

Tribology Division

Michael N. Kotzalas, Editor



Chair's Message

Even though some 27 years have passed, the "ASME/ASLE Joint Lubrication Conference," as it was called back in 1980, is still very fresh in my mind. American Society of Mechanical Engineers celebrated its centennial in San Francisco by holding simultaneously a number of conferences hosted by many of its divisions. August of 1980 is memorable not only because of my own experience that indeed "The coldest winter I ever saw was the summer I spent in San Francisco" (a quote attributed to Mark Twain with some debate about its originality), it was also the first Tribology conference I attended. I was amazed with the charm of San Francisco, the elegance of the St. Francis Hotel, but mostly with the list of participants, who I consider to be at the time the forefathers of "modern tribology." Needless to say, the field of Tribology has seen many changes since then. The field evolved from its golden age of hydrodynamic lubrication, EHL, TEHL to today's concentration on MEMS and nanotechnology. If in 1980 the ASME/ASLE "lubrication" conference was by-and-large the "only game in town," today there is a slew of tribology related conferences and events every year worldwide. They are held not only by engineers but also by physicists, chemists, biomedical professionals and physicians. The 3rd World Tribology Congress (WTC III) just held last September has proven that the gathering of professionals from many nations and various disciplines of tribology can bring about an excellent professional program (thanks to ASME's representatives, John Tichy and Rick Cowan, STLE's representatives, Selda Gonsel and Joe Knight, and the ASME and STLE staffs). The fast-approaching Society of

Tribologists & Lubrication Engineers (STLE) / ASME International Joint Tribology Conference (IJTC) will be held on October 23-25, 2006, at the Hyatt Regency, in San Antonio, Texas. It promises to continue the tradition of excellence. The program is now being finalized by the Conference Planning Committee, chaired by Josiah Knight (www.asmeconferences.org/ijtc06/). Special events are also planned for students and there will be a special session devoted entirely to student posters with Prizes awarded to the highest quality papers. I hope that this upcoming conference will be as memorable to first-time participants as the 1980 conference was for me. I am looking forward to IJTC 2006 and to seeing you all in San Antonio.

In the past (in the era prior to email and worldwide web) the linkage between the conference and the two journals (the *Journal of Tribology* and the *STLE Tribology Transactions*) was as sensible as it was practical, using the editorial boards of the two sponsoring societies to assure conference quality. Today's pace of information dissemination cannot afford anymore the luxury of such linkage. This year marks a transition from the full-size paper requirement to the format that has been successful at the WTC III. This is the reason why you will find papers of various formats and lengths in this year's Conference Proceedings. However, the Executive Committee of ASME Tribology Division (TD) and the STLE Board of Directors approved the WTC III format of two-page extended abstract to become the only format for conference proceedings for the next three years. This should allow for the most recent and interesting work be presented at the IJTC without delay, while allowing the editorial board of the *Journal of Tribology* to do its editorial work without being constrained by deadlines imposed by conference events. Contents and abstracts will still be reviewed closely to ensure the quality

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that we have enjoyed in the past. This new format should also curtail some bleeding of papers to other conferences that have adopted a similar mode of operation a long time ago. Authors will have the liberty to seek publication in any venue they may choose without restriction.

The TD is a small division within ASME, but it is a financially stable division that enjoys a devoted and active membership. A new Executive Commit-

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Chair's Message

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tee has recently been elected to govern the Division's business. The new officers are:

- Mike Kotzalas, Secretary/Treasurer.
- Les Miller, Education Committee Chair.
- Ali Erdimer, Technical Exposition Committee Chair.
- Michel Fillon, Chair of the Research Committee on Tribology
- Mike Hoerich, Publications Committee Chair.
- Oludele Popoola, Member-at-Large.

I would like to take this opportunity to thank retiring members of the Division Executive Committee: Andreas Polycarpou, Farrukh Qureshi, Nelson Forster, and Farshid Sadeghi, who have served the Division with great dedication. The division website <http://divisions.asme.org/tribology/> is being revised to provide updated information. I encourage you to become familiar with the Bylaws, the various aspects, structure and functions of the division. In addition to the members of the Executive Committee, there are many others who contribute considerably to the Division operation, varying from the editorial board of the *Journal of Tribology* to the chairs and officers of various business and technical committees. This newsletter contains reports from various standing committees who wish to bring you the most recent information about their activity and the state of the field in their domains. I ask the entire membership to be involved and to help in shaping the Division's future. Please join and support technical committees of your interest. We welcome the formation of new technical committees in those cases where your needs cannot be accommodated within the current structure. Please contact any of the officers listed above or me with ideas or concerns.

