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Effect of Base Lubricating Oil Type on Sodium Grease Production

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ABSTRACT : *This study focused on comparing the production of lubricating greases using virgin Iraqi base oils (Grade 150 and Grade 60) supplied by the Midland Refineries Company, with greases produced from recycled Iraqi base oils processed through clay and sulfuric acid methods. The greases were manufactured using a thickening agent based on sodium hydroxide and beef tallow, with varying percentages of the thickening agent at 20%, 23%, 26%, and 28%.The physical and chemical properties of the three base oils were examined, including viscosity, flash point, density, pour point, color,. Additionally, the manufactured greases were evaluated for properties such as drop point, penetration grade, water resistance. The results revealed that the grease made from Grade 60 base oil exhibited the highest evaporation rate, making it less efficient for high-temperature applications. In contrast, the grease produced from recycled oils showed a lower evaporation rate, with evaporation measured after exposing the samples to 90°C for 22 hours., while the optimal drop point for greases was achieved using 26% of the thickening agent. The highest drop point for sodium grease was observed in grease made from recycled oils. Most penetration values ranged between (NLGI 2-3), and the majority of the studied properties met acceptable standards according to ASTM specifications, with the lowest penetration values recorded for samples made from recycled oils.*

KEYWORDS -*Lubricating greases, lubricating oils, sodium greases*

I. INTRODUCTION

Crude oil is a homogeneous mixture composed of a large number of hydrocarbons that form its primary component, along with non-hydrocarbon substances such as nitrogen, oxygen, sulfur, and varying amounts of minerals. The refining process of crude oil is carried out in refineries to obtain useful products[1]. Regarding lubricating oils, the lubricating oil industry is considered a strategic sector, as its products are used in most activities and fields. The lubrication process involves the formation of a thin oil film between two adjacent surfaces, one of which moves relative to the other. This film aims to prevent direct contact between the surfaces during motion and reduce frictional resistance to avoid wear that might occur due to direct contact[2]. The functions of lubricating oils are as follows: Lubrication[3],Cooling [4] ,Sealing[5],Cleaning [6],Shock Absorption[7]. As for Recycled oils: recycled oil means the oil whose specifications have changed as a result of use and has become unsuitable for the purpose for which it was produced .That the oil used usually consists of unused base oil, consumed base oil, consumed and oxidized additives, oxidants, mineral and solid particulates, carbonic and acidic materials .

Virgin Bace Oils Industrial processes producing lubricating oils. Vacuum Distillation Unit: Vacuum distillation means distillation under pressure below the normal atmospheric pressure of atm 1 that the objective of the vacuum distillation unit is to break down the input

crude oil into derivatives that can be used as base oils [18], [19]. Propane Deasphalting Unit (P.D.A.) : The goal of the asphalt removal unit: The goal of the unit is to obtain an asphalt-free oil called (de asphalted oil)[20], [21].Furfural Extraction Unit: The goal of the Furfural Unit:Separation of aromatic compounds, some naphthenic compounds, unsaturated and unstable compounds, which are undesirable compounds due to their lack of good lubrication properties, high oxidability and low viscosity coefficient. [20], [21] .De Waxing Unit :The aim of the wax removal unit is that the oil sections resulting from the Fur Vral treatment unit contain in their composition paraffin hydrocarbons (wax sections) that freeze if its temperature drops to about 20 m, which makes the oil unusable as a lubricant, as the separation of compounds freezes and loses its movement, so the wax sections must be removed from the oil[9], [22]. That is, the purpose of this unit is to separate solid (waxy) hydrocarbons from the lubrication oil sections in order to obtain oil of sufficient fluidity at low temperatures (low spillage). In other words, obtainingan oil with a low wax percentage and a wax with a low oil percentage. These units are also called MEK units, according to the method used in this unit[9], [23],.Hydro treating unit of lubricant and Wax: The hydrogenation process is the process of reacting oil or wax with hydrogen in special reactors and under certain operational conditions and in the presence of the auxiliary factor [9], [23], [24]. The most important part of this study focuses on greases. According to the American Society for Testing and Materials (ASTM), lubricating grease is defined as a solid or semi-liquid substance produced by mixing a specific lubricating fluid with a thickening agent and other additives to alter the grease's properties and uses. Greases are preferred over lubricating oils for the following reasons[8], [9]: The operating life of lubricating grease is longer than that of lubricating oils[10]. Unlike lubricating oils, greases do not liquefy due to their gel-like structure[11], [12], [13]. Lubricating greases retain their lubricating properties even after long periods without use[13], [14]. Greases adhere to metal surfaces better than oils.[15], [16]. Greases are preferred under specific conditions, such as high temperatures, high pressures, and low speeds[17].

