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# IMPROVING THERMAL PROPERTIES OF OIL LUBRICANT USED IN PARTIAL JOURNAL BEARINGS OF ROTARY KILN FOR KUFA CEMENT PLANT BY ADDING GRAPHITE GREASE

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## ABSTRACT

Bearings generally suffer from high temperatures under loads, which leads to heat transfer problems between shaft and journal bearing. in this paper graphite grease mixed with oil used in journal bearing in three weight fractions 15%, 20% and 25%. physical properties such as thermal conductivity, viscosity and density would be measured. in cement plants, the effect adding graphite grease to the oil on temperatures of tier, roller, oil, shaft inlet and shaft exit would be measured. Also, SEM images of three concentrations of graphite grease in oil would be investigated..

## KEYWORDS

Graphite Grease, Thermal Conductivity, Viscosity, Oil.

## 1. INTRODUCTION

The cement kiln of the Kufa plant is based on tire-over rollers during rotation together at the design speed(1.5rpm) of the kiln to produce (1500) tons of clinker per day, with temperature of up to (1450) degrees Celsius inside the kiln. The rollers are based on partial journal bearings with the use of an appropriate lubrication process to reduce friction between the shaft of the roller and the bearing linear bronze. The main parts of the heat transfer by conduction outside the rotary kiln down to the partial journal bearings for rollers, there is another source of heat generation from the friction between two surfaces for tire and rollers, third source of heat generation from the friction between the shaft of rollers, which represents the moving part of the partial journal bearings, and bronze linings, which represent the fixed part of the bearings.

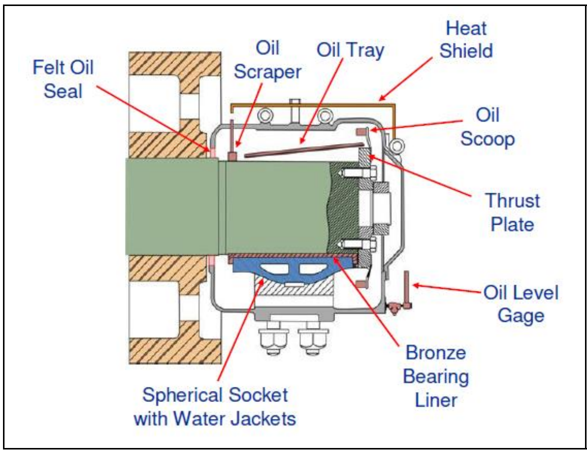


**Fig. 1. Schematic of journal bearing of rotary kiln**

**Fig. 2. Rotary kiln of cement plant**

Many authors have studied improving the thermal performance of oils used in different types of machines, for example, Abbas et al. (2024), checked the Performance of the journal bearings by studying the thermal hydrodynamic model (THD) with the steady state of bearings system. Malik et al. (1981), Analyzed the effect of the oil speed sliding between the two parts of bearings, the liner and the shaft. Gao et al. (2014), conducted the numerical analytic comparison study between the several thermal boundary conditions to check their influence on bearing's thermal properties efficiency. Zhang et al. (2013), discussed the various thermal boundary conditions mostly set in the context of thermo- hydrodynamic simulations of the partial journal bearings. Bhat et al. (2007), investigated the 60º radial Arce for journal type of bearing. Using analytical computing system for studying and analyzing the different calculations of the bearing performance by applying CFD with Csd. Dobrica et al. (2006), studied and analyzed different type of bearing journal and experiment additive with host lubricant, and for specific areas of lubrication region. Maddah et al. (2013), Applied and compared between two various of the conditions for the thermal limits of the system. the 1st boundary condition was neglecting heat generated with reject and considering it constant inside the bearing liner and outside shaft surface. Rashmi Deshmukh et al. (2016), presented a review and achieved the performance efficiency analysis of journal bearing after adding Hybrid Nanomaterials to hosts oil study. Samir et al., used the theoretical equations and experimental of the thermal conductivity and viscosity, specifications of most engineering materials in nature have shown, and they found that the physical and thermal properties of materials in the Nano fluids augment improve with the particles size of nanoparticles. Theo et.al. (2007), Study the applications of grease due to high viscosity rate at room temperature, but its uses are limited in high-efficiency lubrication systems, as it does not meet the requirements of these systems, except after the use of additives with the best properties. Muhannad et. al (2013), concluded that most grease containing additive materials prevent rust and corrosion when used in bearings have much better oxidation resistance than grease have no additive. Liang et al. (2016), investigated the extent of thermal to elastohydrodynamic performance enhancement of partial plain bearings with constant angular value (θ) at several values eccentricity (ε). Souad j. et. al (2020), studied the elasto-thermo-hydrodynamic (ETHD) performance of partial journal bearings in two cases. The first is when the inner surface of the bearing is entirely smooth, while the other takes into account the effect of scratches likely to exist on the bearing inner surface during operation.

