



Editorial

Tribology Education: Present Status and Future Challenges

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Introduction

The ASME Research Committee on Tribology (RCT) has been concerned that some of today's engineering students may not be learning enough about the fundamentals of tribology. After considerable discussion of the topic by RCT membership, it was decided to commission a survey of engineering curricula in the United States to gather data on the present status of tribology education. The survey was followed by a panel discussion which evaluated the significance of the survey results and obtained further input from educators, researchers and practicing engineers representing a broad spectrum of views in different sectors of academia, industry and federal government. This panel session was held at the Joint ASME/STLE Tribology Conference in 1987. Included in the panel and the subsequent discussions were representatives from other countries; their input was important in incorporating the experience and the views on the tribology education. The panel consisted of the following distinguished tribologists: Professor E. E. Klaus, Pennsylvania State University; Professor W. O. Winer, Georgia Institute of Technology; Dr. N. P. Suh, National Science Foundation; A. O. Dehart, General Motors Research; T. A. Harris, MRC Bearings, K. J. Brown, Ontario Hydro; and Professor C. M. Taylor, the University of Leeds.

Survey of Tribology Education in the United States

A questionnaire was developed and sent to engineering departments and selected science departments in American universities. The purpose of the survey was to answer the following questions:

1. The extent to which tribology is being taught in engineering colleges in the United States.
2. Whether important topics from tribology are currently included in undergraduate curricula.
3. Whether comprehensive courses in tribology are available at either graduate or undergraduate level.
4. Availability of graduate coursework and theses in tribology.
5. The need for action by technical societies, government or industry to improve tribology education.

The questionnaire was sent to about 280 departments in over 250 different American universities and colleges during 1987. The questionnaire was addressed to the following individuals at the institutions: faculty active in tribology research (based

on a survey carried out by NSF in 1986), members of STLE and the ASME Tribology Division affiliated with universities, and Mechanical Engineering department chairmen. Individuals receiving the questionnaire were asked to respond about course offerings and contents of these courses throughout their institution. If they felt that another person at their institution might be better able to answer the specific questions, they were asked to forward the questionnaire to that individual.

Eighty-eight responses were received from eighty-five different universities. This was slightly over a thirty-three percent response rate, but most institutions with known research activity in tribology responded to the survey. It is assumed that a non-response meant that the university had little or no tribology activity.

Results of the Survey

Thirty-three schools offer a comprehensive course in tribology with the majority being offered by mechanical engineering departments as an elective course available to either graduate students or advanced undergraduates. These universities and colleges are listed in the table. Considering that there are approximately 250 universities and colleges offering engineering degrees, only thirteen percent offer tribology courses. The survey also indicated that there is no single widely-accepted textbook for a comprehensive Tribology course.

Many mechanical engineering undergraduates, but by no means all, receive some exposure to important tribological topics in their undergraduate curriculum. Rolling element bearings, fluid film lubrication and friction are topics most commonly covered, with much of that coverage coming in Machine Design courses and some in Fluid Mechanics courses. Even in those courses, however, coverage is spotty. Analysis of the returns showed that tribology topics had a better chance of being covered in Machine Design or Fluid Mechanics courses if there was tribology research activity in the department offering the courses. As a result, undergraduate mechanical engineering students in many institutions (i.e., eighty percent of all engineering colleges and universities) appear to get little introduction to important topics in tribology. Exposure to tribology in engineering curricula other than mechanical engineering, appears to be very limited at the undergraduate level.

A major reason that tribology topics do not receive more adequate coverage is that there is not enough room in the already stuffed undergraduate curriculum. The lack of knowledgeable faculty and inadequate coverage in textbooks are other important reasons that tribology is not covered in greater depth.

Many respondents indicated that better or more comprehensive textbooks dealing with tribology are needed. The respondents also indicated that short courses would be helpful in making their faculty more knowledgeable in the field of tribology.

The situation at the graduate level seems to be quite fragmented. A surprisingly large number of universities, 54, in-

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icated that research is being conducted in tribology on their campus. In 36 of those institutions a graduate student can specialize in tribology, principally by doing a thesis in tribology or related area. Many of the universities also offer graduate-level coursework in tribology, with the number of such courses available ranging from one (at 21 schools) to four (at one school). Most of the graduate study and research in tribology takes place in Mechanical Engineering departments, primarily Materials Science/Engineering or Chemical Engineering, also offering research or coursework in some institutions. The major source of external funding for university-based tribology research is the federal government, although many institutions also have research support from industry.

The most important conclusion that can be drawn from the survey is that tribology is not adequately covered in the engineering curricula. This conclusion is based on the small number of tribology courses being offered and the limited coverage of a few tribology related areas in machine design courses. The problem is actually more serious than appears. The attendance in the tribology courses are very low, approximately 5 to 15; and the courses are not usually offered on a regular basis. Furthermore, we can assume that the colleges and universities which did not respond to this survey do not cover any aspects of tribology. Then, we are left with the conclusion that only a limited number of engineering graduates are exposed to tribology. This exposure is mainly through machine design courses in mechanical engineering. A cursory review of some machine design textbooks, however, reveals that much of the coverage is out of date and does not include current tribology design practices.

