LUBRICANTS FOR MECHANICAL EQUIPMENTS AND INNOVATION IN THE SECTOR

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ABSTRACT

Lubricants are substances placed between two movable surfaces or a fixed and a movable one, forming a protective film whose main function is to reduce friction, wear, temperature and sealing of machine and motor components, and may also be a force transmission agent And movement. Therefore the objective of this work is to contribute to the construction of materials on the subject, aiming to analyze the types of lubricants, their characteristics, as well as the innovation in the sector. Thus, the applied methodology is mainly a literature review followed by an analysis. It should be noted that each type of lubricant is important for different types of equipment but is not yet in the state of the art and new technologies such as liquid crystal must be developed, which is highly efficient but still has a very high cost..
Keywords: Lubrication, Machinery, Mechanical Equipment.

LUBRIFICANTES PARA EQUIPAMENTOS MECÂNICOS E INOVAÇÃO NO SETOR

RESUMO

Os lubrificantes são substâncias que colocadas entre duas superfícies móveis ou uma fixa e outra móvel, formam uma película protetora que tem por função principal reduzir o atrito, o desgaste, temperatura e vedar componentes de máquinas e motores, podendo também ser agente de transmissão de força e movimento. Logo o objetivo deste trabalho é contribuir para a construção de materiais sobre o assunto, visando analisar os tipos de lubrificantes, suas características, tal como a inovação no setor. Assim a metodologia aplicada trata-se principalmente de revisão de literatura seguida de uma análise. Se pôde notar que cada um dos tipos de lubrificantes é importante para tipos de equipamentos diferentes, porém ainda não estão no estado da arte e devem ser desenvolvidas novas tecnologias como é o caso do cristal líquido, que apresenta grande eficiência, mas que ainda tem um custo muito elevado.
Palavras-chave: Lubrificação, Máquinas, Equipamentos Mecânicos.

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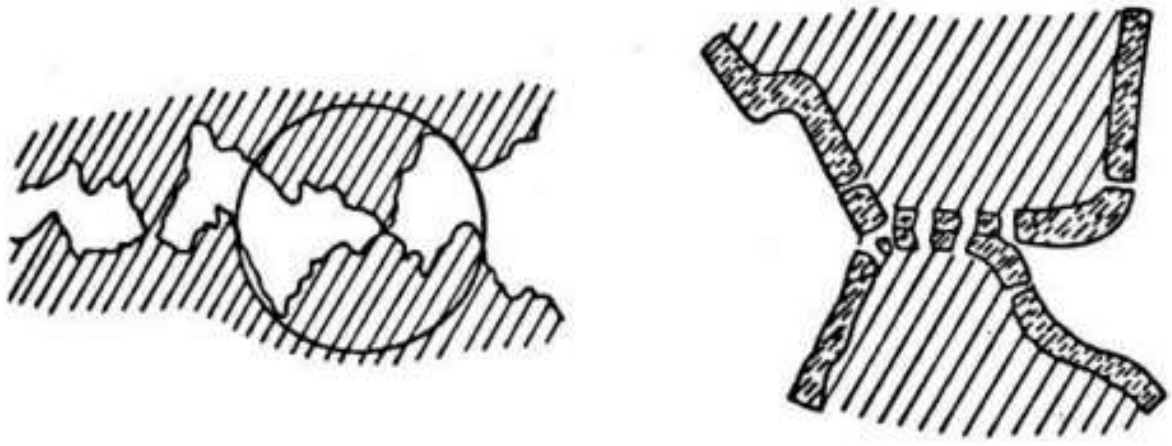
INTRODUCTION

Lubrication is an important task in the conservation of a machine or a vehicle and its correct application reduces costs in several sectors, such as maintenance, changing parts, downtime, among others. It presents advantages that were discovered by the Egyptians in 1700 BC, according to the discovery made in the sarcophagus of Ram Em Ka, when, by means of drawings, was indicated the use of tallow of animal origin to lubricate the base of sleds for the movement of stones, that is, reduce the friction it is main application until today (CORDEIRO; AZEREDO, 2013).