In this research, graphite grease will be added to the oil used in the bearings of rotary kilns in the Kufa Cement Factory in weight percentages of 15%, 20%, and 25%. Its effect on thermal properties such as thermal conductivity and specific heat capacity, as well as its physical properties such as viscosity and density, will be studied to improve the thermal performance of the oil.

## 2. EXPERIMENTAL WORK

### 2.1. Materials used

In this research, graphite grease grade (G-3) which properties indicated in Table 1 was used as a material that improves the thermal properties of type code No. (6003) oil whose properties are shown in Table 2 which is used in the kiln bearings of the Kufa cement factory. Graphite grease was used because it has high thermal properties such as thermal conductivity and specific heat capacity. Both materials, oil and graphite grease, were supplied from the Dora refinery in Baghdad.

**Table 1. Properties of graphite grease**

| property | value |
|---|---|
| Grade | G-3 |
| Cone penetration at 25 °C | 220-250 |
| Drop point °C | 100 |

**Table 2. Properties of oil 6003**

| property | value |
|---|---|
| Code No. | 6003 |
| Density | 860 kg/m$^3$ |
| Specific gravity at15.6 °C | 0.911 |
| Viscosity (cp) | 145-165 |

### 2.2. Methodology

The experimental part can be divided into two parts, one of which is laboratory work in the laboratory of the Nanotechnology Research Unit at the College of Engineering - University of Kufa. In this part, graphite grease was mixed with the oil was used in this research in three weight fractions 15%, 20%, and 25%. The thermal properties such as viscosity dynamics, thermal conductivity and density were measured. The other section was carried out at the Kufa Cement Factory site to measure temperatures of the journal bearings and oil before and after adding graphite grease in different weight fractions. These weight fraction of 15%, 20%, and 25%, came as a result of conducting some experiments to increase the thermal conductivity of the oil.

### 2.3. Experiment works in the lab.

In this part, oil type (6003) was mixed with graphite grease in weight ratios (15, 20 and 25) % using a magnetic stirrer for 15 minute, as shown in the Fig. 3, and then the mixture was placed in the ultrasonic homogenizer for 30 min as shown in the Fig.4.


**Fig. 3. magnetic stirrer**


**Fig. 4. ultrasonic homogenizer**

After the mixing process for all weight ratios, the effect of adding graphite grease on thermal conductivity was investigated using KD2 device as shown in the Fig. 5 then, the viscosity was measured using Fungilab device as shown in the Fig. 6. Also, the density was also calculated at the room temperature of 25 °C.

**Fig. 5. Thermal conductivity measurement**

**Fig. 6. viscosity measurement**

### 2.4. Experiment works in plant

The second part of experimental work was conducted in Kufa Cement plant, which represented by reading the temperatures of the surface of the tire and the roller for the third base of the first furnace, as well as reading the temperatures of the oil entering the bearing and the temperatures of the shaft at two points at the entrance (near the roller) and at the exit (near the end of the shaft). the temperature measurements were done for above points in journal bearing before and after adding the graphite grease to the oil used in the process of lubrication of the partial bearing three weight ratios 15% , 20% and 25% as shown in Figs 7 and 8.

