatings and lubricants	06/03	50%	60/10/30	0/2/3	-	3
CH6 ES	Development of engine and transmission simulation tests to characterize friction,wear...	01/03	10%	-	1/1/1	-	7
CH7 SE	Coating materials optimised for lubricant contacts	07/03	25%	50/30/20	0/5/3	-	6
CH8 DE	Correlation between oxidation and tribological propertie of thermally sprayed hardmetal coat.	05/03	20%	-	0/0/1	-	4
CH9 PL	Composite materials for regeneration of the friction machine elements	02/04	10%	60/0/40	0/0/1	-	0
CH10 RO	Nanostructured composite coatings obtained by electrode-position to be used in tribcor. sys	09/03	10%	0/0/100	4/2/2	-	1
		1/ 03	40%	55/10/35	13/14/10		24

Projects Summary II

APPROVED AND IN THE PROCESS FOR GETTING FUNDING

	Title	*Leader*
M16 FIN	*Tribo-chemically reacting surface coatings for superior friction and wear control*	P. Vuoristo, Tampere Univ. Technology, Finland

NEW PROPOSALS

	Title	*Leader*
P17 SE	*The influence on friction and wear of aged environmentally adapted lubricants*	E. Höglund, Luleå Univ. Technology, Sweden
P18 SE	*Influence of molecular structure on lubricant properties and performance*	E. Kassfeldt, Luleå Univ. Technology, Sweden
P19 CR	*Nanostructured coating systems a-C-Si with low internal stress, high hardness and contact fatigue resistance*	P. Bohac, Inst. Physics, Czech Republic

Projects Summary III

Chemical interactions:

CH1,CH2, CH3, CH5, CH7, M16, (P17, P18)

Development and characterization of new mat.:

CH1, CH7, CH9, CH10, M16, (P19)

Corrosion, oxidation and oxidation stability:

CH4, CH8, CH10, (P17)

Development of dedicated tests:

CH6

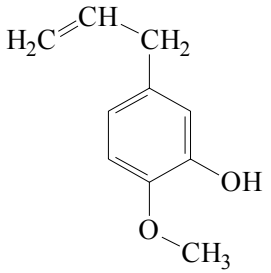
Projects Summary IV

MAIN RESULTS (8/10)

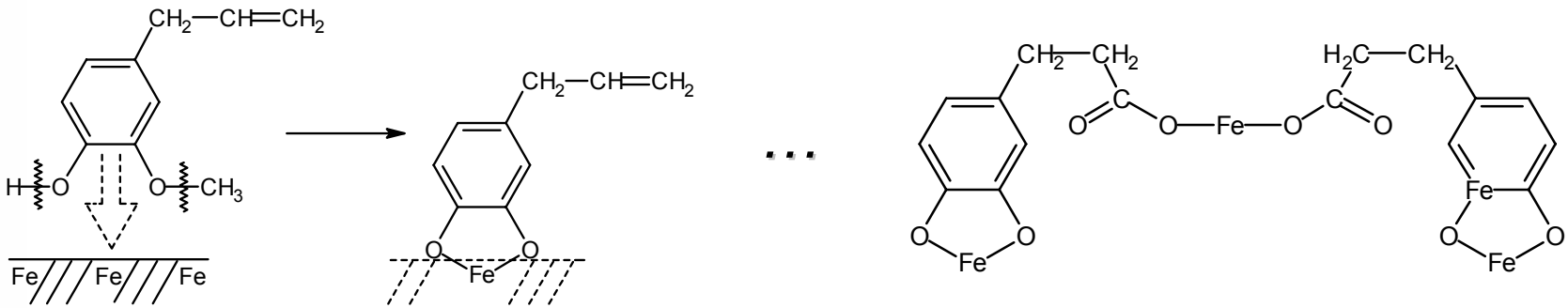
CH2 - *Interactions of lubricant additives and materials of rubbing elements*

- preparation of model lubricants
- determination of AW/EP characteristics
- chemical structure of boundary layers

4-allyl-2-methoxyphenol
good AW/EP properties



Based on FTIR and XPS analyses model of boundary film formation is proposed – formation of ***carboxylate structure***



Projects Summary IV

MAIN RESULTS

CH3 - The influence of water contamination on endurance life

To quantify rolling bearing lifedecrease caused by water cont. by:
- quantifying hydrogen transport into and in steelas
- quantifying influence of surface shear stress on hydrogen transport.