According to Silvestre (2013), the mechanism by which surface resistance forces develop when sliding between two bodies in contact is knows friction, however the lubricants seek to reduce friction between components. Friction occurs due to the existence of irregularities, often microscopic, on the sliding surfaces, as shown in Figure 1.

Figure 1: Representation of regions of true contact between two sliding surfaces



Source: Helman, 1988 (apud SILVESTRE, 2013).

It is possible to say that friction is a state of roughness or roughness between two solids in contact, which allows an exchange of forces in a tangential direction to the contact region between solids. This force is called the frictional force and its direction is always contrary to that of sliding between the solids in contact (SUNDARKRISHNAA, 2012).

The frictional force hinders the operation of different mechanical equipment and therefore it is necessary to develop materials that enable the performance of these machines. So, have been invested in the development of lubricants over the years.

In conformity with Areias & Rezende (2016) it is necessary to take care of the proper lubrication, since not only the type of lubricant, but quantity of this material can cause serious problems to a certain activity. In both cases, improper lubrication can impair the rotation of rolling elements, which have difficulties in running through the oil film, heating the equipment and accelerating the failure process.

Although the problem is present in everyday life, the literature on the particularities of the theme may still have relevant collaborations, so this work is justified due to its main objective of collaborating for the bibliography on the subject and discussing the specificities and innovations about lubricants and the lubrication for mechanical equipment comprehensively.

In the structural aspect, the article is divided into five parts, with the first setting out the context and the final objectives of the approach proposed in this study. In a second part, the methodological strategies used in the research are presented. The third part provides an understanding of the content studied, exposing characteristics present in the literature and is followed in a fourth part by the discussion of these results. And in the last phase, the achievement of the goals pursued in the objective of the study is concluded.

METHODOLOGY

As the purpose of this research is to analyze the main characteristics of lubricants used for mechanical equipment from previous studies, the method used was the bibliographic research through the scientific portals, Google Scholar and Portal periódicos CAPES was utilized to investigate the research topic with a exploratory character.

The study was developed in order to obtain detailed knowledge of the investigated object to expand the degree of knowledge on the subject, however with a more flexible and less structured research process wanting catch up the purpose of providing greater familiarity with the problem, making it more explicit and enabling the construction of hypotheses.

The bibliographies of the theoretical references of fundamental authors on the basic concepts were analyzed, and data were collected on more recent works to support the elaboration of the theme of this work. The references considered years of scientific and in order to achieve the object of this study.

RESULTS

By Andrade & Horta (1997), accurate examinations prove that it is not possible to produce a truly smooth and flat surface, so there have always been points of contact between two surfaces and the greater the load, the greater the existence of these points of contact that with movement will result in an internal release of heat leading to seizure and rupture of parts.

Friction and wear come from contacting the surfaces and the best method to reduce them is to keep the surfaces separate by placing a layer of lubricant between them, which defines lubrication (AHMED; NASSAR, 2013).

Lubrication Types

As stated by Norton (2004) the basic types of lubricants used are liquids, solids, greases and gases, and each one is utilized in situations where their properties fit better.

With the correct choice and management of lubricants it is possible to effectively target the organization costs and indirect expenses (PRATA; ASSIS, 2016).

Solid lubricants can be classified as mixed, synthetic or mineral, and are typically composed of a solid, a binder and additives such as corrosion inhibitors or solvents. They are used where it is important for the lubricant to stay in place, typically have a temperature range over which they are effective, but its features may vary depending on the quantity of additives inserted during the manufacture (BART; GUCCIARDI; CAVALLARO, 2013).

Grease is a product with a solid or semi-solid characteristic, produced by dispersing a thickening material in a lubricating oil and providing clean operation with little dirt or debris in the lubricated area. In its composition to achieve desirable characteristics, it is found vegetable or mineral oil (lubricating liquid), the thickening agent (lithium, barium or aluminum soaps), calcium or clays, and some additives (NAILEN, 2002).