**Fig. 7. Temperature measurements of oil**

**Fig. 8. Temperature measurement of kiln roller**

## 3. RESULTS

Table 3 and Figs.9 to 11 show the physical properties of the oil mixture with graphite grease in weight fractions 15%, 20%, and 25% of the oil. It is clear that adding graphite grease by 25% increases the thermal conductivity of the mixture by up to 15% because the thermal conductivity of graphite grease is 3 W/K.m and is considered high compared to oil. As for viscosity, its increase reach to 23%, and this increase comes due to the high viscosity of graphite grease. This increase in viscosity is considered suitable for the flow of oil over the journal bearing. As for the density, its increase reach to 3.5 %. This increase is considered appropriate because it is not large enough to cause the graphite grease particles to agglomerate.

**Table 3. Physical properties measurement**

| Graphite grease % | Thermal conductivity (w/m.k) | Kinetic viscosity (cp) | Density ( kg/m$^3$) |
|---|---|---|---|
| 0% | 0.151 | 1.6 | 893 |
| 15% | 0.157 | 1.725 | 900 |
| 20% | 0.163 | 1.834 | 906 |
| 25% | 0.174 | 1.97 | 925 |

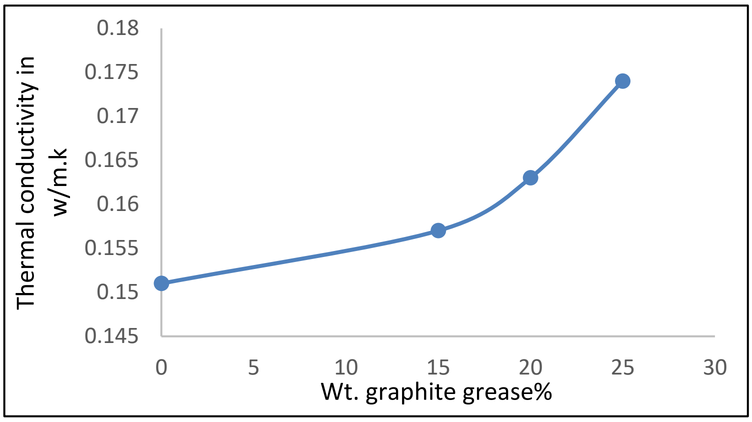


**Fig. 9. Thermal conductivity of oil with different %wt. of graphite grease**

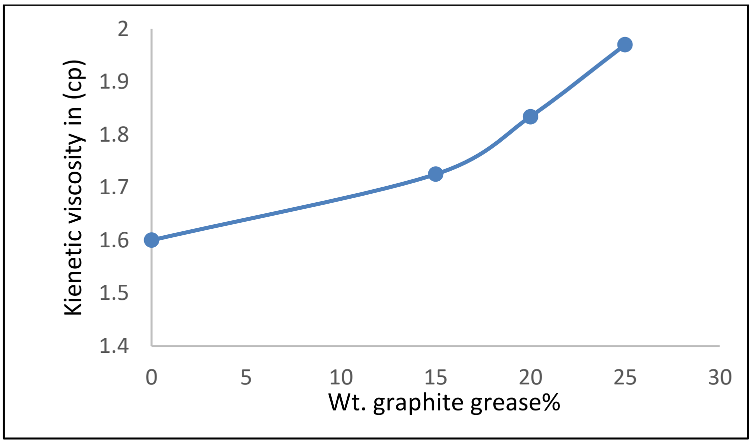


**Fig. 10. Viscosity of oil with different %wt. of graphite grease**

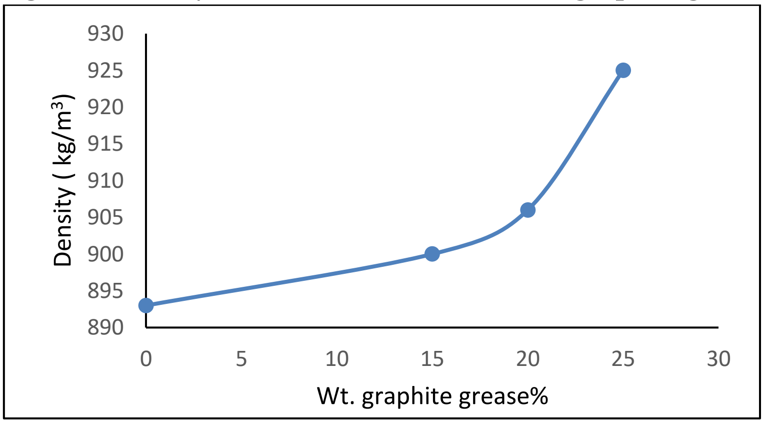