- hydrogen moves around in the steel as a function of stress variations
- hydrogen in steel is absorbed at theree different energy levels, indicating at least three different types of positions in the steel, where the hydrogen is located
- hydrogen distribution in soft and hardened 52100 ball bearing steel is very different. Soft steel had a rather evenly distributed hydrogen concentration, while hardened steel had large hydrogen concentration variations within a fraction of a millimeter

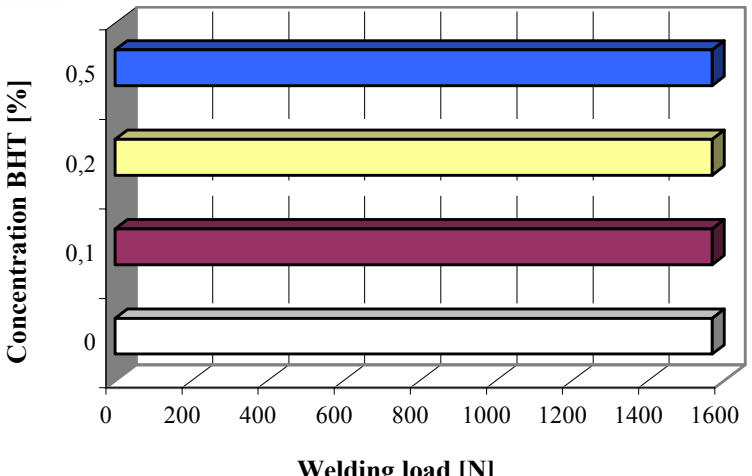
Projects Summary IV

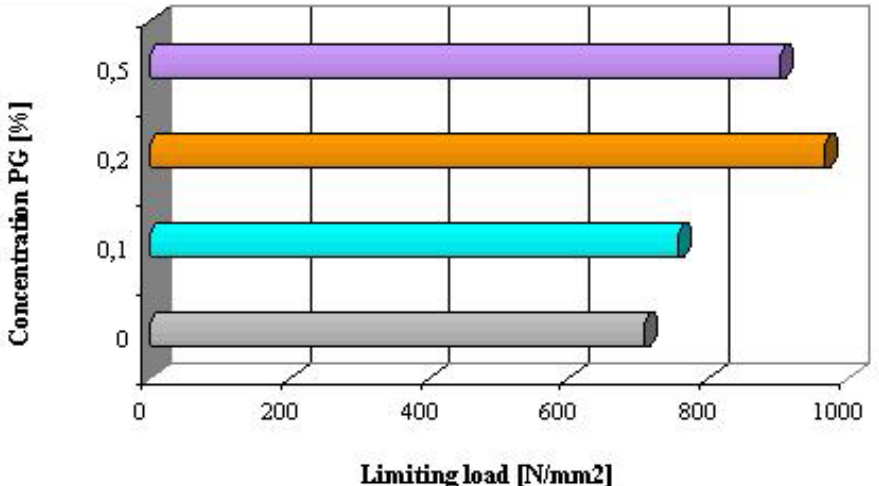
MAIN RESULTS

CH4 - Oxidation stability of non-toxic greases

- tribological properties of modified oils containing two antioxidants (butylated hydroxyphenol, propyl gallate)
- influence of antioxidant concentration on antiwear and antiseizure

For both antioxidants added to vegetable oil antiseizure properties does not change with their concentartion (BHT>PG)
Antiwear properties depend on oil composition (0.2%, PG>BHT)



