Methodology

This report describes findings from STLE's 2017 Emerging Issues and Trends in Tribology and Lubrication Engineering research study. The first wave was conducted in 2014 by STLE with McKinley Advisors (McKinley), an association consulting firm contracted to help implement and analyze the research. It included focus groups and in-depth interviews with industry experts in order to identify new technologies and trends impacting the field. A research survey was also included in the project in order to quantify the importance and significance of those trends. This iteration of the research builds on the 2014 "trends" report, and includes a look into more recent advances and topics that have surfaced since the publication of the original report.

In order to refresh the list of topics for study, STLE and McKinley initiated the 2017 project with a qualitative research phase. Approximately 15 industry experts participated in in-depth interviews in order to provide feedback regarding the topics included in the original report as well as suggestions for new focus areas for 2017. Their input was collected and then supplemented with a literature review of recent industry publications, conference abstracts and other materials.

The findings from the initial phases of the project were then used by the STLE and McKinley project team in order to revise and update the survey instrument. The survey was launched and fielded to a broad, international list of STLE contacts throughout April 2017. In total over 900 respondents participated in the survey, garnering a 6% response rate. Subsequently, STLE and McKinley provided initial survey results to approximately 30 survey respondents that agreed to participate in follow-up interviews in order to provide context and narrative to the quantitative findings. Their attributed quotes and remarks are found throughout the report.

Executive Summary

This report is divided into two sections dealing with separate, but important, topics related to the field of tribology and lubrication engineering. The first section, Field Discipline Areas, provides an in-depth look into trends and technologies that have surfaced in the recent past. Sample sizes for survey results are smaller for this section, since each discipline (e.g., transportation, energy) reflects only the opinion of experts that specialize in that area. The section provides a snapshot into the future of the field.

The second section, Field Issues, provides a broader lens into issues that cross-cut field disciplines. All survey respondents, regardless of their area of specialization, participated in providing their expertise on each of the topics included in the section. This portion of the report highlights several trends, issues and concerns that not only impact the development of the field, but also the future of the world's population and health.

Several key findings from each section are described next.

Field Discipline Areas

Transportation: The area of transportation has undergone significant development over the past several years and is poised to continue with new advancements for years to come. Uncertainty exists regarding which technologies will "win out," whether it will be pure-electric vehicles (PEVs), hybrids, or even traditional gas-run automobiles, which are ever more fuel-efficient and emit progressively less pollution. The latter may continue to dominate due to the significant barriers limiting the adoption of new technologies (e.g., limitations on distance capacity in electric vehicles, infrastructure concerns, etc.). Also of interest is the impact that these changes will have on the demand for lubricants. While some experts believe that new technology will reduce lubrication usage, others envision new applications, even in electric vehicles.

Medical/Health: Tribologists and lubrication engineers are finding an increased level of demand as well as new applications for their services in the area of biotribology. This trend appears to be driven by aging populations in developed nations who are living longer and have an increased need for prosthetic devices, implants and other products that relate to tribology and lubrication. New advancements in this area are expected to hasten as the field continues research and development (R&D) efforts in nanotribology.

Energy: There is great pressure and demand for sustainable energy in order to stem environmental concerns over carbon emissions and climate change. However, the world's population continues to grow and demand increasing amounts of energy. Meanwhile, sustainable alternatives remain expensive compared to traditional fossil fuels. Similar to the area of transportation, tribologists and lubrication engineers vary in their perceptions relative to how the energy landscape will develop in the coming years. The current socioeconomic trends point to the opportunity to focus on developing renewable energy technologies.

Manufacturing: Under constant pressure to increase productivity and efficiency, the manufacturing sector is poised to continue moving toward automated and high-tech solutions. These include the use of robotics, continuous monitoring of machines and equipment through sensors and computers, and investment in more environmentally-friendly production processes, such as recycling. However, advancement in the manufacturing sector is slowed by large investment costs, off-shoring to locations with fewer environmental regulations, and the need for further technological development. Additive manufacturing/3D printing offers great promise to increase the efficiency of manufacturing and reduce waste, but will require further development before it can be used as a staple in the production process. The movement toward increased efficiency and continuous monitoring heightens the focus on tribology in many ways because of the ability of the field to extend the life of moving parts and address potential problems before a machine falters.

Field Discipline Areas (cont.)

Communications and Data Management: Due to a general reduction in the use of print media as a communication device, as well as newer computing systems that require fewer moving parts, there has generally been less demand and application for tribology and lubrication in the area of communications and data management. However, advanced monitoring systems in manufacturing allow sensors within machines and equipment to communicate operating conditions to plant operators—creating a new but extremely promising area of focus for the tribology and lubrication engineering field. Experts believe that continuous monitoring will greatly improve the efficiency and longevity of manufacturing equipment because of the potential to address issues proactively as they arise. These innovations may yield advancements in other areas as well, experts said.