**Fig. 11. Density of oil with different %wt. of graphite grease**

Table 4 and Figs.12 and 13 show the variation of tier and roller temperatures with weight fraction of graphite grease. It seems that adding graphite grease in different weight fractions doesn't affect the temperatures of tires and rollers because they are considered a nonconductive materials of heat in addition to its far distance from the rejoin of the furnace's heat influence.

**Table 4. Temperature of journal bearing parts**

| Graphite grease% | Tire Temp.(°C) | Roller Temp. (°C) | Inlet Shaft Temp. (°C) | Exit Shaft Temp. (°C) | Oil Temp.(°C) |
|---|---|---|---|---|---|
| 0 | 130 | 80 | 78.5 | 76.3 | 71.5 |
| 15 | 131 | 81 | 51.5 | 50,2 | 47 |
| 20 | 130 | 80 | 43.8 | 42.8 | 42.6 |
| 25 | 130 | 80 | 43.5 | 41.5 | 41.4 |

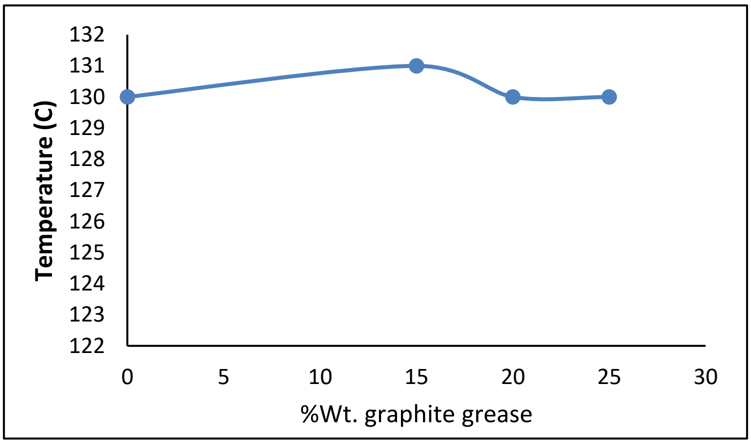


**Fig. 12. Tier temperature vs %wt. of graphite grease**

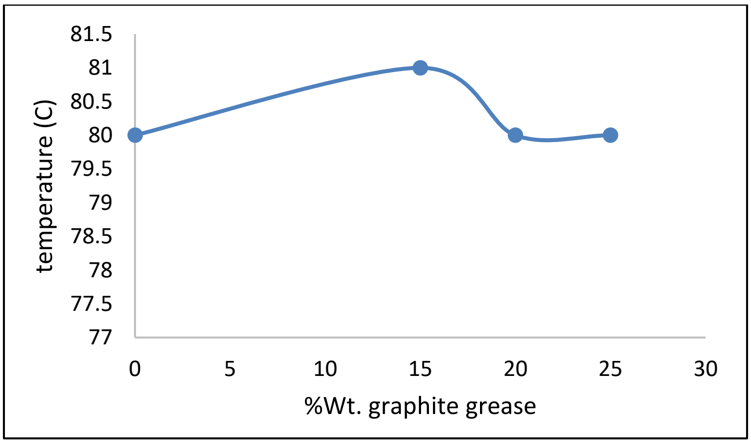


**Fig. 13. Roller temperatures vs %wt. of graphite grease**

Table 4 and Figs.14 to 16 show the differences in temperatures of inlet shaft, exit shaft and oil with variation of weight fraction of graphite grease. It clear that the significant effect of these temperatures rejoins by adding graphite grease in different weight fractions due to the enhancement in thermal properties such as thermal conductivity of oil/ graphite grease mixture as indicated in Table 3. Also, there is direct contact between the hot surfaces of the inlet and