Currently, liquid lubricants use mineral oils, before they used animal and vegetable fats, their application always brings improvements in mechanical processes because friction levels are reduced, but their manufacturing processes are not yet fully known (FOLLE; FERRARINI; SCHAEFFER, 2010).

For gaseous lubricants the characteristics and effects are the same for low recess pressures than to liquids lubricants but tend to lessen at higher recess pressures, but gases are used only in specific situations (OSTERLE; HUGHES, 1958).

Thus each of the different types of lubricants can culminate in lubrications by gravity, capillarity, splash, immersion, forced system, grease or centralized system (ANDRADE; HORTA, 2017).

The gravity lubrication can be manual, which is an inefficient method, since it depends on the direct action of the human, being able to be done by means of blends and causing conditions of lack or excess of lubricant (ALMEIDA, 2017).

It can use a needle cup, a device where there is a needle that passes through a hole with a diameter slightly larger than yours, resting its tip on the shaft, when the shaft rotates it prints a movement and the needle that releases the flow of the lubricant. Or dropper cup, which is widely used in the industrial environment, as it allows the amount of lubricant released per minute to be regulated (Almeida, 2017).

Capillary lubrication is done by cup with wick, when the lubricant flows through a wick (over time this wick can accumulate dirt preventing the correct flow of the material) and the flow depends on the lubricant viscosity, operating temperature, stroke and wick size; or tow, which is a method based on the capillary action of the tow soaked in oil, where the tow is placed at the bottom of the shaft and by capillary action the oil seeps towards the bearing, these systems are widely used to lubricate the wagon axle bearings (Godlevski *et al.,* 1998).

In splash lubrication, the movement of the parts is used to spray the lubricant over the desired area. This is how Ring or Chain lubrication is characterized, consisting of a reservoir that is located below the bearing and a ring that is immersed in the oil and around the shaft, when the shaft moves the ring (or the chain, when the amount of lubricant required is very high) accompanies this movement by spreading the oil throughout the part, mainly in operations with small engines (NEUROUTH, 2017).

Splash lubrication can also use a collar, where only the ring is replaced by a collar fixed to the shaft, generally used when there is a high speed in shaft rotation (NEUROUTH, 2017).

In immersion lubrication, an oil bath occurs and the parts to be lubricated are dipped in an oil container, the excess lubricant will be distributed to other parts through grooves in the part that has been dipped. Method used in gearboxes (Ahmed *et al.,* 2007).

Forced lubrication system can occur by Loss, where a pump is used that removes oil from the reservoir and the force between the parts to be lubricated; or by Circulation, where the oil is pumped from a tank to the parts where lubrication is required, after passing through the parts it returns to the tank (Mistry; Maynus, 2016).

The forced system lubrication method can occur in several ways, being widely used in the single pump method, where the pump connected to the motor shaft is usually immersed in the oil in the tank providing pressure to the points where lubrication is required, and thus returning to the deposit for cooling (Mistry; Maynus, 2016).

Grease lubrication can be performed by brush or spatula, manually, where a layer of grease is applied on the surface to be lubricated; with Pistol, when using a hand pump that applies the grease through the greasing pin; with Stauffer Cup, which are greased cups with a screw arrangement in which the grease is expelled from the bottom of the cup when the lid is turned; or by filling, which is used in rolling bearings, where grease is applied manually up to half the capacity of the tank (Andrade; Horta, 1997).

By Almeida (2017) a Centralized System is a method of lubricating oil or grease with the purpose of lubricating a high number of points. It is a very efficient system, as it significantly reduces the amount of labor and allows precise control of the amount of lubricant needed for supply.

Centralized Systems can be operated manually, when the points circuit is small and the lubrication frequency is moderate, and automatically, used where there is a need for continuous lubrication, thus it has an electric motor that allows the determination of operations by work time (Almeida, 2017).