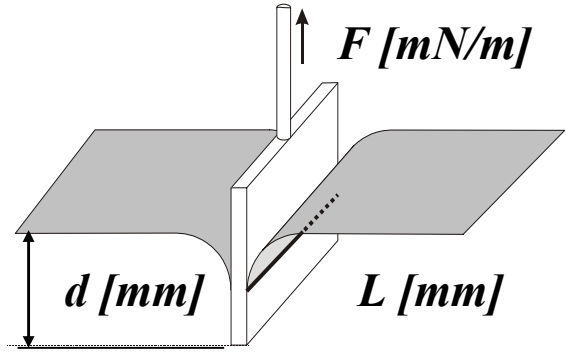


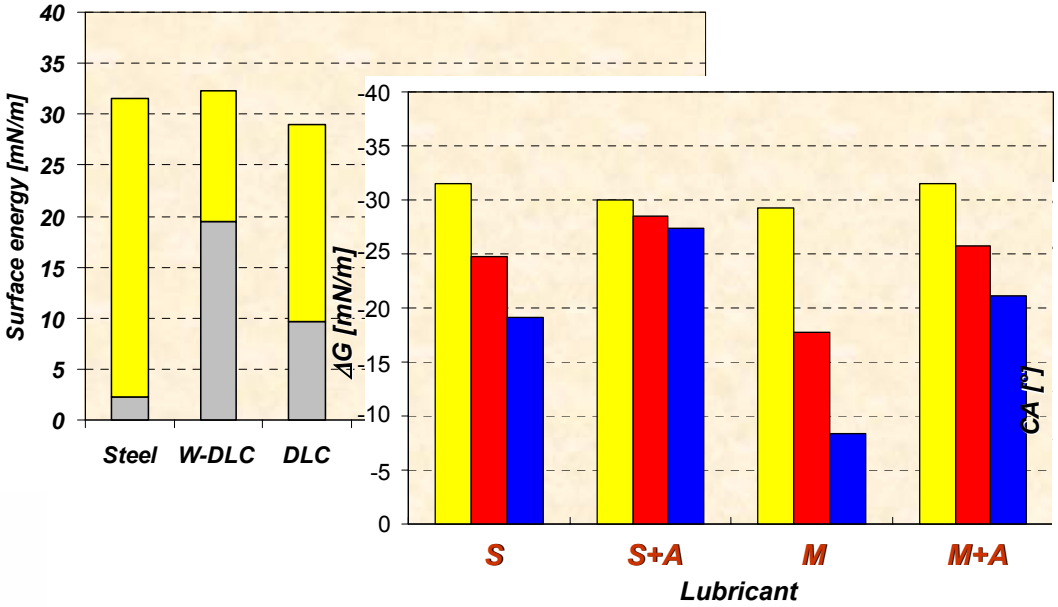
Projects Summary IV

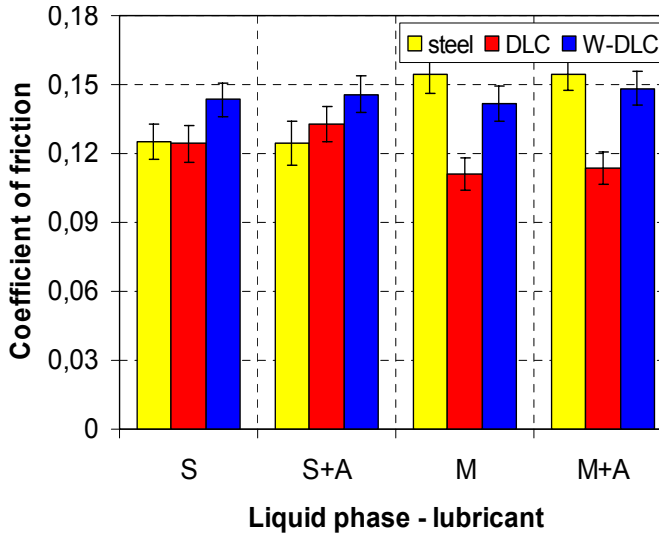
MAIN RESULTS

CH5 - *Interactions between hard coatings and lubricants*

Surface energy measurements
Polar shares – wettability - friction







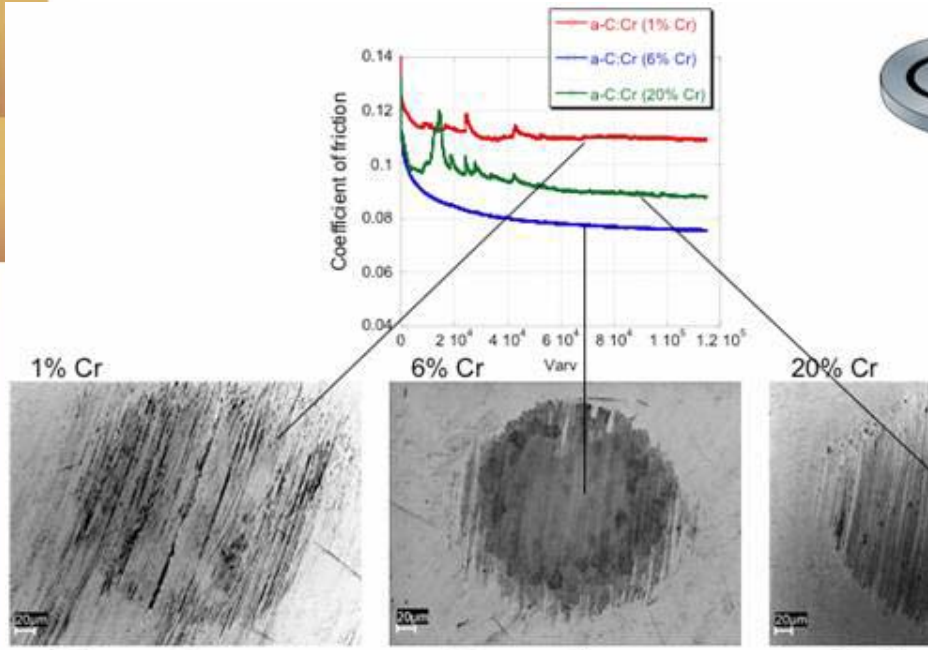
Projects Summary IV

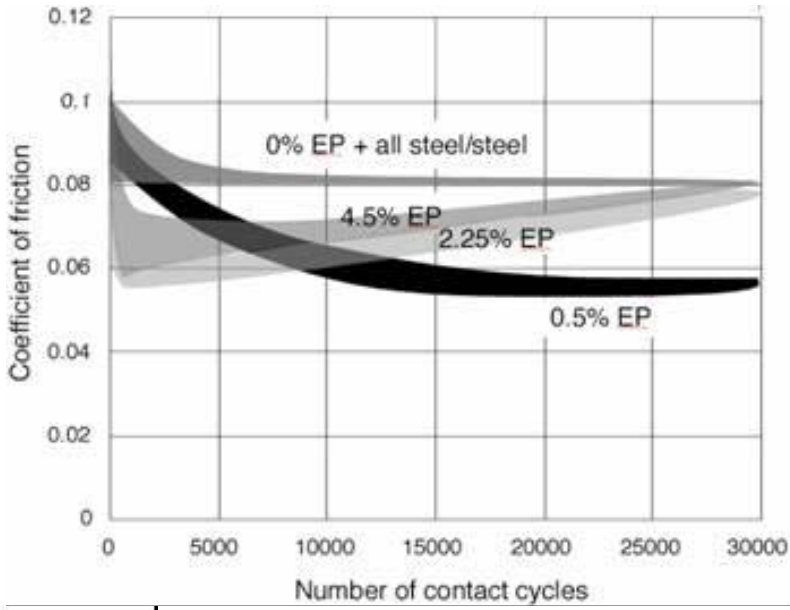
MAIN RESULTS

CH7 - Coating materials optimised for lubricant contacts

Possibilities to optimise the coating material with respect to:

- Wear resistance
- Running-in properties
- Ability to form stable, low friction tribofilms on countersurface





Projects Summary IV

MAIN RESULTS

CH8 - *Correlation between oxidation and tribological propertie of thermally sprayed hardmetal coatings*