Atomistic Processes: Academic researchers and scientists are focused on several areas that may create a new frontier of advancement for the tribology and lubrication engineering field. These include the linking of atomic-scale behavior with large-level systems behavior, the study of surface factors and increasingly powerful simulation technology. Together, these methods and approaches to understanding friction may provide for the next generation of advancements across all industries. However, they are generally seen as commitments that will develop over the long-term (10+ years), and, as referenced in the Outlook on the Field section of this report (see page 35), the pace of advances may be limited by the availability of funding for R&D.

Trends in Tribology and Lubrication Engineering Field Discipline Areas: At a Glance

Top Short-term Trends (Significant through next 5-10 years)	Top Long-term Trends (Significant 10+ years into future)
Transportation	
• Lower viscosity motor oils • Improved combustion and valve timing • Increased turbo charger pressures	• Pure-electric vehicles • Self-driving, autonomous vehicles • High-efficiency vehicles
Medical / Health	
• Soft matter	• Greater use of prosthetics • Greater expectations for personal mobility
Energy	
• Natural gas • Hydraulic fracturing	• Decreasing use of fossil fuels • Solar energy • Batteries as a substitute for liquid fuel in automobiles
Manufacturing	
• Reduction in costs of production • "In-sourcing" of manufacturing services from foreign countries • Increased competition for fat supplies due to biodiesel movement	• Greater automation of tasks / fewer human workers • Increased reuse of materials in manufacturing (recycling) • Continuous monitoring of production process through real-time data collection
Communications and Data Management	
• Continuous monitoring of lubricants and moving mechanical parts through ongoing data collection and algorithms to detect problems and increase efficiencies • Solid-state memory and devices (no moving parts)	• Free-flow of information that does not require physical information systems (i.e., demise of print media)
Atomistic Processes	
• Investigating formation of films on surfaces to study antifriction and antiwear layers • Aluminum rolling	• Linking of atomic-scale behavior with larger systems-level behavior • Increasing attention paid to surface factors

Field Issues

Outlook on the Field: As the field has matured and become more complex, experts have continued to express concern over the ability to attract talented and bright individuals to careers in tribology and lubrication engineering. Although the concern stems from a perceived lack of awareness and interest in the field, the issue may be exacerbated due to the lack of many opportunities to study tribology and lubrication engineering, which further limits the ability of business and academia to replace an experienced and retiring workforce. Other top concerns for the field include pollution generated from the production and usage of lubricants and tribological products, the availability of funding for the field, and the cost and availability of raw materials.

Government Regulation: Tribologists and lubrication engineers expressed varied opinions on government regulation. On one hand, goals related to worker safety and environmental protection are necessary, experts said. Moreover, regulations have provided a catalyst for certain types of innovation. On the other hand, many regulations wind up being short-sighted, harmful and result in unintended consequences. Survey participants stressed the need for a more scientific and informed approach to developing rules, ordinances and regulations.

Safety and the Environment: Participants in the study were well-acquainted with safety issues and environmental concerns that impact the field. However, because of technological advancement, they stressed the opportunity to reduce pollution and waste and to ensure the safety of the production workforce while meeting the significant challenges that society faces in demand for manufacturing, energy, transportation and other areas. Respondents pointed to the development of biodegradable products as an important area of advancement in protecting the environment, but they were most optimistic about the ability of robotics and automation as solutions that would protect the safety of workers. Placing robots in environments that may have been hazardous to humans in the past will help reduce workplace risk and minimize injuries, respondents said.

Basic Human Needs: As a field that cuts across every industry, tribology and lubrication engineering has enormous potential to help satisfy and meet basic human needs. Survey respondents evaluated multiple areas, from water desalination to reducing industrial waste, but were most in agreement with the notion that the field's greatest impact would be in furthering the production of sustainable energy and reducing emissions that lead to air pollution. These related issues are considered by many to be the greatest challenges facing the global population. The tribology and lubrication engineering field stands poised to help protect and improve the quality of life for all people in the 21st century.

Trends in Tribology and Lubrication Engineering Field Issues: At a Glance

Outlook on the Field

Top areas of concern:

- The ability of the field to attract talented and educated employees
- The challenge of reducing pollution related to the production / usage of products created by tribologists and lubrication engineers
- The availability of research funding from both government and for-profit sources compared to other scientific disciplines
- The cost of materials, chemicals and other resources

Government Regulation

Regulatory areas with greatest impact on the field:

- Industrial waste regulations
- Restrictions on water pollution
- Particulate matter emissions regulations
- Carbon monoxide regulations

Safety and the Environment

Most significant trends impacting safety and the environment:

- Automation replacing workers (minimizing risk to humans)
- Biodegradability
- Technology that allows greater ability to determine where environmental hazards originate
- Particulate matter emissions from lubricants

Basic Human Needs

Areas where tribology and lubrication engineering will have the greatest impact:

- Production of sustainable energy
- Reducing air pollution and emissions
- Reducing costs of manufactured goods through added efficiencies
- Reducing industrial waste