II. Literature Revie

Hoyer Leon Tan, Harumi Fini Rossi Passarella, researchers investigated the recycling of used lube oil by treating with three types of acids such as nitric acid, hydrochloric acid and sulfuric acid. The aim was to obtain high-quality refined lube oil using acid as an alternative to the distillation process. The properties and quality of the treated lube oil were compared with the base oil through various tests such as pour point, dynamic viscosity, kinematic viscosity, specific gravity and ash content, according to the American Society for Testing and Materials (ASTM) standards. First, filtration was applied to remove dirt that may be present in the used lube oil, followed by adding benzene to the used lube oil and centrifuging at 1500 rpm for 10 min. Atmospheric distillation was performed to completely remove water and benzene. Finally, the lube oil was treated with acids (nitric acid, hydrochloric acid or sulfuric acid) and neutralized with 6% sodium hydroxide before being separated by sedimentation and centrifugation. The results showed that sulfuric acid was superior to nitric acid and hydrochloric acid in the treatment of used lubricating oil. Moreover, the used lubricating oil treated with 20% sulfuric acid was comparable to fresh lubricating oil. The results showed that the used lubricating oil could be reused after acid treatment .[25]

F. U gwele, derase, investigated the purification of used Mobil oil by acid/clay, acid/charcoal, and acid/clay/charcoal methods; each method used three different acids (sulfuric acid, hydrochloric acid, and acetic acid) as washing agents respectively. The samples of used and refined oil were characterized to determine their physical and chemical properties for easy comparison with the properties of fresh and standard oils respectively. The results obtained indicated that during use, the properties of fresh Mobil oil such as specific gravity and sulfur content increased while the viscosity, flash point, and flash point decreased. The deviation of these properties from the normal state revealed that the oil became contaminated with worn metal parts, dust particles and other impurities during use; which means that as the lubricating property of used Mobil oil decreases, its polluting capacity or effect increases. Purification processes using either method were successful in recycling the recycled oil as evidenced by the fact that the physical and chemical properties of purified Mobil oil tended to be closer to those of fresh oils. The effectiveness of all methods was compared and the acid/clay method using sulphuric acid was found to be the best method as it gave the most acceptable purified

Mobil oil [26].

Timitayo E. Oladimeji, Owenlola R. Ubanla . The evaluation of the various recycling processes showed that the acid mud process has the highest environmental risks and the lowest cost: thus, this process added a processing method for the primary products after the acid mud was processed, thus reducing the environmental concerns caused by the acid and acid mud formed in the process. The acid ratio was changed between 0 and 20% and the adsorbent ratio between 15 and 25% The lubricating oil used in automobiles and the lubricating oil used in industry were treated with two different samples, acid and adsorbent: the increase in acid concentration showed a significant difference in oil properties such as density. Viscosity, flash point and other physical and chemical properties However, increasing the amount of acid above the optimum point made on the large change The change of adsorbent ratio showed little effect on density and flash point while yield and viscosity were unaffected. The optimum acidity at 10% gave 25% adsorbed clay acid an ideal result. All metal contaminants have been removed significantly, the total basal number has improved, while the flash point has increased and the effectiveness of the method is considered good. Processing of used synthetic oils was found to be more prone to re-refining due to less contamination [27]