Itzhak Green
Tribology Division Chair

Past Chair's Message



The Tribology Division remains a strong and active technical division within the Basic Engineering Group of the American Society of Mechanical Engineers (ASME). Our membership has been stable for several years and financially the division is in excellent shape, and the envy of many other divisions. The significant changes within ASME International that have been taking place during the last several years have now been finished and the overall impact to our division's activities has been minimal. We are still part of the expanded Basic Engineering Group with the following five divisions: Applied Mechanics, Bioengineering, Fluid Engineering, Heat Transfer and Materials. Within this capacity our division has been working closely with the other divisions to improve the International Mechanical Engineering Congress and Exposition, select distinguished members for awards and strengthen ASME International in general.

The main event that took place during the past year was the 3rd World Tribology Congress (WTC III) co-organized with our partner society, the Society of Tribologists and Lubrication Engineers (STLE). This premier event took place in September 12-16, 2005, in Washington D.C. and was very well attended with 1000 delegates from around the world. Truly this event was a success and well received by the delegates. Needless to say this event could not have been possible if it was not for the tireless effort of many volunteers and staff from both ASME and STLE. These are the volunteers of the oversight committee, the track chairs, session chairs, authors and all of you that con-

tributed to the success of this event. The Tribology Division and myself personally are thankful for all your hard work and making this a truly historic event.

We will continue to maintain our established strengths of techni-

cal excellence in publications, conferences, education and service to members. The *Journal of Tribology* is in excellent shape under the leadership of our editor Mike Bryant. The 2006 International Joint Tribology Conference organized by STLE/ASME will be at the Hyatt Regency in San Antonio Texas from October 23-25, and is shaping up with a superb technical program. Please plan to attend and also advertise this event to your colleagues. Our Executive Committee meetings are held at the Joint STLE/ASME Joint Tribology Conference and at the STLE Annual meetings in May of each year. These meetings are open to all ASME members, which are strongly encouraged to attend and participate in the divisions' activities.

A new Technical Committee has been formed, the nanotribology and micro/nano systems Chaired by Shao Wang. The main objective of the new committee is to strengthen the bridge between fundamental knowledge and advanced engineering applications in the exploration of micro/nano systems. The newly formed committee is organizing a symposium at the upcoming STLE/ASME International Joint Tribology conference.

I would like to take this opportunity to express my sincere thanks to all that have supported me personally as the Chair of the division this past year, including the Executive Committee, past Chair Rick Cowan, members, friends and my family. Serving the division for 5 years in the Executive Committee through various technical committees has been a very rewarding experience and seen the division change, grow and strengthen. The newly elected Chair Itzhak Green takes this position after serving in various Executive Committee positions and brings with him many new ideas along with an interest to continue improving the Division. ASME Tribology Division continues to be a premier society and a strong influence on how we shape up the future of our discipline.

As you read the reports from the various committees, enclosed in the newsletter, please share with us your thoughts on how the Division might be of further service to you and others. We welcome your thoughts and most of all we welcome your involvement in committee activity. Volunteer some time for advancing our profession.

Andreas A. Polycarpou,
Past Tribology Division Chair

SPECIAL SYMPOSIA ON CONTACT MECHANICS

Several special symposia at the 2006 STLE/ASME Joint Tribology Conference, devoted to a variety of existing and emerging areas in contact mechanics, are being put together. These areas are: Fundamental of Contact Mechanics, Nanotribology and Contact, Mechanics in Micro-/Nano-Systems, Interfacial Phenomena in MEMS, Friction and/or Wear Modeling, Friction Induced Vibration, Thermal and/or Plastic Aspects, and Wheel - Rail Contact. The symposia are free to all conference participants, so plan to join us and watch for next years call for papers.

ASME's Continuity and Change

What Does the New ASME Mean to Me?

Since July 1, 2005, ASME has been operating under a new organizational structure. This new structure was the result of the Continuity and Change Initiative, which was designed to better position ASME to meet member needs in a very competitive global environment.

One major change you might have noticed is that the Council on Engineering (COE) no longer exists. The COE was made up of the technical groups and the technical divisions, including the Tribology Division. In this new organization all of the previous five councils were dissolved, including the Council on Member Affairs which was made up of the regions, local sections and student sections.

In their place are now five sectors: Knowledge & Community (K & C), Institutes, Centers, Codes and Standards and Strategic Management. The K & C Sector is where the majority of the technical divisions, including the Tribology Division, now reside. But also included in K & C are the districts (replaced regions), local sections, student sections and the new Affinity Communities, which include the self forming Communities of Practice. In all, more than 800 member units make up the K & C Sector.

Putting the technical divisions in the same sector as the local sections was intentional. The objective is to get the

technical division and section volunteers to collaborate, using the division's access to technical content and the section's access to local members to meet the needs of our members.

