Investigation Of Usage Of Zeolite In Lubrication Industry

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ABSTRACT: *Zeolites are materials that can be produced naturally and/or synthetically with a wide common usage area. There are different types of zeolites according to their usage areas and sizes. Greases are generally classified according to their soap types. Although, it is necessary to add load resistance and wear improving additives to the formulation of most grease products when they are operated under heavy loads in their usage conditions. In this study, the potential of clinoptilolite type zeolites to be applied as solid lubricants was investigated. In order to investigate the effect of particle size on solid lubricant performance of clinoptilolite zeolites, 10 µm, 40 µm, 100 µm and 700 µm sized zeolites were selected and used. The performance characteristics of clinoptilolite type zeolites in lithium soap grease products when used as load resistance and wear improving additives were investigated. In addition, the effect of size on the anti-wear and load resistance performances of clinoptilolite type zeolites in lithium soap greases was investigated and detailed results were reported.*

Keywords: Lubricant, Grease, Load Resistance, Wear Scar, Zeolite

Date of Submission: 09.06.2023 Date of Acceptance: 12.07.2023
https://doi.org/10.5281/zenodo.8200521

1. INTRODUCTION

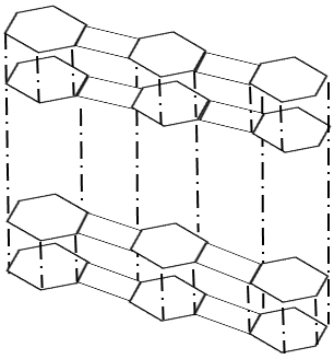
Main purpose of liquid, semi solid and solid lubrication is reducing friction[1]. Reducing friction helps the decreasing of energy losses. Reducing energy loss helps protection of environment by reducing emissions.[1]

Greases are semi solid lubricants. Lithium soap greases have been used globally during long years. Lithium soap greases have wide usage area. Lithium base greases have a wide range of usage area because of their inherent performance characteristics. Nevertheless in some cases producers or mechanical systems require improved performance aspects like extreme pressure resistance, anti wear properties and resistance to water. Good water resistance performance expect from greases. To improve water resistance of greases traditionally different types of polymers have been used in ındustry. Clinoptilolite types zeolites have good water adsorption properties.[2] Zeolites are generally used for water and waste water treatment to water purification.[6]
Zeolites are naturally abundant-the most abundant molecules. They have wide range of usage ares. [1]Besides all of these properties zeolites are not harmful to the health.[1,5] Moussa Zaarour et al.[3] used zeolite nanocrystals as protection agent from acidic decomposition products.

According to I. Markovska et al.[4]'s study clinoptilolite type zeolites could adsorb the metallic by products sourced from working of greases on operating conditions.
General structural properties of clinoptilolite type zeolites are[6];

- Crystalline lattice form
- Porous structure: 0,45 nm -0,6 nm
- Acidic adsorption
- Water adsorption

Figure 1. *Structural form of clinoptilolite type zeolites*



2. MATERIALS AND METHODS

In this study we have been used lithium soap greases. Consistency level of used greases selected NLGI grade 3 which is one of the most used NLGI grease grade.

As zeolite, we have been used clinoptilolite type zeolites. And to observe difference performance effects of different sizes we have been selected and used 10 µm, 40 µm, 100 µm and 700 µm sized zeolites. All type of zeolites applied respectively 0 %, 0.5 %, 1 %, 2 % ratios into lithium soap NLGI 2 grease sample. Observation of extreme pressure and anti wear potential of zeolites applied with different types of base oils. Group 3, group 1 and food grade base oils have been used. Group 1 and group 3 base oils were ISO VG 22 grade and as food grade base oil we have been selected castor oil.

2.1 Equipments and Test Methods

All performance analysis tested at POTEM. Consistency, 4 ball wear scar, weld load, water spray off, water resistance, dropping point and copper corrosion trend analysis of synthesed greases have been reported. Consistency test applied according to ASTM D217 test standart. 4 ball wear scar test applied according to ASTM D2266 test standart. Weld load test applied according to ASTM D2596 test standart. Water spray off test applied according to ASTM D4049 test standart. Water resistance test applied according to ASTM D1264 test standart. Dropping point test applied according to ASTM D566 test standart. Copper corrosion test applied according to in-house revised ASTM D4048 test standart.