Researchers Kan Wu, Shuaishuai Li, Jing Ni . It has been widely demonstrated that nano-additives significantly improve the frictional properties of conventional greases, and the synergistic effect of multiple nanomaterials to improve the performance of greases is a promising research direction. In this paper, based on the hardness of the GCr15 steel bearing material, harder SiO_2 nanoparticles and softer ZnO nanoparticles were selected to synthesize soft core and hard shell composite nanoparticles ($ZnO@SiO_2$) by chemical precipitation, and were used as a grease additive for the first time. The $ZnO@SiO_2$ composite nanoparticles have better dispersion and frictional properties than the actual mixed nanoparticles (ZnO/SiO_2). When 1 wt% of $ZnO@SiO_2$ was added to the grease, the friction coefficient and wear scar diameter were reduced by 11.5% and 25%, respectively. The special hard structure with soft core of the composite not only has good dispersion, but also forms a special hard friction layer on the surface of the friction pairs. The SiO_2 shell can absorb a large number of long-chain lubricant molecules and increase the viscosity of lubricant oils in the friction zone, thus forming a solid-liquid phase composite lubricant film, which plays an important role in reducing friction and resisting wear.[28]

Researchers Noorul Waheeda Bint Abdulrahman and Muhammad IzzuddinBin Abdul Aziz conducted a study to evaluate the anti-wear properties of greases manufactured from used engine oil (WEO) with the inclusion of additives. Two types of greases were developed: sodium-based grease and fumed silica (FS) grease. These formulations were prepared using specific weight ratios, with or without additives. The greases were then subjected to consistency, FTIR (Fourier Transform Infrared Analysis), and anti-wear properties tests. The results revealed that the addition of additives did not significantly impact the properties of the greases, except for sodium grease, as shown by the FTIR analysis. Sodium grease exhibited a spectrum with a peak below 600 cm^{-1}. Moreover, the formulated greases displayed low corrosiveness toward copper strips, classified as class 1.In terms of anti-wear performance, the addition of additives did not enhance the properties. The coefficient of friction (COF) for greases without additives was lower than for those with additives. However, the additives were effective in reducing the wear scar diameter of the greases. Overall, the study concluded that while the additives did not alter the primary properties or significantly improve anti-wear characteristics, they did contribute to a reduction in wear scar diameter. [91]

Researchers Akumefula MI1 *, Eze SO and Chikwe IC1.Grease is a mixture of a fluid lubricant usually petroleum oil and a thickener (soap) dispersed in the oil. The base oil (i.e., petroleum oil) can be substituted with recycled waste lubricating oil. Since the petroleum prices increase yearly, the use of recycled waste lubricating oil as base oil for greases production becomes the best solution to this problem. Sodium soap thickener was formed by reacting sodium hydroxide with palm kernel oil. The production of low-cost sodium grease was achieved. Three different waste lubricating oil samples (150 N, 350 N, 600 N) were recycled and analyzed, to determine the quality of the recycled lubricating oil samples. The results are tabulated. The recycled waste oils were used to produce sodium greases. The produced greases were tested for dropping point (600 N=180, 350 N=160, 150 N=145) °C, worked penetration (180 N=220, 350 N=240, 150 N=300), moisture content (Insignificant), appearance (fibrous and buttery), finger impression (adhesive) and water resistance (susceptible to water). This production was bound by a technology which embraces saponification, evaporation, melting of soap formed and blending with calculated quantity of base oil at the temperature ranging from 170°C to 180°C. The result obtained from the analysis showed that two out of the three products fall within the American Society for Testing of Materials (ASTM) and National Lubricating Grease Institute (NLGI) standard specifications for ball-bearing grease No. 14 and No. 2. respectively. However, the products of this research are economical in terms of cost and availability of raw materials in Nigeria, when compared with imported greases liketheAbro-products.[29] .