So what does all of this mean to you as a Tribology Division member? From a structural and operational view, the Tribology Division is largely unchanged. What has changed is the upper level governance of ASME above the Tribology Division. However, the Technical Group alignment (<http://www.asme.org/Communities/Technical/Divisions/>) has not changed, and the Tribology Division is still a member of the Basic Engineering Group.

While it may not seem like a lot has changed within the Tribology Division, the changes within ASME will allow us more opportunities for collaboration with other technical divisions and local sections. This in turn should yield more networking opportunities among ASME members, which will help you solve the tough problems faced by Mechanical Engineers in today's fast paced global marketplace.

Your hard work and dedication has helped make ASME a premier professional society and your continued involvement will ensure ASME's success in the future.

Burt Dicht,
Managing Director

Publication Committee

The publications committee is responsible for all the publications of the Tribology Division. In typical years, such as this, it means following activities of the *Journal of Tribology*, the division website and editing the newsletter you are reading right now. Since the last newsletter was published in Fall of 2003, all three publication avenues have undergone some level of change.

The first of which includes a new webmaster, Brad Pederson, who took control of the site early this year. Since that time, Brad has been working hard to update the content and standardize the format of the site, but he can only publish the information supplied to him. To help keep the website fresh and up-to-date, please forward any new and interesting information to Brad (look on the site to find out how).

Second, Mike Bryant became the Editor for the *Journal of Tribology*, replacing John Tichey who served two terms.

The Publication Committee would like to thank John for his years of dedicated service, during which an electronic paper submission and review tool was launched to speed up and simplify the publication process. Even though this was a significant change that recently occurred, Mike Bryant is not standing still as the new Editor. I suggest you read the *Journal of Tribology* Editor's Note later on in the newsletter to learn more about his achievements and plans for the future.

Finally, the newsletter you are reading now was compiled and published during the spring of this year. As it was late in ASME's year (committee terms start July 1st) you will notice that several of the updates were written by the past chairs (including the one you are reading right now). Also, this newsletter will be published and distributed in an all electronic format for the first time, so printed versions will not be mailed as done in previ-

ous years. The electronic distribution should speed up the newsletter publication process in the future and reduce the overall cost to the division.

With all of the changes in the Publication Committee that have already occurred, we are not standing still as you can see from my update. New publication options are always being considered and information continues to flow through the division to our members. I encourage all of you to read the *journal*, website and newsletter and submit information to Mike Bryant, Editor of the *Journal of Tribology*, Brad Pederson, webmaster of the Tribology Division site or Mike Hoeplich, the new Chair of the Publications Committee. The Publications Committee is working for you to keep you informed of what is going on and to allow you to inform others of what you are doing, so please make use of us and our available media.

Mike Kotzalas,
Past Chair

Education Committee

The Education Committee is to develop, identify and organize special meetings, education programs, and other appropriate venues for the dissemination of basic and/or specialized tribological knowledge that would be of interest to the membership of the Tribology Division. In 2003, the Education Committee had developed and proposed to the Executive Committee a comprehensive list of educational activities that included

1. Development of introductory one-hour videotapes concerning tribology fundamentals,
2. Development of three-hour tutorials on topics of current interest,
3. Organization of one-day workshops on topics such as friction and wear effects on machine elements, or standards and codes,
4. Develop a series of tribology lectures on selected topics covering both fundamental and practical aspects,
5. Development of several short courses that can be offered bi-annually on new topics.

The Education Committee will continue with the planned approach and develop new activities as deemed appropriate.

Farshid Sadeghi,
Past Chair

Membership Development Committee

The primary goal of the Membership Development Committee is to increase the number, involvement, and diversity within the Tribology Division members. This year, the committee's thirteen members have been working on two major projects to fulfill our mission. The first is a project to design and distribute a brochure that will highlight aspects and benefits of the Tribology Division, such as its publications, awards, and technical committees. The brochure will also emphasize employment opportunities related to tribology, including the types of jobs available to tribologists and the industries that employ tribologists. The brochure will be targeted to students, early-career engineers, and those who work within the field of tribology but are not members of the ASME Tribology Division and therefore may not be aware of the membership benefits. A wide distribution is planned. Each Tribology Division member will receive one along with a letter asking them to display the brochure on an appropriate bulletin board within their workplace or university if possible. The second project involves establishing an ASME Tribology Division Young Engineer Paper Contest to increase interest and involvement of young engineers in the Division. Contestants will be asked to submit a maximum 2000 word paper describing any engineering study they have undertaken within the broad area of tribology. Undergraduates and early graduate students are eligible to participate. The papers will be judged on their originality, technical significance, logic of approach, clarity, and percentage of student participation. Six finalists will be invited to present their papers at the 2006 ASME IMECE in Chicago, IL. Each finalist who presents will be awarded \$300 to partially defray the cost of travel to the conference, and the top two finalists will be awarded an additional \$300 prize. More information about eligibility, contest rules, and how to apply can be found at the Tribology Division website: <http://divisions.asme.org/tribology/studentprograms>

