Journal of Tribology Science and Technology
Industry Opinion
Publication Date: 31 December 2025
Submission Date: 20 December 2025

Lubricating Greases – Indian Scenario: Bridging Academia and Industry

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1.0 INTRODUCTION

Lubricating greases are indispensable in modern industrial applications, particularly where operating conditions demand lubricant retention, sealing against contaminants and reliable performance under adverse environments (Fig.1). Greases comprise three key components: **base oil**, **thickener** and **performance additives**. Among these, the base oil and thickener constitute the structural backbone, while additives fine-tune performance to meet application-specific requirements. The thickener may be visualized as a sponge-like matrix that retains lubricating oil and releases it gradually under mechanical stress, ensuring continuous lubrication at contact surfaces.

Grease lubrication has played a significant role in the evolution of modern industry. Historical evidence suggests the use of grease-like substances as early as 1400 BC, potentially for lubricating chariot wheels using animal fats and vegetable oils. The transformation in grease technology accelerated after the discovery of petroleum and the drilling of the first oil well by Colonel Edwin Drake in 1859, which enabled the widespread use of mineral oil-based lubricants. Since then, greases have become critical to both automotive and industrial sectors.

As per **ASTM D 288**, lubricating grease is defined as: "A solid to semi-fluid product of dispersion of a thickening agent in a liquid lubricant. Other ingredients imparting special properties may be included."

Fig. 1: Typical applications of grease in industry

2.0 GREASE COMPOSITION AND FUNCTIONALITY

A typical lubricating grease consists of:

- **Base Oil:** 70–95% by weight
- **Thickener:** 3–30% by weight
- **Additives:** 0–10% by weight

2.1 Base Oils

Base oils may be mineral or synthetic. Mineral oils dominate production due to cost and availability; synthetic oils are preferred where wide temperature ranges, oxidation resistance, or long service life are required.

2.2 Thickeners

Thickeners provide the semi-solid structure characteristic of grease. Common thickeners include metallic soaps (lithium, calcium, sodium, aluminum). Complex thickeners, formed by reacting metallic soaps with complexing agents, are preferred for high-temperature and high-load applications. Non-soap thickeners such as polyurea, bentonite clay and silica are used for specialized applications requiring enhanced thermal stability.

2.3 Additives

Additives enhance specific properties, including:

- Oxidation resistance
- Rust and corrosion protection
- Extreme pressure (EP) and anti-wear performance
- Friction reduction (e.g., molybdenum disulfide, graphite)

3.0 INDIAN GREASE MARKET SCENARIO

3.1 Market Size

The Indian grease market is estimated at approximately **150 thousand metric tonnes (TMT)**, covering both organized and unorganized sectors.

3.2 Thickener-Wise Market Share

Lithium-based greases dominate due to versatility, while complex and non-soap greases are steadily gaining share in high-performance industrial applications (Fig.2).

Thickener Type	Market Share (%)
Lithium Soap	70.0
Lithium Complex	5.1
Sodium	3.5
Non-Soap (Polyurea, Clay)	1.5
Aluminium & Aluminium Complex	2.5
Calcium / Calcium Complex / Others	14.9
Calcium Sulphonate Complex	2.5

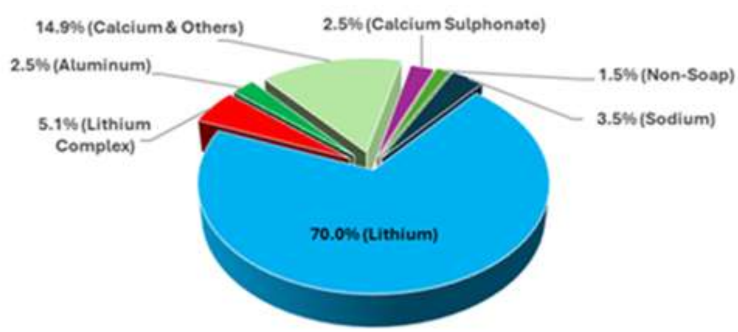

Fig. 2: Thickener-based market share of greases

4 . PERFORMANCE REQUIREMENTS OF LUBRICATING GREASES

Greases are preferred over liquid lubricants when lubricant retention is critical and re-lubrication is difficult. Key functional requirements include:

- Reduce friction and wear
- Act as a seal against contaminants
- Resist water ingress and washout
- Maintain structural stability during service
- Prevent rust and corrosion
- Resist leakage and throw-off
- Serve as carriers for solid lubricants

These properties are governed by **raw material selection** and **manufacturing methodology**.

Key Grease Performance Characteristics

Property	Description
Consistency	Resistance to deformation
Shear Stability	Ability to retain consistency under stress
Oil Separation	Controlled oil release
High-Temperature Stability	Resistance to softening at elevated temperatures
Oxidation Stability	Resistance to chemical degradation
Low-Temperature Mobility	Pumpability at low temperatures
Water Resistance	Stability in presence of water
Corrosion Protection	Protection against chemical attack
Anti-Wear & EP Properties	Protection under boundary and high-load conditions

5. TESTING AND EVALUATION OF GREASES – NEED FOR TRANSLATIONAL APPROACH

Grease performance evaluation traditionally relies on **standardized laboratory tests** developed by ASTM, IP and NLGI. While valuable for quality control, these tests often fail to replicate complex thermo-mechanical conditions encountered in actual service.

From an R&D and application engineering perspective, a key challenge is the **limited correlation between laboratory results and field performance**. This highlights the need for a **translational lubrication engineering approach**, where academic research is systematically validated through industrial trials.

Academic institutions can play a critical role by:

- Developing advanced **rheological and tribological test methods**
- Studying **oil release mechanisms** under dynamic loading
- Modeling **grease degradation** and relubrication intervals

Industry, in turn, must provide **real-world operating data** to ensure relevance.