This study aims to provide a comprehensive comparison between virgin and recycled oils for the production of lubricating greases, focusing on their physical and chemical properties and their impact on the quality of the resulting greases. The research utilizes high-quality virgin oils and recycled oils processed using traditional methods to remove impurities and restore essential properties. Greases were produced using sodium hydroxide as a thickening agent, with analyses conducted on properties such as viscosity, pour point, flash point, density, and color before and after manufacturing. The evaluation also included grease characteristics such as penetration grade, water resistance, and evaporation rate. The study seeks to understand the relationship between the quality of the oil used and the performance of the produced greases, highlighting the potential of recycled oils as an economical and efficient alternative in the petroleum industry. Additionally, the research supports sustainable development and environmental impact reduction by offering practical solutions for reusing waste oils, enhancing production efficiency, and meeting the demands of various industries.Industrial processes producing lubricating oils

III. EXPERIMENTAL DETAILS

Preparations:

The method of preparation generally depends on preparing the fatty substance, then mixing it with the alkaline substance to form the thickening substance, then adding the base oil to it. The thickener present in this work is sodium soap. The alkaline substance added to the fatty substance can be calculated by pouring cow fat, according to Equation Equation

$$m = \frac{SV * Mw}{MkoH} = \frac{SV * Mw}{56}$$

Whereas:

m: The mass of the alkaline material (gr).

SV: Saponification presumption (gr).

MW: Molecular weight of the alkaline material to be added (gr/mol).

MKOH: Molecular weight of potassium hydroxide (gr/mol).

Lubrication Grease Preparation:

The fatty substance in the reaction flask until the temperature reached (90) degrees Celsius. We dissolve the necessary amount of NaOH in a certain amount of water and then add part of the C This process continues for 45 minutes. After that, the reaction temperature is raised to (120) ° C to ensure that the water is removed from the mixture. The base oil is added in batches until homogeneity is continuously stirred for 45 minutes. After that, we raise the temperature to (150) ° C for 30 minutes. After that, the temperature is gradually reduced to room temperature to ensure the formation of a regular and homogeneous soaple network to be filled and its properties studied after that.

It shows the lowest amounts of substances involved in the composition of sodium grease.

Table 1: Percentages and quantities of materials used in the manufacture of sodium grease using

Iraqi base oil grade 60

Base oil	Percentage of thickener %	Amount of fatty substance (gr)	Quantity Sodium hydroxide (gr)	The amount of water (gr)	Base Oil Percentage %	Quantity of Base Oil (gr)
Iraqi base oil grade 60	20	53.41	8.26	8.26	80	280
	23	61.42	9.5	9.5	77	269.5
	26	69.43	10.74	10.74	74	259
	28	74.77	11.6	11.6	72	252

Table 2: Percentages and quantities of materials used in the manufacture of sodium grease for Iraqi oil 150 degrees

Base oil	Percentage of thickener %	Amount of fatty substance (gr)	Quantity Sodium hydroxide (gr)	The amount of water (gr)	Base Oil Percentage %	Quantity of Base Oil (gr)
Iraqi base oil grade 150	20	53.41	8.26	8.26	80	280
	23	61.42	9.5	9.5	77	269.5
	26	69.43	10.74	10.74	74	259
	28	74.77	11.6	11.6	72	252

Table3: Proportions and quantities of materials used in the manufacture of sodium grease from Recycled oil

Base oil	Percentage of thickener %	Amount of fatty substance (gr)	Quantity Sodium hydroxide (gr)	The amount of water (gr)	Base Oil Percentage %	Quantity of Base Oil (gr)
Recycled oil	20	53.41	8.26	8.26	80	280
	23	61.42	9.5	9.5	77	269.5
	26	69.43	10.74	10.74	74	259
	28	74.77	11.6	11.6	72	252

IV. RESULTS AND DISCUSSION:

Results of tests of used base oils

1-Results of the viscosity tests and the viscosity coefficient of the base oils used**.**The three samples 150-degree oil, 60-degree oil, and recycled oil—were examined, and the findings are shown in Table (4).