Dr. Brad A. Miller,
Chair

International Coordination Committee

The International Coordination Committee is responsible for coordinating international activities of the ASME Tribology Division and for promoting collaboration among the international Tribology Division members. The functions of this committee are to:

1. Create a link between international members of ASME in tribology;
2. Generate a forum for exchange of ideas and new knowledge in tribology and related areas;
3. Set up a mechanism for regional workshops, short courses and education activities;
4. Seek collaboration on funded joint research projects and workshops (in cooperation with the Research Committee of this Division);
5. Increase the number of international members in the Tribology Division;
6. Involve ASME members in international activities such as in the International Tribology Council, the OECD Wear Group, VAMAS-Wear Standards group, etc.

This committee regularly meets in the fall at the ASME/STLE Joint Conference and in the spring at the STLE Annual Meeting. The committee consists of more than 20 members, and 3 officers each serving 2 years. The current officers are: Chair, Benyebka Bou-Said; Vice-Chair, Jean Frene; Secretary, Joze Vizintin and Tribology Division Member at Large (Advisor/Past Chair), Bo Jacobson.

The International Coordination Committee has now successfully expanded to have representatives for all regions of the world outside USA and Canada:

South America and Mexico:

Omar Linares (linares@extremate.net, linareso2@asme.org)

Asia: Kuniaki Dohda (dohda@mech.gifu-u.ac.jp)

Australia and New Zealand: Gwidon Stachowiak (gws@mech.uwa.edu.au)

Middle East and Africa: Abdallah Elsharkawy (abdallah@kuc01.kuniv.edu.kw)

Europe: Jean Frene (frene@lms.univ-poitiers.fr)

The International Coordination Committee is active in promoting international conferences via advertising in ASME publications such as the Tribology Division Newsletter, Mechanical Engineering Magazine as well as on the ASME Tribology Division Web Site. At conferences, the International Coordination Committee establishes a booth to provide infor-



Prof. Nobuo Ohmae receiving the Tribology Division Award at the ITC 2005 conference in Kobe, Japan.

mation on Tribology Division activities and to encourage membership to the Tribology Division of ASME International. ASME Tribology Division also presents an award to a tribologist recommended by the conference organizers and ratified by the International Coordination Committee and Executive Committee.

Such arrangements were successfully accomplished in the past and during 2004 with the following conferences:

NORDTRIB 2004 SYMPOSIUM, Tromsø, Harstad, Bodø, Norway, June 1–5, 2004

AITC 2004 CONFERENCE, Rome, Italy, September 14–17, 2004

ITC 2005 CONFERENCE, Kobe, Japan, May 29–June 2, 2005

Prof. Kristian Tønder, Prof. Roberto Bassani and Prof. Nobuo Ohmae were the recipients of the Tribology Division Award at the respective conferences. Congratulations to these three well deserving tribologists!

Benyebka Bou-Said,
Chair

Journal of Tribology Editor's Note

During the past year, the ASME *Journal of Tribology* has maintained its position as one of the world's most respected archival journals in the field of tribology. I believe we are the most prestigious and desired publication venue of the tribology journals, certainly the most selective. Our acceptance rate is about 50%, whereas the acceptance rate of our competitors is much higher. I wish to extend my appreciation to the authors, Associate Editors, and reviewers who have contributed to the *Journal's* continued success.

During the period September 1, 2003 to August 31, 2004, the *Journal of Tribology* published 99 technical papers and 8 technical notes on various aspects of tribology. The breakdown of published papers during the year is as follows:

Subject	Distribution (%)						
	03-04	02-03	01-02	00-01	99-00	98-99	97-98
Contact mechanics	21	15	19				
Friction and wear	11	16	13	30	30	26	23
Hydrodynamics (including gas)	24	21	18	22	28	27	21
EHL/rolling elements	19	21	28	17	12	12	18
Magnetic storage, micro- nano-	17	16	12	18	20	17	18
Other (including seals, coatings, manufacturing)	8	11	10	13	10	18	20

The distribution of papers per subject matter in the *Journal* has varied only slightly during the past seven years, as shown above. In many cases, the assignment of a paper to one category or another is fairly arbitrary: a gas bearing paper could be "hydrodynamics" or "magnetic storage," an adhesion paper could be either "contact mechanics" or "other," etc. The range of type of papers in the "other" category is huge: from our most scientific papers on, say, molecular nanotribology; to the most applied papers on, say, wear in forming processes. The number of magnetic storage papers is climbing back up after several years of decline. I attribute this to a number of factors: poor economic conditions in that industry, maturity of the field – thus fewer research papers, and the fact that magnetic storage presentations at the ASME/STLE Tribology Conference are given in special sessions, apart from the reviewed papers.