6. TYPES OF LUBRICATING GREASES

6.1 Soap-Based Greases

Simple Soap Greases:

- **Calcium Soap:** Excellent water resistance; used in marine, industrial and agricultural applications.
- **Sodium Soap:** Fibrous structure; suitable for low-speed, heavy-duty bearings.
- **Lithium Soap:** Multipurpose grease with excellent mechanical stability.
- **Aluminum Soap:** Highly adhesive; suitable for surface lubrication.

Complex Greases:

- **Calcium Complex:** High dropping point, EP capability; ideal for steel plant applications.
- **Lithium Complex:** High-temperature stability and load-carrying ability; widely used in industrial and automotive sectors.
- **Aluminum Complex:** Excellent water resistance and oxidation stability; suitable for food, steel and industrial applications.
- **Calcium Sulphonate Complex:** Outstanding corrosion protection; used in steel, cement, and heavy industries.

6.2 Non-Soap Greases

- **Polyurea Greases:** High oxidation resistance; ideal for electric motors and "fill-for-life" applications.
- **Clay-Based Greases:** Suitable for extreme temperatures; limited by base oil oxidation.

7. BRIDGING THE GAP BETWEEN ACADEMIA AND INDUSTRY

Despite advances in grease chemistry and manufacturing, a significant gap persists between academic research and industrial application. Bridging this divide requires structured and collaborative efforts in research, development and application engineering.

7.1 From Fundamental Research to Application Engineering

Academic research often emphasizes fundamental aspects such as soap fiber morphology, thickener chemistry and tribofilm formation. Industrial challenges, however, demand practical answers, including:

- Which grease performs reliably under contamination, misalignment, or heavy load?
- How does grease compatibility affect re-lubrication and maintenance schedules?
- What is the optimal relubrication interval for specific applications?

Bridging this gap requires **joint research programs** that start with industry-defined problem statements and culminate in validated field solutions. This translational approach ensures that academic discoveries are aligned with real-world lubrication challenges.

7.2 Strengthening Grease R&D through Academia–Industry Collaboration

Collaborative R&D initiatives should focus on:

- Development of high-temperature and long-life greases
- Indigenous formulation of calcium sulphonate and polyurea greases
- Optimization of additive–thickener interactions for enhanced performance
- Sustainability through bio-based base oils and environmentally friendly additives

Such partnerships enable academia to apply theoretical knowledge in practical contexts, while industry benefits from reduced development cycles, lower formulation risks and accelerated commercialization of advanced grease technologies.

7.3 Advanced Characterization as a Knowledge Bridge

Modern analytical and characterization tools provide a critical bridge between theory and industrial application. Integration of these techniques into R&D workflows enables **science-driven grease design** rather than trial-and-error formulation. Examples include:

Academic Tool	Industrial Benefit
Rheometry	Predict pumpability, shear stability, and flow behavior
SEM / TEM	Understand soap fiber networks and microstructure
FTIR / DSC	Monitor oxidation and thermal degradation pathways
Tribometers	Simulate boundary lubrication behavior under load

Applying these tools allows manufacturers to fine-tune grease formulations based on predictive science, improving reliability and performance in service conditions.

7.4 Application Engineering: The Missing Link

In India, lubrication engineering remains underrepresented in formal education. Application engineering—including **grease selection, compatibility assessment, failure diagnosis and condition monitoring**—is largely learned through experience.

Introducing structured **lubrication engineering modules** into engineering curricula, supplemented by industry case studies, will develop a skilled workforce capable of translating research outcomes into practical solutions. This step is critical for closing the knowledge gap between laboratory research and field performance.

7.5 Field Data Feedback into Research

Industry possesses valuable operational data, including:

- Premature bearing failures
- Grease hardening or oil bleed
- High-temperature oxidation
- Water contamination issues

When anonymized and shared with academia, such data can guide applied research projects, ensuring that experimental work addresses **real-world industrial challenges**. This feedback loop strengthens the relevance and impact of research, while supporting the development of **next-generation greases**.

8. ROLE OF INDUSTRY ASSOCIATIONS AND KNOWLEDGE PLATFORMS

Professional bodies such as **NLGI-India Chapter** serve as bridges by:

- Organizing **technical conferences and workshops**
- Facilitating **academia–industry interaction**
- Encouraging **publication of application-oriented research**
- Promoting **harmonization of global standards**

These platforms help translate research insights into practical lubrication solutions.

9. SKILL DEVELOPMENT AND HUMAN CAPITAL

The future of grease technology depends as much on people as on formulations. Structured training for:

- Sales engineers
- Maintenance professionals
- R&D chemists

…is essential for correct grease selection, application and troubleshooting. Academia–industry co-developed certification programs can elevate lubrication competency across sectors.

10. EMERGING RESEARCH AREAS REQUIRING JOINT EFFORT

Future-focused areas include:

- **Smart greases** with condition-monitoring capability
- **Long-life greases** for sealed-for-life applications
- Greases compatible with **electric vehicles** and renewable energy equipment
- **Sustainability-focused formulations**

These challenges demand **multi-disciplinary, collaborative research**.

11. CONCLUSION

The evolution of the Indian grease industry will increasingly depend on the **effective translation of academic research into industrial solutions**. Bridging the gap between academia and industry is essential for innovation, reliability and global competitiveness.

Structured collaboration between **universities, grease manufacturers and end-user industries**—supported by professional bodies—can position India as a global hub for advanced grease technology and application engineering.

✍️ ***Author's Note***

*This article reflects the author's professional experience in **grease formulation, R&D and application engineering**, with the objective of fostering meaningful collaboration between academia and industry for the advancement of lubrication science in India.*