2.2 Tables and Figures

The results of the analysis of the study are shown in the figures and tables below.

Figure 2. Wear diameter test results

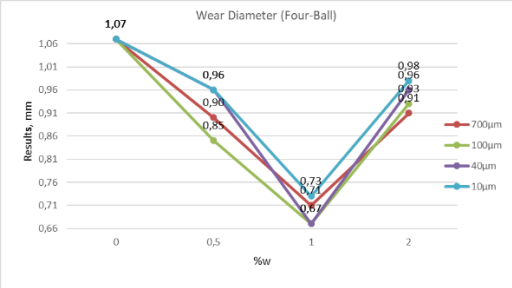


Figure 3. Water washout test results

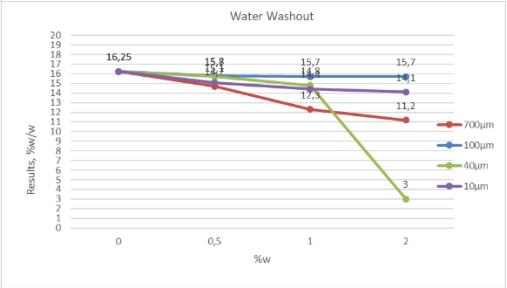


Figure 4. *Water spray off test results*

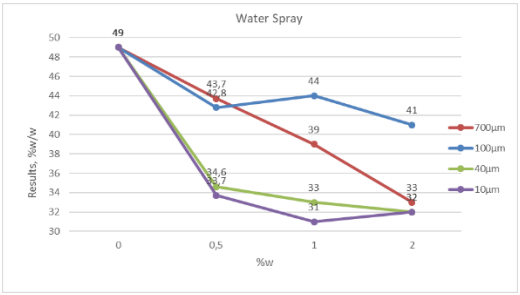


Table 1. *Analysis results of formulations with 700 µm clinoptilolite zeolites*

FORMULATION, %w/w, 700 µm		**1**	**2**	**3**	**4**
NLGI-2 grade Lithium Soap		**100**	**99,5**	**99**	**98**
Clinoptilolite Zeolite, 700µm		**-**	**0,5**	**1**	**2**
Cone Penetration,25ºC	D-217	**228**	**217**	**218**	**220**
NLGI No.		**3**	**3**	**3**	**3**
Wear Diameter (Four-Ball), mm, kg, min	D-2266	**1,07**	**0,9**	**0,71**	**0,91**
Extreme Pressure (Four Ball), kg	D-2596	**400**	**315**	**315**	**315**
Water Spray,38ºC, (38 °C, 40 psi, 5 min), %w/w	D-4049	**49**	**43,7**	**39**	**33**
Water Washout ,79ºC, %w/w	D-1264	**16,3**	**14,7**	**12,3**	**11,2**
Dropping Point, ºC	D-566	**206**	**208**	**209**	**205**
Copper Strip Corrosion, 150C, 24h	in house	**1B**	**1B**	**1B**	**1B**
Copper Strip Corrosion, 150C, 36h	in house	**1B**	**1B**	**1B**	**1B**
Copper Strip Corrosion, 150C, 48h	in house	**1B**	**1B**	**1B**	**1B**
Copper Strip Corrosion, 150C, 60h	in house	**1B**	**1B**	**1B**	**1B**

Table 2. *Analysis results of formulations with 100 µm clinoptilolite zeolites*

FORMULATION, %w/w, 100 µm	**1**	**2**	**3**	**4**
NLGI-2 grade Lithium Soap	**100**	**99,5**	**99**	**98**

