# GREASES: THE NEW FRONTIER

Greases are complex and highly functional lubricants that are meticulously designed to act as essential functional carriers that keep our mechanical systems in motion. Despite their importance in a wide range of industries, lubricating greases are often underrepresented in the technical literature. The Special Issue, "Grease," edited by Dr. Raj Shah, Dr. Mathias Woydt, Dr. Simon C. Tung, and Dr. Andreas Rosenkranz, features several top research papers pertaining to the most recent developmental trends of lubricating grease applications. This book published by MDPI discusses the achievement of significant research progress in recent years concerning greases applied for electrified powertrains, ranging from specific grease chemical formulations for special applications to how grease interacts with various surfaces [1]. "Grease" aims to establish an annual trend for discussing the latest global developments encompassing all R&D areas related to the innovation development of greases for automotive and manufacturing industries and has been very well reviewed by the industry after its launch last month.

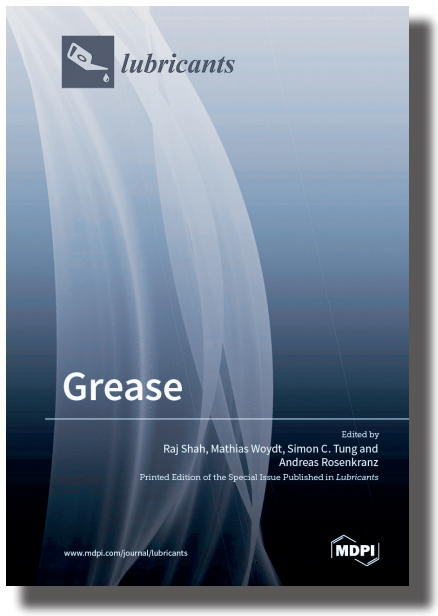


*Figure 1. Printed Edition of the Special Issue "Grease" (Hardcover)*

This book discusses some of the latest research being done worldwide related to tribology and lubricating greases. For instance, one of the authors Conrad et al. investigated the influence of thickeners on the crystallization, melting, and glass transition of lubricant greases. The type and concentration of the added thickeners had a notable impact on the properties of greases formulated from mineral oil, polyalphaolefin, alkylated naphthalene, propylene glycol, and trimellitate [2]. Three manuscripts in this compendium focus on analyzing the tribological behavior and performance of varying greases for their intended applications. Senatore et al. studied the tribological behavior of novel 7.5 wt.-% carbon nanotube-based (CNT) lubricant greases in polyalphaolefin (PAO) with and without 1.0 wt.-% MoS2. Their results indicated that the novel CNT-based greases exhibited superior tribological properties when compared against other commercial greases [3], which can have immediate real-world implications.

Meanwhile, Vafaei et al. compared and evaluated the lubrication properties of three different bio-based polymer thickener systems and developed bio-based greases via a ball-on-disc tribometer [4]. In a study presented by Garrido et al., the tribological performance of four commercial electric motor (EM) greases, with varying quantities of polyurea or lithium thickener with mineral or synthetic-based oil, were evaluated through the measurement of friction and the wear of silicon nitride sliding on hardened 52,100 bearing steel. The results provided an explicit comparison of commercially available EM greases across a wide range of applications and relevant metrics [5]. Studies such as this are peppered throughout the book and will have a significant effect on grease technology for years to come.

Gurt and Khonsari highlighted the relevant parameters associated with the rheometer penetration test and the recommended testing procedure for measuring the consistency of various greases. Their results were compared to data obtained from yield stress, crossover stress, and cone penetration tests [6]. For a different methodology, Khonsari, Shah et al. detailed the results of a novel approach for the evaluation of the water-resistance of greases to quantify degradation. This newly developed approach, known as the contact angle approach, involves the measurement of the contact angle of a water droplet on the surface of a sample of grease [7]. A patent was granted on the work, with currently Koehler Instrument Company having already designed a prototype and will work with ASTM to make a new test method for the contact angle studies with greases. Work such as this from this new publication have immediate ramifications for the lubes and grease industry, which is why this new book has become popular amongst grease manufacturers and users alike.

Kakoi presented a formulation of a point-contact elasto-hydrodynamic lubrication analysis for an isothermal, non-Newtonian flow, with the employment of a coordinate system of pressure gradient. The formulation detailed in this study was applied to a grease that had previously been evaluated to compare results to verify the validity of the formulation [8].