Lubricant Functions

For Andrade & Horta (1997) due to the friction, wear and other damages that can occur in a metallic part, it is ideal to use lubricants that have some main functions among its diverse applications, such as:

- Friction control - transforming solid friction into fluid friction, thus preventing energy loss.
- Wear control - minimizing contact between surfaces, the source of wear.

- Temperature control - absorbing the heat generated by the contact of the surfaces (motors, cutting operations, etc.).
- Corrosion control - preventing acids from destroying metals
- Power transmission - working as a hydraulic medium, transmitting force with a minimum of loss (hydraulic systems, for example).
- Shock absorption - transferring mechanical energy to fluid energy (as in automobile shock absorbers) and dampening the shock of gear teeth.
- Removal of contaminants - avoiding the formation of lees, lacquers and varnishes.
- Sealing - preventing the release of lubricants and the entry of foreign particles (function of greases), and preventing the entry of other fluids or gases (function of oils in the cylinders of engines or compressors).

Almeida (2017) explains that the lack of lubrication causes a series of problems in the machines. These problems can be listed, depending on the occurrence, in the following sequence:

1. Increased friction;
2. Increased wear;
3. Heating;
4. Expansion of parts;
5. Misalignment;
6. Noises;
7. Stapling;
8. Breakage of parts.

The Innovation of Liquid Crystals

The definition of liquid crystals, also known as the fourth state of matter, is that of a molecular organization with characteristics of order and fluidity. They have interesting properties, such as the facility to suffer external stimuli by electric or magnetic fields that are not observed in other physical states of matter (CHANDRASEKHAR, 2010).

Some studies have been carried out on the use of liquid crystal as a lubricant, this is a fluid with a self-organizing capacity, being considered as a complex fluid, which can be used from basic physics to demonstrate phase transitions, intermolecular and interfacial forces, to the most diverse technological applications such as the food, pharmaceutical, cosmetic industries, and more recently the lubricating oil industry (TROVO; DOMICIANO, 2012).

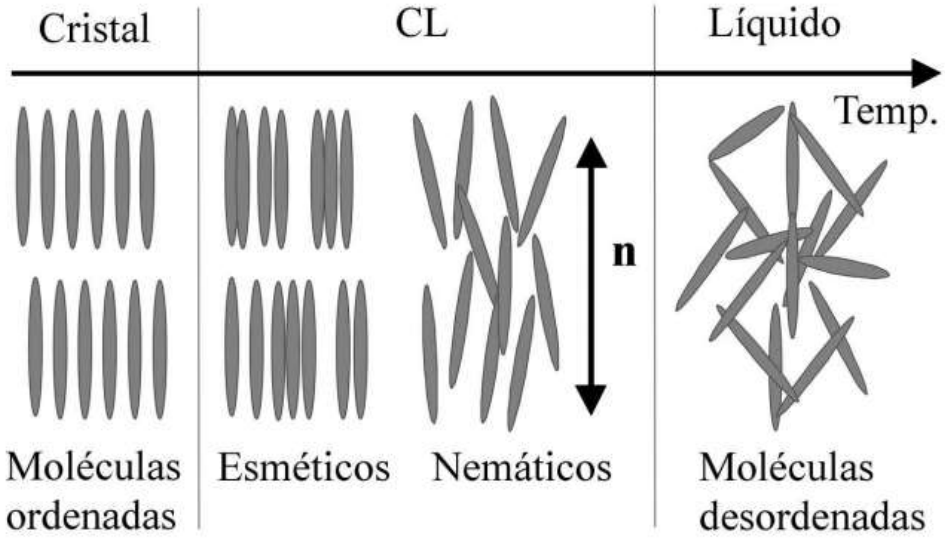
Liquid crystals are substances with special lubricating properties, and although they are liquid, they have a molecular structure very similar to that of crystalline solids, being called Mesomorphic. Thus, the tribological properties of liquid crystal friction have been studied, both for pure liquid crystalline components and for mixtures of crystals with lubricating oils, in order to apply it to the lubrication of mechanical equipment components. (TROVO; DOMICIANO, 2012).