Clinoptilolite Zeolite, 100µm		-	0,5	1	2
Cone Penetration,25ºC	D-217	228	220	222	221
NLGI No.		3	3	3	3
Wear Diameter (Four-Ball), mm, kg, min	D-2266	1,07	0,85	0,67	0,93
Extreme Pressure (Four Ball), kg	D-2596	400	315	315	315
Water Spray,38ºC, (38 °C, 40 psi, 5 min), %w/w	D-4049	49	42,8	44	41
Water Washout ,79ºC, %w/w	D-1264	16,3	15,8	15,7	15,7
Dropping Point, ºC	D-566	206	210	208	206
Copper Strip Corrosion, 150C, 24h	in house	1B	1B	1B	1B
Copper Strip Corrosion, 150C, 36h	in house	1B	1B	1B	1B
Copper Strip Corrosion, 150C, 48h	in house	1B	1B	1B	1B
Copper Strip Corrosion, 150C, 60h	in house	1B	1B	1B	1B

***Table 3**. Analysis results of formulations with 40 µm clinoptilolite zeolites*

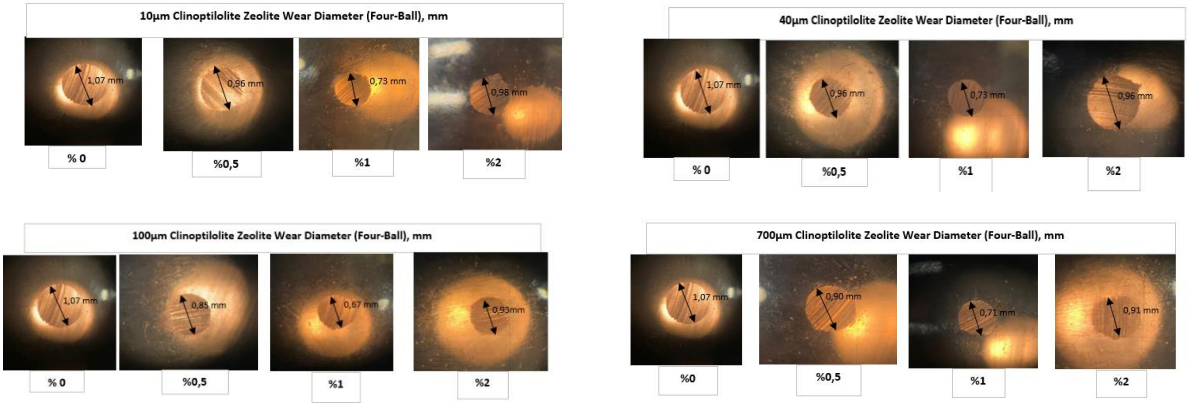
FORMULATION, %w/w, 40 µm		1	2	3	4
NLGI-2 grade Lithium Soap		100	99,5	99	98
Clinoptilolite Zeolite, 40µm		-	0,5	1	2
Cone Penetration,25ºC	D-217	228	220	223	224
NLGI No.		3	3	3	3
Wear Diameter (Four-Ball), mm, kg, min	D-2266	1,07	0,96	0,67	0,96
Extreme Pressure (Four Ball), kg	D-2596	400	315	315	315
Water Spray,38ºC, (38 °C, 40 psi, 5 min), %w/w	D-4049	49	34,6	33	32
Water Washout ,79ºC, %w/w	D-1264	16,3	15,7	14,8	14,3
Dropping Point, ºC	D-566	206	208	206	207
Copper Strip Corrosion, 150C, 24h	in house	1B	1B	1B	1B
Copper Strip Corrosion, 150C, 36h	in house	1B	1B	1B	1B
Copper Strip Corrosion, 150C, 48h	in house	1B	1B	1B	1B
Copper Strip Corrosion, 150C, 60h	in house	1B	1B	1B	1B

***Table 4**. Analysis results of formulations with 10 µm clinoptilolite zeolites*

FORMULATION, %w/w, 10 µm		1	2	3	4
NLGI-2 grade Lithium Soap		100	99,5	99	98
Clinoptilolite Zeolite, 10µm		-	0,5	1	2
Cone Penetration,25ºC	D-217	228	222	226	227
NLGI No.		3	3	3	3
Wear Diameter (Four-Ball), mm, kg, min	D-2266	1,07	0,96	0,73	0,98

