ASIATRIB 2002International Conference
JEJU ISLAND, KOREA

RECENT AND CURRENT TRENDS IN BASIC TRIBOLOGY RESEARCH

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Tribology research is constantly changing focus as new drivers for the research emerge. They include new industrial needs and barriers to performance, new possibilities brought about by new observation and modeling tools, and new people with different backgrounds. We outline the changes in basic academic tribology research over the past 15-20 years, as it is reflected in the research portfolio of the US National Science Foundation. While independent tribology programs may be a thing of the past there is a clear tendency for tribology research to continue as part of other activities, such as nano- and biotechnology and computational materials research.

Keywords: Basic Research, Changes, Direction, Funding

1. INTRODUCTION

It is now nearly forty years since the Jost report [1] brought us a new name, "Tribology", as a new discipline, combining friction, lubrication and wear under one umbrella and suggesting that very substantial benefits would accrue mankind by diligent research in this new field.

While the term "tribo-" (Greek for rubbing) had been used previously, e.g., in triboluminescence, triboelectricity and tribophysics, the Jost report was the first to bring clear focus on the word tribology and on the new discipline and all its promises. It generated much enthusiasm, and soon journals, conferences and professional societies or society divisions sprung up all over.

In recent years, however, there has been changes. In the U.S. separate funding programs in tribology have disappeared from DOE, AOFSR, NSF, NIST and other agencies and membership in professional society divisions dedicated exclusively to tribology remains small. Given this general background it seemed worthwhile to pause and try to take stock of where the field may be heading. The point of view taken here is based primarily on the evolution of NSF's tribology funding "portfolio" over the past 15-20 years. The reasons for selecting the NSF program as basis are that the funding portfolio develops largely in response to unsolicited proposals from the academic community, proposals which are reviewed by peers from the same community and industry, and only the most highly recommended proposals will be considered for funding. Thus, the portfolio can be seen, at least to a significant extent, as a reflection of the academic research community's interests.

2. BRIEF HISTORY

Tribology has been an integral part of engineering as long as mankind has built structures and made devices. But it did not receive much recorded serious study until the Renaissance, with Amontons' first publication of a study of friction in 1699 [2]. Interest grew rapidly during the industrial revolution when railroads and factories had great needs for reliable lubrication, and mineral oil had become available. In the twentieth century tribological advances helped usher in modern society and played critical roles in helping open new frontiers in space, high temperature technology, bioengineering and communication. Research in tribology has typically been driven by industrial needs combined with a certain amount of intellectual curiosity. Thus, when NSF uses the term "basic research" in tribology it is, like all engineering basic research, in reference to generic results that have some relevance to broad industrial use, perhaps 10-15-20 years in the future, in some ways following the spirit of Leonardo da Vinci's statement [2] that

"There is no result in nature without a cause, understand that cause and you will have no need of the experiment".

At the NSF an independent Tribology Program was started in 1985. It evolved from one of five emphasis areas in a mechanical systems program. A grantees meeting was held in 1987 and the proceedings from that meeting [3] have been used here to develop part of the historical baseline. A review of the status in the mid-1990s was given by the author in 1994 [4] and provides data for that year.

3. 15 YEARS' EVOLUTION

In the early 1990s there was a great growth of activities in surface science and engineering, much of it spawned by the availability of new tools, such as the AFM. Since much of surface engineering is geared towards improving the tribological performance of a surface, it was natural to incorporate the new activities in the program and it became "Surface Engineering and Tribology". That also helped somewhat with name recognition, as the word "tribology" is not well known outside parts of the technical community.

Later on, as the new millennium dawned, a reorganization resulted in the melding of three programs into two and the tribology activities became part of the Surface Engineering and Materials Design program. The data in Table 1 show in summary form how the intellectual focus areas of the research portfolio has evolved over the years, measured as percentage of active projects. Major trends are that studies of component tribology and of wear are rapidly decreasing in number, while surface engineering is growing. Activities in contact mechanics and lubrication have remained nearly steady. The number of active projects, and probably also the inflation-adjusted budget, peaked in the mid-1990s and have decreased considerably to the present.

4. DISCUSSION

Some of the changes noted in Table 1 could probably be expected. The area of fundamental wear research has proven to be much more complicated than anticipated twenty years ago. Ludema [5] outlined the state of affairs some years ago, citing a literature search that found some 182 wear equations with over 100 variables, which at best could be reduced to some 28 basic equations with 33 variables plus a number of proportionality constants. This state of affairs may have resulted in an end to the search for a simple universal wear equation.

In the components area changes have been from modeling and experimental studies of components like cams, gears and hard disks to more basic studies of the behavior of surfaces under moving contact and some studies of newer types of components, such as MEMS devices.

In the remaining areas the move with time has followed developments in other branches of science and technology. These include new analytical instruments, which allow much closer observation and manipulation of the surface material than before; more powerful computational capabilities, which allow modeling of sufficiently large numbers of atoms to be relevant to tribology; and evolution of nanotechnology as a potentially viable new industry with wholly new demands on mechanics, materials engineering, and tribology. In most instances, tribology is not a single player but is part of multidisciplinary efforts. Indeed, much research which can be considered tribology is now appearing as part of larger, overarching activities. That is part of the reason for the change in the number of active projects in the past 5-6 years.

5. CONCLUSIONS

Research in basic tribology, as reflected in the NSF portfolio, changes focus with time in response to changes in demand and experimental and modeling capabilities. It would appear that while the word "tribology" may be less prominent in the research funding agencies, tribology research is alive and well. The difference with the past is that it now tends to be part of larger, overarching efforts rather than a stand-alone research activity.

6. REFERENCES

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[3] Education Extension Service, Georgia Institute of Technology, "NSF Tribology Grantees Conference, Aug. 10-11, 1987", Georgia Tech 1987

[4] Larsen-Basse, J., "Tribology Research and the U.S. National science Foundation", '95 Korea-US Tribology Symposium, Seoul, Oct. 1995, KSTLE, 329-335, 1995

[5] Ludema, K.C., "The State of Modeling in Friction and Wear and a Proposal for Improving that State", ibid, 11-15

Table 1: % of active projects by numbers

	1986	1994	2002
Components tribology	31	20	11
Materials processing tribology	-	7	5
Friction	6	-	8
Lubrication	19	19	24
Wear	22	19	8
Contact mechanics	22	16	18
Surface engineering for tribology	-	19	26
# Active projects	32-36 (est.)	58	38*
Budget, $ M (actual)	1.7	2.65	~3

(*about 25% are nano-technology related)