According to Cruz (2011) for liquid crystals to be used as lubricants, some properties of fundamental importance need to be verified. The behavior of the chemical structure with variations in temperature, viscosity, the organization of crystalline liquids on the surface of solids, as well as the performance of compounds in tribological tests are the main characteristics that need to be analyzed.

In order for liquid crystals to be used as lubricants, some properties of fundamental importance need to be verified, including the behavior of the chemical structure with temperature variations, viscosity, the organization of crystalline liquids on the surface of solids, as well as the performance of compounds in tribological tests are the main characteristics.

Bechtold (2005) says that liquid crystals, in fact, are characterized by having an intermediate molecular order, between the long-range orientation and positional order of crystalline solids, and the long-range disorder of isotropic liquids and gases, where the degree of disorder increases with increasing temperature, as shown in Figure 2

Figure 2: Scheme illustrating the appearance of liquid-crystalline mesophases that may have the degree of disorder increased according to the temperature variation (*Portuguese*)



Source: Bechtold, 2005.

An industrial mechanism needs a lubricating film with viscosity capable of adhering to its surface, always guaranteeing good protection, as well as offering freedom to carry out its movement. And, if that condition is met, an excellent lubricant is obtained. In other words, the application of liquid crystals as lubricants or even as additives to conventional lubricating oils must have a viscosity that guarantees these characteristics. (TROVO; DOMICIANO, 2012).

According to Cruz (2011) when carrying out the first tribological research with liquid crystal lubricant, German scientists from the Fraunhofer Institute noticed that the friction between two metal plates fell almost to zero, with a yield that far exceeds the best lubricating oils currently available, but the cost of producing this product is very high.

On the other hand, the process of mining raw materials and the processing of these materials generate impacts on the environment and as a way of reducing the continuous use of natural resources that are increasingly scarce and a cheaper alternative, it can be reused or the recycling (TEIXEIRA-JÚNIOR et al., 2020).

For Souza et al. (2020) the literature demonstrates an increasing and significant amount on waste management and recycling, which for decades has increased people's awareness and generated answers to fill the gaps between the current legislation and the applicability of the action. This can be a solution to a problem with costs.

Silva et al. (2019) states that a strategy to reduce procedural expenses and increase the product mix offered to the public may involve recycling a large amount of material.

DISCUSSION

From the literature review carried out, the types of lubrication, the functions of the lubricants and a new technology for lubrication were raised. Thus, we sought to analyze the possible benefits of the new technology, the characteristics of liquid crystals, giving it good properties as lubricants, based on the damage caused by mechanical equipment, but its use must be widely studied, since it concerns its organization on solid surfaces, several factors could alter their ordering, impairing their performance and although they are easily synthesized, their cost is still high.

Based on Trovo & Domiciano (2012) it is possible to state that the three main phases in which liquid crystals are found (nematic, smectic and cholesteric), based on tribological tests previously performed, present different behaviors.

Although the smectic crystalline compounds present an excellent initial result, with slight variations in temperature they lose their lubricating characteristics, making it impossible to use in mechanical equipment.

Nematic crystals, despite not showing the best results, maintain their characteristics even with temperature variation. Another feature that deserves to be highlighted is its viscosity, which in general is lower than isotropic emetic liquid crystals, which is a very interesting characteristic because mechanical equipment needs a lubricating film that allows it to adhere to its surface, always guaranteeing good lubrication and ease of movement.

CONCLUSION

It is concluded that for the good performance of mechanical equipment, it is necessary to use lubricants and that each situation requires a type of lubricant to prevent damage such as wear and corrosion, however even with lubrication it is possible that there are still failures, either due to non-replacement or the inadequacy of the type of lubricant used.

It becomes evident that it is still necessary to invest in the development of new technologies such as liquid crystals, which are promising as lubricants, but their high cost makes their use unfeasible and therefore it is viable only as an additive to lubricating oils, still showing a great result.

As future studies it is suggested that experiments be done with different materials in order to present more economically viable liquid crystal alternatives for use as a lubricant, being important to look recycling alternatives.

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