Extreme Pressure (Four Ball), kg	D-2596	**400**	**315**	**315**	**315**
Water Spray,38ºC, (38 °C, 40 psi, 5 min), %w/w	D-4049	**49**	**33,7**	**31**	**32**
Water Washout ,79ºC, %w/w	D-1264	**16,3**	**15,1**	**14,4**	**14,1**
Dropping Point, ºC	D-566	**206**	**207**	**209**	**205**
Copper Strip Corrosion, 150C, 24h	in house	**1B**	**1B**	**1B**	**1B**
Copper Strip Corrosion, 150C, 36h	in house	**1B**	**1B**	**1B**	**1B**
Copper Strip Corrosion, 150C, 48h	in house	**1B**	**1B**	**1B**	**1B**
Copper Strip Corrosion, 150C, 60h	in house	**1B**	**1B**	**1B**	**1B**

Figure 5*. 4 ball wear scar visuals*



3. RESULTS

According to test results shown in table-1,2,3 and 4 addition of 10 µm, 40 µm, 100 µm and 700 µm zeolites at 0.5 %, 1 % and 2 % ratios did not significantly change the consistency values, NLGI grades, dropping points and weld loads of grease product.

According to test results shown in table-1,2,3 and 4 addition of 10 µm, 40 µm, 100 µm and 700 µm zeolites improved 4 ball wear scar performance results of lithium soap grease and 1 % ratio is optimum value.

According to test results shown in table-1,2,3 and 4 addition of 10 µm, 40 µm, 100 µm and 700 µm zeolites improved water spray off performance results of grease. 1 % of 10 µm, 40 µm and 2 % of 100 µm and 700 µm clinoptilolite zeolites ratio is optimum value.

According to test results shown in table-1,2,3 and 4 addition of zeolites improved water resistance performance results of grease. 1% and 2 % for 40 µm and 10 µm and 2 % for 700 µm and 100 µm clinoptilolite zeolites ratio is optimum value.

4. DISCUSSION

Clinoptilolite type zeolites have a great potential to usage in greases as solid lubricants. Likewise some of other solid lubricants clinoptilolite type zeolites have an optimum usage ratio to prevent wear. Above this ratio performance improving effect of clinoptilolite type zeolites turn reverse. For usage in lithium soap NLGI 2 greases this ratio is 1 %. According to test results, this phenomenon could be attributed to the concentration effect of zeolit type solid lubricants. Above 1 % solid lubricant effect of clinoptilolite

type zeolits lose its effectiveness and make scar on surface. These results are as good as a traditional antiwear additive.

Generally all sizes of clinoptilolite type zeolites improved water resistance and water spray of properties of grease. This results could be attributed to the good water absorption properties of clinoptilolite types zeolites. Zeolites inside grease absorbs the water in enviroment and grease did not affected from the water and remains better on the surface.

Additionally, according to Moussa Zaarour et al.[3] study, in the lifetime of usage, zeolites particles would protect the lubricant from decomposition products. Adsorbs the acidis decomposition products.

5. CONCLUSION

Based on the study, the following conclusions can be reached;

- Clinoptilolite zeolites could be classified as solid lubricants.
- Solid lubricant properties of clinoptilolite zeolites have efficient performance results.
- Clinoptilolite type zeolites have been shown good performance improvement results when used in lithium soap greases.
- Additionally to their good anti wear properties, clinoptilolite type zeolites have also good water resistance improving potential when used in lithium soap greases.
- Clinoptilolite zeolites could use as anti wear agents in lithium soap grease formulations. And, decomposition effect of traditional anti wear agents could be eliminated with this approach.
- Other zeolite types could be studied in grease formulations.
- Clinoptilolite type zeolites could be studied in different soap types to evaluate their performance characteristics.

ACKNOWLEDGEMENTS

All materials and methods supplied by Petrol Ofisi A.Ş. and all study applied on Petrol Ofisi Technology Center (POTEM).

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