Summary of the Panel Discussions

The results of this survey were presented and discussed at the Panel Session on Tribology Education. The invited panel members were asked to present their views on the subject. These presentations were followed with open discussions from the panel members, as well as the audience. The following list was compiled by the authors based on the presentations and the discussions:

- Since knowledge in tribology is required for the design of reliable and efficient mechanical systems, tribology fundamentals should be included in the education of future engineers, especially mechanical engineers.
- The amount of basic knowledge that must be gained in an engineering education has increased because of the complexity of modern technology and advanced engineering systems. Undergraduate engineering curricula have expanded to include this additional information. It is difficult or almost impossible to add a required tribology course to the already-stuffed engineering curriculum at most schools. An optional comprehensive course on tribology should, however, be available and the contents should be suitable for advanced undergraduates or entry level graduate students.
- The principles of tribology should be incorporated in relevant undergraduate courses, such as machine design, materials science, applied mechanics, surface science, chemistry or physics. This would require brief, yet complete, written treatments of tribology topics directed towards those courses.
- The undergraduate curriculum should emphasize the fundamentals of tribology and their application. Details and specialization should be left optional or for graduate programs. In

addition to teaching students the basics, undergraduate courses should stimulate the students to learn on their own whatever further details are necessary to solve practical problems.

- One of the best ways to acquaint all students with tribology is to incorporate it into engineering design courses. In this way the relevance of fundamental principles to practical applications can be made clear.

- Tribology should also be introduced in engineering technology education at junior colleges and four-year technical institutes. The coverage should be less scientific and more practice oriented than in universities.

- Currently, a few tribology-related courses are offered in technical and professional societies such as ASME, STLE and ASM. These courses are generally directed to the practice of tribology rather than the fundamentals, and they are important in broadening the experience and knowledge base of practicing engineers. The contents of these courses should be modified to include tribology fundamentals where possible.

- An important issue facing the educators in graduate tribology education is attracting top-quality students to the tribology program. To some extent, tribology suffers from an image that "it is not a respected field," "not fundamental enough," or "too narrow." Since there is a need to increase the number of post-graduates with specialization in tribology, this image must be changed. Possible methods include: incorporation of tribology in more required undergraduate courses, seminars by invited prominent tribologists, and publicizing the research conducted by tribology faculty in departmental seminars.

- There is a direct link between research and the quality of graduate education. This is particularly related to the availability of research funds as well as new and innovative ideas. In this regard, the funding agencies, academic organizations and technical groups such as ASME-RCT should cooperate to promote research and education in tribology. Availability of funds and innovative ideas will stimulate an exciting environment not only for high quality research, but also for a higher level of education.

- In order to educate graduates with a broad knowledge in tribology, we must also train ourselves. One of the principal problems in tribology research is the lack of communication between different disciplines in the field. We as researchers and educators must try to understand all aspects of tribology, at least the basic principles. We should not compartmentalize ourselves with labels such as contact mechanics, fluid film lubrication, wear or lubricant chemistry, but should instead proclaim the interrelationship between those specialties. The education starts with us.

Recommendations

1. An optional course in the fundamentals of tribology should be included in the curricula of all engineering colleges and universities.
2. Undergraduate design courses should include a section

on tribology emphasizing the current fundamental knowledge, and application to design of tribological components.

3. A better tribology textbook covering all aspects of tri-

bology is needed. An alternative approach is to have available brief write-ups on different important tribology topics for use in engineering courses.

U.S. Universities Offering Comprehensive Courses in Tribology

	Level of Course		
	Undergraduate	Undergrad/Grad	Graduate
Bradley University			X
State Univ. of New York, Buffalo		X	
University of Central Florida			X
Dartmouth College		X	
University of Dayton			X
Duke University			X
Georgia Institute of Technology	X		X
University of Houston			X
University of Illinois, Chicago			X
University of Illinois, Urbana	X		X
Illinois Institute of Technology	X		X
Iowa State University			X
Louisiana State University		X	X
Massachusetts Inst. of Technology			X
University of Massachusetts			X
University of Michigan			X
University of Minnesota	X		
Mississippi State University		X	
University of Missouri		X	
University of New Mexico		X	
Northwestern University		X	
Ohio State University		X	X
University of Pittsburgh	X		X
Purdue University			X
Rensselaer Polytechnic Institute		X	X
Stevens Institute of Technology		X	
Tennessee State University			X
Tennessee Technical University		X	
University of Utah			X
Vanderbilt University			X
Virginia Polytechnic Inst. & SU	X		X
University of Washington	X		X
Washington State University		X	
Worcester Polytechnic Institute		X	