Review of the papers submitted to the *Journal* for publication has been carried out under the guidance of a devoted board of Associate Editors. In November 2003, Dr. Takahisa Kato from the National Institute of Advanced Industrial Science

& Technology, Ibaraki, Japan, was appointed Associate Editor for a three-year term (12/1/03–12/1/06). His areas of expertise are nanotribology, microtribology, magnetic storage tribology, contact mechanics and hydrodynamics. In addition, in March 2004, Dr. Cornelis H. Venner from the University of Twente, Enschede, The Netherlands (3/1/01–3/1/07) and Dr. Shifeng Wu from A.W. Chesterton Company, Groveland, MA (3/1/01–3/1/07) were reappointed to our Editorial Board to serve a second three-year term. Finally, In December 2003, Dr. Ton A. A. Lubrecht (12/1/97–12/1/03) completed his six-year appointment as Associate Editor. He carried out his duties conscientiously during his tenure and his effective assistance in this important editorial role is greatly appreciated.

between the date of receipt of the paper and the date of acceptance or rejection. This is essentially the same as last year's average of 5.2 months. Over the previous five years, the average was about 7.0 months. Clearly, the trend is in the right direction, which I attribute to our current roster of Associate Editors. However, this duration is still too long and attempts will continue to be made to reduce this review time.

The *Journal* has a detailed website www.rpi.edu/~tiersh, which contains many features such as instructions for paper preparation, addresses of Editorial Board Members, etc. There are links to the site from the websites of ASME, RPI, and the Tribology Division.

Michael Bryant,
Editor

ASME TRIBOLOGY DIVISION - YOUNG ENGINEER SHORT PAPER CONTEST

The ASME Tribology Division announces a Young Engineer Short Paper Contest. Six finalists will be chosen to present their papers at the 2006 ASME IMECE, November 5–10, 2006, Chicago Hilton & Towers, Chicago, IL. Each finalist will be awarded a \$300 prize to partially defray the cost of travel.

The contest was entered by undergraduate students, recent baccalaureate engineers (graduation after April 2006), and graduate students. Contestants submitted a maximum 2000 word paper describing any engineering study they have undertaken within the broad area of Tribology. Judging criteria were originality, technical significance, logic of approach, clarity, and percentage of student participation.

Watch for next year's call for papers, or check eligibility and other additional information, at: <http://divisions.asme.org/tribology/studentprograms>

The Editorial Board of the *Journal of Tribology* wishes to thank all those who have acted as technical reviewers for the *Journal* during the past year. A list of those reviewers was included in the July 2004 issue of the *Journal*. The input of peer reviewers is critical, and we hope they will continue to provide timely and critical reviews for the *Journal* in the coming year. Reviewer of the Year for the year 2003-2004 was selected and also noted in the July 2004 issue. That person is Dr. Mihai Arghir, LMS, Université de Poitiers, France.

During the past 12-month period, 198 papers were submitted for possible publication in the *Journal*. This is down from the 210 papers submitted during the same period in 2001–2002, and up from 183 papers in 2000–2001. As a general observation, the fraction and number of papers from overseas continues to increase.

The acceptance rate is 51%, the same as last year's figure of 51%, and essentially the same as the 50% average of the last six years. Analysis of the papers published during the past year showed that there was an average delay of 5.1 months

TECHNICAL COMMITTEES:

Research Committee on Tribology

The Research Committee on Tribology is a Technical Committee of ASME's Tribology Division. The Research Committee on Tribology's primary purpose is to assess recent developments in science and technology related to tribology and to appropriately disseminate this information to ASME members interested in tribology. This dissemination is accomplished through sponsored topical workshops, special sessions or panels held during conferences, and publications documenting the results of such workshops and panel studies. The Research Committee on Tribology reports to the Tribology Division Executive Committee through the Research Committee on Tribology Chair. The Research Committee on Tribology can take on special tasking of the Tribology Division Executive Committee when required.

The Research Committee on Tribology was reformed in 1999 at the request of Dr. Said Jahanmir who was then Chair of the Tribology Division Executive Committee. Dr. Hooshang Heshmat was the first Chair of the newly formed Research Committee on Tribology. Research Committee on Tribology Chairs serving after Dr. Heshmat were Professor Michael Bryant, Professor Tim Ovaert, and Dr. Nelson Forster. Three workshops have occurred since the Research Committee on Tribology was reformed:

1. Oil-Free Workshop Co-Chaired by Dr. Chris Della Corte and Dr Heshmat;
2. Bio-Medical Workshop Co-Chaired by Professors Mike Bryant and Thierry Blanchet; and
3. Virtual Tribology Workshop Co-Chaired by Professor Farshid Sadeghi and Dr. Nelson Forster.