Table 4:Viscosity and viscosity coefficient of base oils used

Properties	Base oil 60	Base oil 150	Recycle oil

Viscosity 40c° CST	61.74	396.99	448.3
Viscosity 100c°CST	8.12	29.2	32.8
Viscosity 100c°CST	103.23	101.99	107

The viscosity coefficient and viscosity at 40 and 100 degrees Celsius were examined. It was found that the recycled oil had higher grades when compared to oil at 150 and 60 degrees Celsius. This is a challenge in the production of variable oils, particularly the lower grades, and a benefit in the production of fixed oils with a high number and grease, where a higher viscosity improves adhesion and cohesion with the thickener.

2-Results of density checks of base oils. The three samples 150-degree oil, 60 degree oil, and recycled oil were examined, and the findings are shown in Table (5).

Table 5: Density of base oils used

Properties	Base oil 60	Base oil 150	recycle
Density at 15.6C	0.8820	0.8990	0.8950

According to an analysis of the three oils' densities, they are closely related to one another. Because of the nature of the hydrocarbon chains in the base grade the lower the hydrocarbon chains, the lower the density, and vice versa base oil 60 has the lowest density by a narrow margin This results are close with the study[70],[3] .

3-Results of Pour Point tests of used base oilsThe three samples 150degree oil, 60degree oil, and recycled oil were examined, and the findings are shown in Table6.

Table 6: Pour Point of base oils used

Properties	Base oil 60	Base oil 150	Recycle oil
Pour Point C	-5	-1	1

According to the findings, recycled oil has hardened the most compared to the other oils, necessitating the use of additional additives to increase the amount of spillage

4-Results of flash point tests of used base oils

The three samples 150 degree oil, 60 degree oil, and recycled oil were examined, and the findings are shown in Table (7).

Table 7: The flash point of the base oils used

Properties	Base oil 60	Base oil 150	recycle
Flash Point Apparatus	149	207.5	223

When the flicker level was examined, it was discovered that recycled oil had the highest flicker. Because it will evaporate less than the other oils, this indicates that it is a beneficial factor in the production of grease and lubricating oils. The higher evaporation rate occurs when base oils or lubricating greases are made from grade 60 because of its base oil content.

Physico-chemical tests for sodium grease

1-dropping Point:

Grease samples consisting of oil grade 150, oil grade 60, and reconstituted oil with thickener in the ratios of 20, 23, 26, and 28 were examined.

