lubricants

Editorial

Grease

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Grease is an extraordinarily complex lubricant with a complex material–property relationship, and to shed more light on its importance, we decided to launch the first Special Issue of "*Lubricants*" purely focusing on the most recent developmental trends of grease applications. In recent years, significant research progress has been achieved concerning greases applied for electrified powertrains, ranging from specific grease chemical formulations for special applications to how grease interacts with various surfaces. This Special Issue has compiled top research papers related to lubricating greases, hoping 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.

In total, six research articles, two technical notes, one perspective, and one case report were compiled, all pertaining to tribology and lubricating greases. 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 [1]. Three manuscripts 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.-% MoS_2. Their results indicated that the novel CNT-based greases exhibited superior tribological properties when compared against other commercial greases [2].

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 [3]. 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 [4].

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 [5]. For a different methodology, Khonsari 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 [6].

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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 [7].

On a different subject for grease application in EV and hybrid vehicles (HVs), Shah et al. [8] 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) [8]. 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.

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 [9]. 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 [10].

The editors of this Special Issue would like to provide a final conclusion regarding the importance of grease for future EV/hybrid vehicle lubrication applications [11,12]. 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 [11,12].

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