Additionally, there have been several surveillance sessions at the ASME/STLE International Joint Tribology Conference which have updated members of ASME on the progress of the Research Committee on Tribology's research activities. There was also a surveillance session co-sponsored with the American Vacuum Society on coatings for cutting and forming tools and green manufacturing applications. This session occurred at the International Conference on Metallurgical Coatings and Thin Films.

The most recent technical activity of the Research Committee on Tribology is a surveillance session on tribology related aspects of micro-turbomachinery. A

session is currently being formed by the current Vice-Chair, Professor Luis San Andrés of Texas A&M. This promises to be a very interesting session dealing with high speed gas bearings, coatings for low friction and reduced wear, and environmental effects on the tribology of micro-turbomachinery. Several abstracts have already been received. This session will occur at the 2006 International Joint Tribology Conference to be held in San Antonio, October, 2006.

Nelson H. Forster,
Chair

Nano Tribology and Micro- / Nano-Systems

The fast-paced advancement of science and technology in the micro- and nano-fields has led to the call for a subcommittee within the ASME Tribology Division to boost this important part of tribology research activities. To answer this call, a new technical committee – The Committee on Nanotribology and Micro- / Nano-Systems (NMNS) – is currently being formed. The founding Chair, Prof. Shao Wang (Nanyang Technological University), Vice-Chair, Dr. Michael T. Dugger (Sandia National Laboratories), and Secretary, Dr. Lior Kogut (QUALCOMM MEMS Technologies), have already started organizing a Special Symposium on Nanotribology at the 2006 STLE/ASME International Joint Tribology Conference. The committee aims to promote the technical advancement and communication in both fundamental and applied areas relevant to micro- and nano-scale studies, including such research areas as scanning probe-based technology, nano-films, nano-wear, molecular dynamics, MEMS, and NEMS. This new committee will collaborate with existing technical committees to obtain benefits for all under the Tribology Division. An important objective of the new committee is to strengthen the bridge between fundamental knowledge and advanced engineering applications in the exploration of the micro-/nano-world.

Shao Wang,
Chair

Contact Mechanics

This technical committee was formed at the 2002 International Joint Tribology Conference in Cancun around a dinner

table by a small group of five people. While contact mechanics papers had been presented in various conferences and spread over many sessions it was envisioned that the field can be further promoted and advanced if all such activity is brought under one Technical Committee. The specific purpose of the Committee is to maintain and develop the theory and practice of contact mechanics in moving parts in various types of components and machinery and in various scales (nano to macro). The activities of the Committee includes:

1. The development of information through the encouragement of publications, the solicitation of papers, and panel discussions on subjects of interest to the membership;
2. Assisting individuals, companies, or other organizations in locating information;
3. Standing ready to assist local sections in obtaining speakers or developing programs,
4. The development, if necessary, of recommended practices or standards.

Membership in the Committee is open to all ASME members and will include representatives from the research and academic communities and related industries applicable to this Committee. Since its inception the committee has arranged for many symposia sessions at the International Joint Tribology Conferences, with dozens of high quality proceedings. At the last World Tribology Congress in 2005, the committee arranged four memorable symposia in honor of K. L. Johnson in addition to four regular sessions on contact mechanics. Solicitation for papers and presentations at the 2006 International Joint Tribology conference is going on. Please check tracks 8 (regular sessions) and 15 (symposia) at <http://www.asmeconferences.org/IJTTC06/CallForPapers.cfm>. The committee's bylaws have been approved by the membership, and we have in place subcommittees for membership, paper solicitation, and awards. My appreciation is extended to all officers and volunteers for their diligent work. I hope that you will find this committee to serve your needs and peak your interest.

Itzhak Green,
Chair

TECHNICAL BRIEF

Contact Mechanics

Although contact mechanics has a base in traditional areas of tribology, additional interest in contact mechanics is growing because of its importance in emerging areas. In particular with MEMS devices entering the commercial marketplace and with nanomechanics applications on the horizon, there has been a renewed interest in contact mechanics, especially at these micro- and nano-scales. Because of the scaling effect (i.e. surface forces scale as the square of the dimensions whereas body forces vary as the cube of the dimension), surface forces (adhesion and friction) become relatively more and more important as the size of a body decreases. For this reason components in MEMS devices are prone to failure by sticking together either during fabrication or while in use.