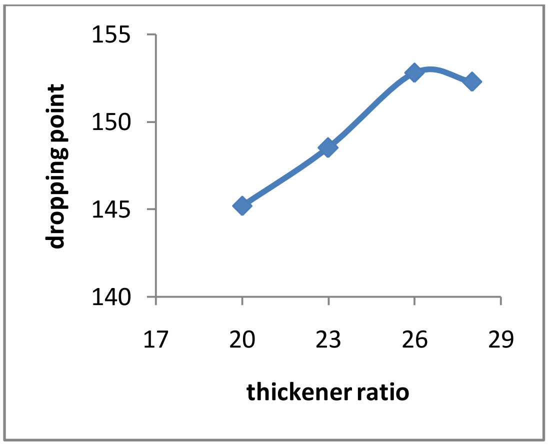

Fig**1**: Dropping point of Grease made from base oil 150 and NaoH

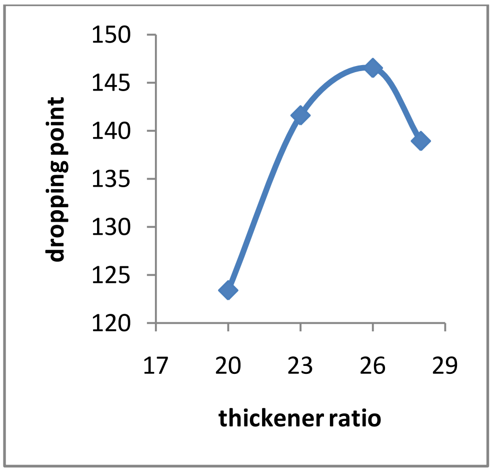

Fig**2**: Dropping point of Grease made from base oil 60 and NaoH

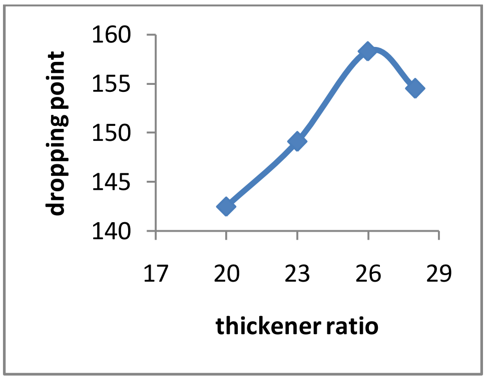

Fig**3**:Dropping point of Grease made from Recycle oil and NaoH

The optimal thickener ratio was found to be 26% based on the findings of the drop point analysis As well as fig 7,8,9. This is because 26% is the highest drop point for sodium grease, and if this percentage is raised, the ratio will start to fall. It was the recycled oil, as for the oils. This determinant also affects the economic feasibility; the lower the thickener percentage, the more economical it was, and as a result, the recycled oil, when used in relation to the degree of fall, is more ideal than his peer. The oil at the highest degree of fall was less than that of oil at 150 degrees. The thickener ratio was adjusted to achieve dropping points before and after the highest dropping point[30]

2-Degree of penetration (hardness test):
Grease samples composed of three types of oils, grade 150, oil grade 60, and reconstituted oil with thickener in the ratios of 20, 23, 26, and 28 were examined. Prior to and following 60 double strokes, the degree of sodium grease samples produced at 25° C was determined.