On a different subject for grease application in EV and hybrid vehicles (HVs), Shah et al. [9] discussed the role of grease lubrication in electric vehicles (EVs) and hybrid vehicles (HVs) in terms of performance requirements. The future development of lubricating grease used in EVs and HVs needs to be improved for meeting the lubrication and thermal management requirements [8]. Shah et al. also pointed out greases need to be formulated for new factors in electrical vehicles (EVs), including the increased presence of electricity, electrical currents, and noise in an EV due to the absence of an internal combustion engine (ICE) [10]. The major differences between EVs and conventional ICEVs can be grouped into the following technical areas: energy efficiency, noise, vibration, harshness (NVH) issues, the presence of an electrical current and electromagnetic fields from electric modules, sensors, and circuits, and bearing lubrication. Additional considerations include the thermal transfer, seals, corrosion protection, and materials' compatibility. Shah et al. reviewed the future development trends of EVs/HVs on driveline lubrication and thermal management requirements. Due to the increased number of electrical components, such as electric modules and sensors, greases must be formulated to be unreactive with electricity. In addition, the role of grease lubrication in electric vehicles (EVs) and hybrid vehicles (HVs) is crucial in terms of performance requirements. Comparisons of grease lubrication in EVs and HVs from IC engines for performance requirements were reviewed in terms of electrical and thermal properties under different operating conditions. This particular paper has been often cited as a critical compilation that can be used by EV manufacturers as well as grease and lube companies that provide their products for EV and HV applications.

Loysula et al. investigated the fictitious lubrication performance in a four-ball tester in accordance with ASTM D2596. The findings of this study indicated that the parameter "speed ramp up time" is an essential component that should be researched by grease manufacturers to prevent the use of grease with fictitious extreme pressure (EP) behavior [10]. Georgiou et al. highlighted the development of a reliable, quantitative method for measuring

the tackiness and adhesion of greases. The study highlighted the influence of temperature on the tackiness of greases and the reproducibility of the standardized tackiness method [11].

Several conclusions regarding the importance of grease for future EV/hybrid vehicle lubrication applications can be reached following a review of this Special Issue. The future development of electric vehicles will globally influence the selection and development of gear oils, coolants, and greases, as they will be in contact with electric modules, sensors, and circuits, and will be affected by the electrical current and electromagnetic fields. The increasing presence of electrical parts in EVs/HVs requires the corrosion protection of bearings and other remaining mechanical components. Thus, it is imperative for specialized greases to be explored for specific applications in EVs/HVs to ensure maximum protection from friction, wear, and corrosion to guarantee the longevity of the operating automobile [12, 13].

This Special Issue, "Grease," is a comprehensive and competent conglomeration of the latest discoveries and innovations pertaining to lubricating greases and their applications throughout various industries, such as automotive, construction, general manufacturing, metal production, power generation, etc. This new book is a must-read for those interested in recent advances in the field of tribology and/or are associated with relevant industries, as it may prove to be a valuable resource. Few technical resources can match this Special Issue in terms of the wealth of up-to-date information and interesting perspectives regarding the future development of lubricating greases. "Grease" represents an insightful compilation of references for discussing contemporary developments worldwide encompassing all areas related to greases, while inciting provocative ideas on their future applications and direction. Truly a master-class technical piece in the field of tribology and grease development technology and is deserving of the highest recommendation.

When Dr. Shah was contacted to discuss this new book, he said that the idea came to him as there is a need to have a platform for the latest technical research in greases to be published and in an open access forum so teaming up with a high impact journal, such as Lubricants (where he serves as an associate editor), made the most sense. He recruited three well-renowned experts in this field from around the world (Germany, Chile, USA, & China) and together they worked hard on compiling this special issue. All four of them have just broken ground on the next issue for the latest breakthroughs in grease research with their attempt at the next Special Issue, "Grease II." Dr. Shah said he was delighted with the success so far of how the printed book has been received and is also glad that anyone can access all the information in the book for free online. A hardcover printed edition of this Special Issue is available for purchase as shown in Figure 1. The link for the PDF of the entire grease book is easily available since the papers and the book are open access and free for everyone . The entire book "Grease" can be found here: https://www.mdpi.com/journal/lubricants/special_issues/grease

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*Dr. Raj Shah shown here, at the Koehler instrument company main laboratory in Bohemia, NY working with the new ASTM D217 penetrometer.*

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