At the same time the development of sophisticated scanning probe equipment has made measurements of atomic level surface topography, as well as single asperity contacts, possible. This combination of new applications and instrumentation has helped to fuel a renaissance in the theoretical and applied aspects of contact mechanics, with an emphasis on adhesion and scale-dependent friction.

It is well known from everyday experience that to displace one body relative to another when the bodies are subjected to a compressive force necessitates the application of a specific tangential force, known as the static friction force. Until that required force is applied the bodies remain at rest with respect to each other. Accurate prediction of the static friction force may have an enormous impact on a wide range of applications such as bolted joint members, work-piece fixture element pairs, static seals, clutches, compliant electrical connectors, magnetic hard disks, and MEMS devices, to name just a few.

Static friction was considered by the pioneers of friction research: Leonardo da Vinci, Guillaume Amontons, Leonard Euler, Charles Augustin de Coulomb, George Rennie, Arthur-Jules Morin, Robert Hooke and others. In early experimental work it was observed that the proportionality of the force opposing relative motion to the force holding the bodies together seemed to be constant over a range of conditions. Amontons, for example, is remembered for his two laws of friction:

TEXAS TECH UNIVERSITY RESEARCHERS DEVELOP FRICTION BASED FABRIC QUALITY EVALUATION METHOD

LUBBOCK — Researchers at The Institute of Environmental and Human Health at Texas Tech University have developed computer software that accounts for the complexities involving the frictional evaluation of textile and polymeric materials.

A simple parameter that takes into account the material and surface properties has been developed, and the calculation of this parameter has been automated with the development of the software.

"This friction parameter has been accepted in 10 peer reviewed journals in polymer science, tribology and textile chemistry and science," said Seshadri S. Ramkumar, assistant professor and lead researcher for the project. "Journals, such as *Wear*, *Journal of Applied Polymer Science*, *Textile Research Journal* and *AATCC Review*, have carried articles on the finding."

Friction in materials plays an important role in fabric manufacturing, final quality and marketing, Ramkumar said. The smaller the frictional forces, the smoother the fabric surface is, which makes a softer- and higher-quality material. Research has shown that characterization of the friction of viscoelastic

materials, such as fiber, textiles, etc., is complex and requires in-depth calculation.

The software automatically calculates the friction factor and is compatible with Windows based operating systems such as Windows 98, 2000, ME and XP. The software has Microsoft Access database for storing and retrieving results, he said. Texas Tech University is making available the user-friendly product to the materials industry.

"The software will be of immense use to fiber, fabric, nonwoven, polymer, leather and related industries and provides an easy solution to friction evaluation in material related industries, instead of having people calculate it, this software will make the whole process easier and quicker" said Ramkumar.

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1. The force of friction is directly proportional to the applied load,
2. The force of friction is independent of the nominal area of contact.

A common method for calculating the static friction force (Coulomb friction law) was drawn from these two basic laws by multiplication of the normal applied load by a proportionality constant, known as the static friction coefficient. Static friction coefficients are conveniently tabulated as a function of the contacting materials and have been incorporated into engineering handbooks for at least 300 years. However, these tabulated values represent average coefficients of friction which vary significantly over a broad spectrum of test conditions. While these numbers provide a general guideline of the sensitivity of the coefficient of friction to the materials in contact, they may not necessarily be representative of the coefficient of friction that will result between actual contact pairs. The friction coefficient is presently recognized as both material- and system-dependent and is definitely not an intrinsic property of two contacting materials.

The friction coefficient is an established, but somewhat misunderstood, quantity in the field of science and engineering. While friction coefficients are relatively easy to determine in laboratory experiments, the fundamental origins of sliding resistance are not so clear. Hence, it is extremely important to understand the processes involved in friction. Indeed, a great deal of progress has been made since the pioneering work of Amontons in 1699 and Coulomb in 1785, as is evident from recent works that consider both the atomistic point of view and continuum mechanics principles.

Tabor, in his general critical picture of friction understanding, pointed out three basic elements that are involved in the friction of dry solids:

1. The true area of contact between mating rough surfaces,
2. The type and strength of bonds formed at the interface where contact occurs,
3. The way in which the material in and

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around the contacting regions is sheared and ruptured during sliding.

The importance of these three elements can be easily understood from the definition of the static friction coefficient, μ :

$$\mu = Q_{\max} / F = Q_{\max} / (P - F_s) \quad (1)$$

where Q_{\max} is the tangential force needed to fail the junctions created between the contacting surfaces, and F is the total normal external force. This force is the balance between the actual contact load, P , in the true area of contact and the attractive intermolecular forces, i.e. the adhesion (F_s) acting between the surfaces in contact. The right hand side of Eq. (1) contains all the three elements mentioned above. The contact load, P , is related to the true area of contact. The adhesion force, F_s , is related to the strength of the bonds formed at the interface. The maximum tangential load, Q_{\max} , is related to the failure of the contact. While extensive investigation and modeling efforts have become available in recent years, when compared with controlled experiments it is clear that we still do not completely understand the adhesive static friction mechanism and that further work is needed.