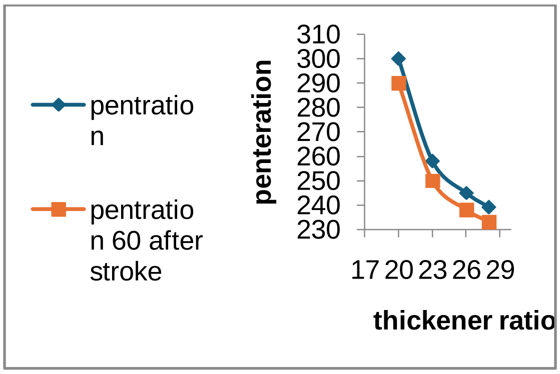

Fig4: Penteration ofGrease made from base oil 150 and NAOH

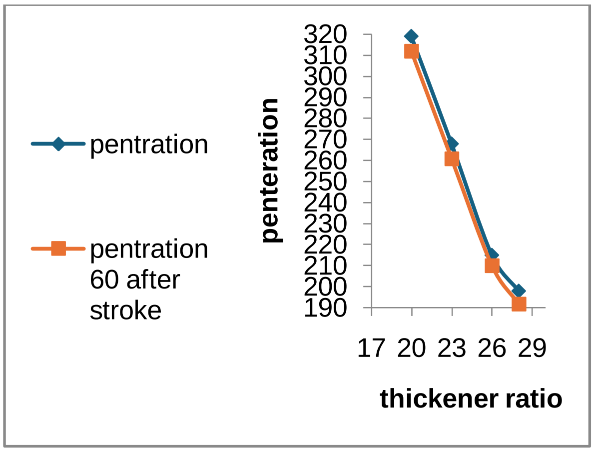

Fig5: Penteration ofGrease made from base oil 60 and NAOH

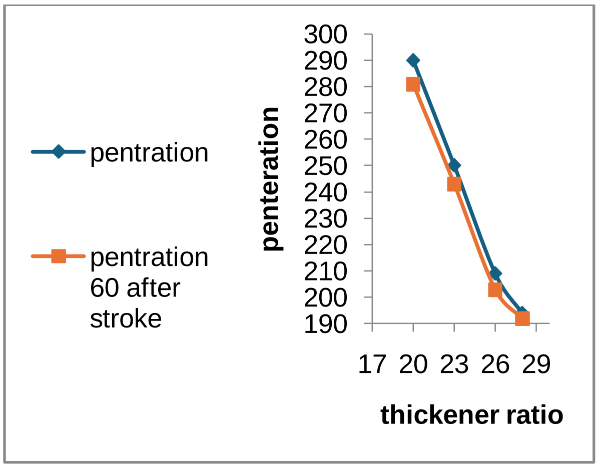

Fig6: Penteration ofGrease made from Recycle oil and NAOH

Before and after 60 strokes of operation, the degree of Penteration of sodium grease was measured at 25 degrees Celsius. The stitching numbers of the non-operated and operated grease samples are displayed in the table below. It was observed that recycled oil has the highest rigidity, or the lowest penetration degree numbers of 150 and 60 degrees in oil, because the majority of the samples fell between 2 and 3 degrees of penetration, according to NLGI The thickening ratios have been used to get these grades that are commonly used as in[30][31]

3-Evaporation Ratio:

The three types of grease samples were examined: 150°C oil, 60°C oil, and reconstituted oil with thickener ratios of 20, 23, 26, and 28. The evaporation rate of the sodium grease samples produced at temperatures between 25 and 50°C and 90°C was measured for 22 hours, and the results of all manufactured sodium grease are displayed in Table 8.

Table 8 Percentage of evaporation of sodium grease samples

Temperature	Base oil 60	Base oil 150	Recycled oil
25	No evaporation rate was recorded for this grease	No evaporation rate was recorded for this grease	No evaporation rate was recorded for this grease
50	the evaporation rate was less than 0.4%	the evaporation rate was less than 0.4%	the evaporation rate was less than 0.4%

90	the evaporation rate is less than 1.2%	the evaporation rate is less than 0.9%	the evaporation rate is less than 0.8%

Following knowledge of the lithium grease evaporation results, and the sodium grease evaporation outcomes. It turns out that the primary factor influencing evaporation is the type of essential oil used, which is crucial to understanding how well the grease can withstand high temperatures without becoming more rigid over time and operating outside of its range.

4-Grease Water Resistance:

Grease samples made of the three oils—oil grade 150, oil grade 60, and oil returned with the thickener in the proportions of 20, 23, 26, and 28 were examined to determine how resistant sodium grease samples were to water. It was discovered that this type of grease is significantly impacted by water, as evidenced by the swelling of the grease, which indicates that it has absorbed water. As a result, the grease lost its mechanical properties, ruined its structure, and could drift from the lubricated piece This results are close with the study[32]

V. CONCLUSIONS

The findings derived from this study can be summarized as follows: Reconstituted oils processed with acid and impurities require the least amount of thickener to achieve a desired level of consistency compared to base oils of 60 and 150 grades. However, base oil of grade 60 exhibits a notably low flash point, which is a disadvantage in both the lubricant and grease industries. On the other hand, grade 150 oil showed a higher susceptibility to corrosion, indicating the presence of acidic or sulfuric compounds, reflecting the existence of harmful contaminants in the oil production process. For drop point testing, the optimal case revealed a 26% efficiency for sodium-based grease across all oil types. It was also observed that an increase in the percentage of thickening agent leads to reduced fluidity, resulting in greater grease stiffness. Furthermore, grade 60 oil demonstrated the highest evaporation rate, rendering it unsuitable for high-temperature applications, while grade 150 oil exhibited superior evaporation resistance. Sodium grease, however, lacks adequate water resistance, making it unsuitable for equipment exposed to moisture. While it is challenging to determine an absolute preference among different types of grease due to their distinct characteristics suited to specific applications, greases formulated with reconstituted oils performed well, followed by those based on grade 150 oil. In contrast, greases using grade 60 oil were of lower quality. Overall, most greases produced in this study are suitable for a variety of industrial uses.

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