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Introduction to the Symposium on Case Studies of Wear-Related Failure Analyses

The one-day Symposium on Case Studies of Wear-Related Failure Analyses, sponsored by ASTM Committee G–2 on Wear and Erosion, was held at the Dallas-Fort Worth airport on 8 December 1993. The Call for Papers for the symposium included the statement: "Wear is so pervasive in machines of all types that its role in initiating, exacerbating, or causing failure is easily overlooked or considered uncontrollable." Some broad definitions of "machine" include "an assemblage of parts that transmit forces, motion, and energy one to another in a predetermined manner," and "a living organism or one of its functional systems." In these broad senses, the symposium lived up to the motivating premise very well. Of course, when we talk about failure, we are dealing with a situation or events that cause a departure from operation in the anticipated or predetermined manner.

The case studies reported at the symposium involved systems that ranged all the way from a certain type of prosthetic heart valve to a chain with links $4^1/_2$ in. (11.43 cm) in diameter, used to anchor a mooring buoy. In between were reports of excessive wear in some very expensive precision spur gears and an analysis of fatigue failures that occur in wire ropes. The pervasiveness of wear is exemplified well by this considerable range.

The fact that only five papers were contributed, including one from the Symposium Chairman, is taken as evidence that, indeed, the role or potential role of wear in failures is not well recognized or acknowledged by those who are not directly involved with tribology. It is sincerely hoped that, in some small way, the symposium and subsequent publication of some of the presented papers will remedy the situation and help to heighten awareness of the insidious phenomena called wear and the problems they can cause.

Although the limited response to the Call for Papers was disappointing in a way, it also permitted relaxed scheduling that allowed each presenter ample time to fully disclose investigative details. There were none of those ten to twenty minute synopses. There was time also for attendees to actively contribute through their in-depth questions and comments. However, no recording or transcript of the discussion sessions was kept, so only those who attended will have benefited from them.

The introductory summary, prepared and presented by this author, identified microscopy, topographic measurements (including profilometry), metrology, and energy-related techniques (including chemical analysis, surface analysis [EDS or WDS], metallography, and stress state determinations such as hardness testing) as important ways to analyze wear-related failures. A macroscopic visual examination was implied as a prerequisite. Service monitoring and certain laboratory techniques were also mentioned as potential sources of helpful information in some cases. The introductory paper included some examples, but the case studies that followed were more complete and illustrated applications of additional techniques. In two cases, the ultimate damage was the wear itself. In the other two cases, wear was a precursor to fracture.

The investigation of explanted heart-valve discs by Milligan, Johnson, and Engel involved microscopy, profilometry, and metrology. But, in addition, optical interferometry was used to study wear scar shapes, and the examinations of worn valve parts were augmented by impact testing intended to simulate the wear conditions. All of this contributed to a model of the applicable wear process.

In his analysis of precision gear wear, Budinski employed microscopy, metallography, and hardness testing, but his most important result came from adjunctive wear testing. This allowed him to associate differences in wear resistance to differences in microstructure and hardness that, in turn, were caused by heat treating differences.

Schrems examined dimensional changes and surfaces associated with worn sites and fractures of wire rope strands, using microscopy, metrology, and fractography. She also analyzed for chemical anomalies. Her conclusion was an unexpected one involving energy-related considerations of compressive versus tensile stresses.

Perhaps the most straightforward failure occurred during most unusual conditions, as reported by Dahlberg. A massive anchor chain failed after it experienced extremely rapid adhesive wear and very large volume loss (about 9 dm^3) in a three-day period during a typhoon. Fracture surfaces were examined and metallography, metrology, and microhardness testing were used in a study of deformation and work hardening in layers beneath worn surfaces. The work indicated that no material defect was responsible for the failure, although a more wear resistant material would have been advantageous. The basic problem, apart from the severe weather, was a temporary and asymmetric arrangement of anchor chains that caused the chain that failed to be highly loaded. Some details of the incident have been published separately [*1*] and are not being supplemented by further publication here.

If any of this has excited your interest—and I hope it has—please continue reading on the following pages to learn more.

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Acknowledgments

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Reference

[*1*] Shoup, G. J. and Mueller, R. A., "Failure Analysis of a Calm Buoy Anchor Chain System," *Proceedings, Sixteenth Offshore Technology Conference,* Society of Petroleum Engineers, Vol. 2, 1984, pp. 451–461.