It is evident that available tabulated values of the static friction coefficient do not account for such important parameters as surface roughness, surface energy, mechanical properties and contact load that have strong effects on friction. Adequate theoretical models will eliminate the current need for extensive empirical work and will shed more light on understanding the dominant parameters affecting the static friction coefficient. The aforementioned approximate models for the static friction coefficient, although showing the right trend when compared with controlled experiments, still remain to be improved by considering, for example, the stick condition in the contact interface as well as the possibility of junction growth.

The contact problem and the way it is solved remains a key point in most computer codes and related analysis. It includes commercial or academic software based on the finite element method, the boundary element method, the semi-analytical method, and also the granular model, the smooth particle hydrodynamics method, molecular dynamics, and at another scale multi-body dynamics. The

contact solver is usually costly in terms of CPU time and allocated memory, and it is at the origin of inaccuracy when the contact options and the effects of the mesh size are not clearly understood before performing a simulation. Moreover, engineers who are looking for the solution of a "generally very complex problem" for a given application cannot afford long computing times or the expansion of resources to solve such problems. As a consequence numerous assumptions need to be made prior to building the model, leading to the danger that it may lead to a numerical model that is quite different from the real application.

The assumption of elasticity is very common in contact problems and related phenomenon such as wear, rolling contact fatigue, cracking, fretting, stick-slip, EHL, sphere-to-sphere interaction, adhesion, etc., from macro to nano scales. This hypothesis is suitable when one is looking for an analytical solution, for example for use in a statistical model of contact between asperities, but it does not provide a true image of the stress and strain state found during loading and unloading in most real applications. Except for the wheel-on-rail application for which FEA has been extensively used during the two last decades to deal with plasticity, elastic or plastic shakedown and ratcheting, it is clear that the contact models used in many applications do not fit the physical behavior of most materials since the yield stress is easily exceeded. Some attempts have been made to overcome this difficulty, such as using a threshold value for the contact pressure, roughly 2.8 or 3 times the yield stress, implemented in what is known as the elastic-perfectly plastic contact model. This type of assumption could be useful to estimate the real contact area, the pressure distribution, the rigid body displacement or the gap between two static rough surfaces in order to estimate the leakage or flow, but not to describe the subsurface stress and strain states since plastic strains and subsequent residual stresses are not considered. Nevertheless, plasticity is of prime importance since residual stresses may explain why sometimes a micro-crack does not propagate in compressive zones as it does in tensile ones. In addition many physical models of fatigue are based on the accumulation of dislocations or plastic strains, leading to the initiation of a micro-crack either in a homogeneous or inhomogeneous media.

Progress in computer performance and better knowledge of the material behavior allow the implementation of

various physical phenomena in our models considering the inelastic properties of the materials and these for a wide variety of new applications. For example, isotropic or anisotropic properties could be introduced for both coatings and the substrate. Inelastic deformations may progressively increase the complexities of the material behavior by introducing cyclic hardening or softening due to plasticity, along with some viscous effects for transient analysis (impact or very short solicitation time). Likewise thermal effects, softening of the material with temperature and the effects of an electrical current may also become extremely important in some applications of high speed sliding under extreme electromagnetic loading.

Unlike some other research areas in tribology which are now well understood and established, contact mechanics is providing an opening into a very exciting and novel area left to be explored.

George Adams, Izhak Etsion,
Daniel Nelias, and Itzhak Green

SPECIAL SYMPOSIUM ON NANOTRIBOLOGY

Organized by Committee on Nanotribology and Micro-/Nano-Systems (NMNS)

This special symposium at the 2006 STLE/ASME International Joint Tribology Conference is devoted to various aspects of tribology at the nanometer scale, encompassing fundamental research and applied studies. Papers of the following areas were solicited (2–8 page extended abstracts, 4–6 preferred): Studies of nanotribology with scanning-probe based technology (AFM, STM, LFM (FFM), etc.), nano-wear of solid films/coatings, characterization of nano-scale solid films and nano-scale lubricant films, friction and wear at the atomic and molecular scales, tribo-chemical or tribo-physical effects in nanotribology, surface forces, adhesion and rheology of nano-scale films, nano-materials or nano-particles as additives in lubricants, molecular dynamics simulation of friction, wear and lubrication, superlubricity of nano-films/materials, nanotribology in micro-/nano-manufacturing, and other aspects of nanotribology. Join us at the 2006 STLE/ASME International Joint Tribology Conference to learn more about Nanotribology and watch for next year's call for papers.