Report
of
The U.S./West Germany Workshop in Tribology
"The Limits of Tribocontact Behavior"

13–17 September 1982
Bundesanstalt für Materialprüfung
West Berlin

Co-chairmen and Organizers

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Introduction

The bilateral (USA/West Germany) Workshop in Tribology was held at Bundesanstalt für Materialprüfung (BAM) in West Berlin, 13–17 September 1982. The workshop was jointly funded by the Deutsche Forschungsgemeinschaft and the U.S. National Science Foundation. The scientific focus of the workshop was "The Limits of Tribo-Contact Behavior." Twenty-five scientists, ten from the U.S. and 15 from West Germany participated. Each attendee gave a presentation and extensive discussion took place in the nine sessions over the five days.

The objectives of the workshop were to familiarize the research community in both countries with their colleagues, identify research needs, and explore the possibilities of cooperative research activities in tribology. The concensus of the attendees was that the objectives were met.

Proceedings

The proceedings included introductory presentations by the organizers [Czichos and Winer] in which they gave overviews of Tribology research in West Germany and the U.S. respectively. These were followed by a presentation from each participant on sub-disciplines of tribology. The last sessions were devoted to the identification and definition of research needs and of possible areas of bilateral research. Appendix A is a list of presentation topics and attendees.

Research Needs Identified

The final two sessions of the workshop were devoted to the identification, definition and prioritization of research needs in Tribology related to the limits of tribo-contact behavior. Suggestions from all participants were listed and voted on by the group. An initial list of about 60 suggestions was received. Each participant was asked to list the ten of those which he believed were most important.

Based on the priority ranking by the group the co-chairmen developed two lists of research needs. The first list is shown in Table A and consists of 31 basic research needs divided into four priority groups based on the votes. The four groups are listed in order of decreasing priority but there is believed to be no significance to the listing of research needs within a priority group. The second list shown in Table B consists of those research needs identified by the group which are of an applied nature. Table C contains a cross-reference of the basic research needs in terms of tribological systems categories. This table demonstrates the breadth of subject matter in the research needs identified.

As with any such group generated list, these research needs are the result of the interests and personalities of the participants. Table D lists the distribution of self-declared disciplinary interests of those participating in the Workshop. Although participants with a background in mechanical engineering were the largest contingent, all disciplines in the field were well represented.

Conclusion

The meeting was very productive professionally for all the participants and met the stated objectives. A large number of research needs of mutual interest were identified. A number of both formal and informal cooperative bilateral research efforts are expected as a result of the workshop.

At the close of the Workshop a press conference was held between five attendees and three science reporters of the West Germany Press. An article appeared in the Berlin Tagespiels on 18 September 1982.

In conclusion the Workshop was a significant and productive event in the tribology communities of West Germany and the U.S.A. which is expected to influence for the better the future of the discipline.

H. Czchios
Co-Chairman

W. O. Winer
Co-Chairman

October 1982

Fundamental Research Needs (Table A)

Priority category		Description
I	(*a*)	Determination of temperatures in tribo-contacts and the role of temperature in tribological processes.
	(*b*)	Characterization of tribo-systems (elements and testers) with respect to relevant system operating characteristics *including kinematics, dynamics, contact conditions,* thermal, environmental/chemical interactions.
	(*c*)	Examination of wear debris by modern analytical tools of physics and chemistry.
	(*d*)	Determination of failure regimes of lubricated concentrated contacts relating failure modes to governing parameters.
	(*e*)	Studies on advanced composite materials which may serve as both bulk structural and tribological elements.
	(*f*)	Continued development of surface coating and modification technology for tribo-elements.
	(*g*)	Determination of the role of vibrations in tribo-system behaviour.
II	(*a*)	Investigations of wear transfer material: structure, development and governing variables.
	(*b*)	Correlation of wear, scuffing and fatigue data between tribo-testers and tribo-elements.
	(*c*)	Determination of the mechanisms by which lubricants and additives influence pitting in rolling contact fatigue.
	(*d*)	Investigations of chemical reactions and mechanical behaviour of surfaces before and during tribo-stressing.
	(*e*)	Study of surface films and coatings in tribo-behaviour.
	(*f*)	Investigations of rolling contact fatigue of plastics.
	(*g*)	Determination of the influence of wear debris (generation, presence and transport) on tribo-systems performance.
	(*h*)	Investigation of mechanisms of crack initiation and propagation in tribo-contacts.
III	(*a*)	Development of improved stress analysis in rolling contact fatigue.
	(*b*)	Improvement of elastohydrodynamic and hydrodynamic lubrication using non-Newtonian lubricants.
	(*c*)	Application of fracture mechanics concepts to sliding tribo-contacts.
	(*d*)	Development of alloys with low adhesive energies and studies of material compatibility in adhesive failure.
	(*e*)	Determination of the role of lubricant rheology in machine elements and tribo-testers.
	(*f*)	Determination of the role of lubricant degradation in tribo-system performance.
	(*g*)	Investigation of changes in tribo material behaviour from elastic to fully plastic bulk deformation.
	(*h*)	Development of synthetic lubricants for high temperature applications (300 to 1000°C).
IV	(*a*)	In situ studies of tribo-surfaces (e.g. by X-rays and electron channelling patterns).
	(*b*)	Determination of the real area of contact during wear.
	(*c*)	Comparison of lubricant rheological behaviour at low temperature.
	(*d*)	Studies of wear phenomena at high temperatures ($\approx$1000°C).
	(*e*)	Determination of the thermal and physical properties of tribological surface films.
	(*f*)	Determination of load-compliance relations for rough surfaces.
	(*g*)	Study of new non-destructive testing techniques for predicting tribo-failure.
	(*h*)	Investigation of age hardening in tribo-behaviour.