Application-related comparative study of the oxidation of hardmetals (WC-Co(Cr), WC-Ni(Cr), Cr_3C_2-NiCr, TiC-basis-Ni(Co)) and their tribological behaviour in different conditions

- TiC-based coatings [(Ti,Mo)(C,N)-Co] paired with polycrystalline alumina under unlubricated sliding conditions showed significantly lower total wear rates as compared with Cr_3C_2-NiCr coatings
- Wear rates were in the range of those found in the region of mixed/boundary lubrication
- the coefficients of friction were found to be lower for (Ti,Mo)(C,N)-Co coatings

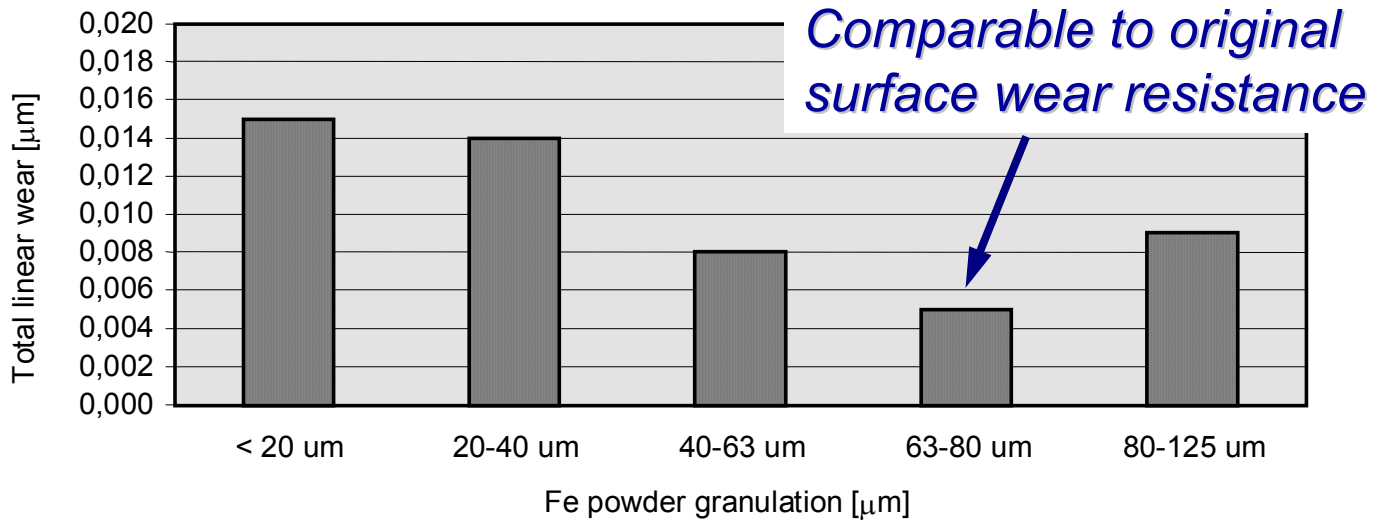
Results so far demonstrates the immense potential of TiC-based coatings for sliding wear applications.

Projects Summary IV

MAIN RESULTS

CH9 - Composite materials for regeneration of the friction machine elements

- analysis of working conditions in tribosystems possible for regeneration (shares of machine tools, and medium-loaded sliding bearings selected)
- based on components properties and physico-mechanical investigations, epoxide resin was selected, followed by Fe powder grain composition optimization



Projects Summary IV

MAIN RESULTS

CH10 - *Nanostructured composite coatings obtained by electro-deposition to be used in tribocorrosion systems*

- The influence of $Zr0_2$ particles on nickel electroplating studied using electrochemical impedance spectroscopy
- Tribocorrosion properties studied (Pin-Disc with electrochemical cell)

1. Dispersed particles modify the impendence and cathodic polarization in correlation with changes on the texture and surface morphology of the coating
2. Analysis of worn surfaces showed different content of Zr particles inside and outside the wear track (7%/13%).