Applied Research Needs (Table B)

- A statistical study of tribo-failures in machine elements to determine order of economic importance.
- Development of wear and failure maps as tools for machine tribo-element design.
- Publication of atlases for:
  - tribo-testers used in the US and W-Germany,
  - wear mechanisms and wear surfaces,
  - rheological data of lubricants.

Fundamental Research Needs by Systems Category (Table C)

Tribological System Categories		Research Needs (Priority numbers of Table A, multiple nominations possible)
(i)	Total system behavior	(Ib), (Id), (IIb), (IIg), (IIIe), (IIIf)
(ii)	Operating variables (load/stress, kinematics, temperature)	(Ia), (Id), (Ig), (IIIa), (IIIh), (IVd), (IVf)
(iii)	Structural components:	
	(α) Solid Materials	(Ie), (IIf), (IIIc), (IIId), (IIIg), (IVh)
	(β) Surfaces	(If), (IId), (IIe), (IVa), (IVe), (IVf)
	(γ) Lubricants	(IIc), (IIIb), (IIIe), (IIIf), (IIIh), (IVc)
(iv)	Interaction processes:	
	(α) Lubrication mechanisms	(IIc), (IIIb)
	(β) Contact processes	(IIh), (IIIg), (IVb)
	(γ) Friction processes	(IIId)
	(δ) Wear processes	(Ic), (IIa), (IIc), (IIg), (IIf) (IIh), (IIIa), (IIIc), (IIId), (IVb), (IVd)
(v)	Measuring techniques	(Ic), (IVa), (IVb), (IVg)

Attendance Composition by Discipline (Table D)

Discipline	Number*)	Percent
• Mechanical Engineering (including applied mechanics and precision engineering)	12	41
• Materials Science (including metallurgy and physical metallurgy)	7	25
• Chemical Sciences (including organic, physical, polymer, tribochemistry and chemical engineering)	5	17
• Physics	5	17

*) seven attendees indicated they belonged to more than one discipline

APPENDIX A

Program Presentations

I. Introduction

W. O. Winer. Georgia Institute of Technology, U.S.A.
Survey of research activities in tribology in the USA

H. Czichos. Bundesanstalt für Materialprüfung, West Germany
Survey of research activities in tribology: West Germany

II. Possible Causes of Failures in Tribosystems

H. Peeken. Institut für Maschinenelemente und Maschinengestaltung West Germany
Possible failure conditions of tribotechnical machine elements

K.-H. Habig. Bundesanstalt für Materialprüfung, West Germany
Tribological failure as observed in laboratory investigations

J. Holland. Institut fur Reibungstechnik und Maschinenkinetik, West Germany
The limits of hydrodynamic and elastohydrodynamic lubrication

F. F. Ling. Renesselaer Polytechnic Institute, U.S.A.
The role of surface mechanics in tribosystem failure

III. Limiting Operating Parameters [load/stress, kinematics, temperatures]

E. Broszeit. Institut fur Werkstoffkunde Techn. Hochschule Darmstadt, West Germany
Stresses in materials in tribo-contacts

K.-H. Zum Gahr. Gesamthochschule Siegen FB Maschinenbau/Werkestofftechnik, West Germany
Limiting conditions in view of fracture mechanics

M. D. Bryant. North Carolina State University, U.S.A.
A pitting model for rolling contact fatigue

W. O. Winer. Georgia Institute of Technology, U.S.A.
Temperatures in tribosystems

IV. Limiting Structures of Tribosystems

J. J. Wert. Vanderbilt University, U.S.A.
The role of microstructure of materials in tribology

E. E. Klaus. Pennsylvania State University, U.S.A.
Lubricant chemistry over the range of bulk system to concentrated contact conditions

P. Studt. Bundesanstalt für Materialprüfung, West Germany
Influences of lubricant's chemistry on tribo-contact behaviour

D. H. Buckley. NASA-Lewis Research Center, U.S.A.
The role of surfaces and environment on the tribological behaviour of materials. [did not attend but sent written contribution]

S. Ramalingam, University of Minnesota, U.S.A.
Improvements in tribological systems by surface coatings

V. Mechanisms of Tribological Interactions

H.-G. Feller. TU Berlin, West Germany
Interactions in metallic tribo-contacts

D. A. Rigney. Ohio State University, U.S.A.
Mechanisms of wear debris formation

N. S. Eiss. Virginia Polytechnic Institute and State University, U.S.A.
Wear mechanisms of polymers

H. S. Cheng. Northwestern University, U.S.A.
Asperity interactions in lubricated concentrated contacts

VI. Analytical Techniques [failure detection, friction and wear measurements, surface analysis]

R. Heinz. Bosch GmbH, West Germany
Methods and techniques of friction and wear testing and their industrial relevance

D. Klaffke. Bundesanstalt für Materialprüfung, West Germany
Study of tribological surfaces by SEM

L. D. Wedeven. NASA-Lewis Research Center, U.S.A.
Interdisciplinary approaches to tribological research [did not attend but sent written contribution]

VII. System Simulation Techniques

S. Kalpakjian. Illinois Institute of Technology, U.S.A.
The role of tribosystem mechanical properties in friction and wear

E. Broszeit. Institut für Werkstoffkunde Techn. Hochschule Darmstadt, West Germany
A case study of simulative testing

Also Attending from BAM/West Germany

Dr. P. Feinle
Dr. H. Sander
Dr. T. Win