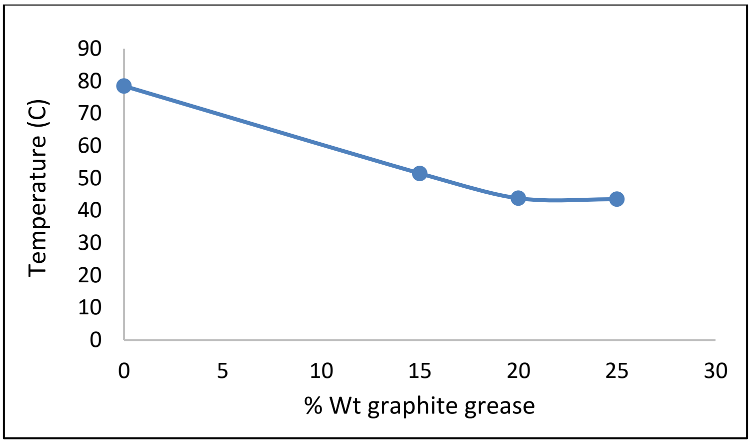


**Fig. 14. Inlet shaft temperatures vs %wt. of graphite grease**

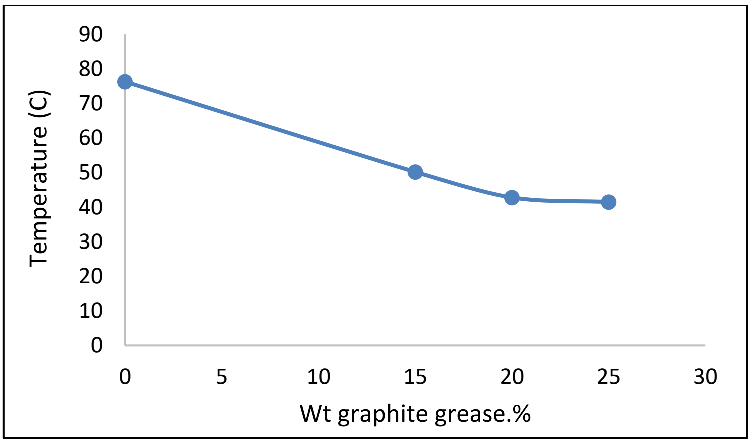


**Fig. 15. Exit shaft temperatures vs %wt. of graphite grease**

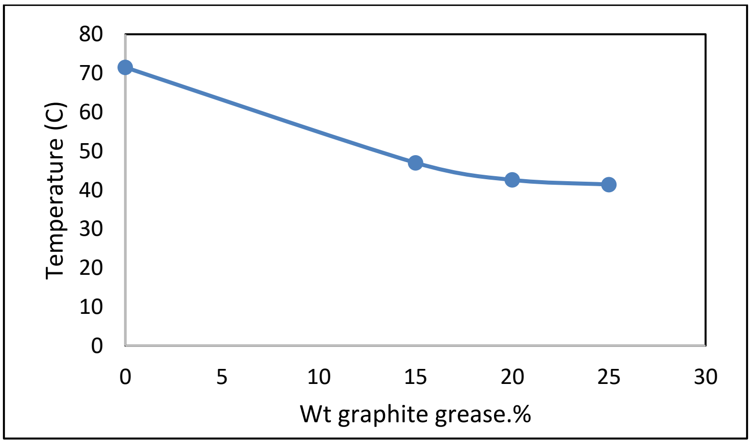


**Fig. 16. Oil Temperatures vs %wt. of graphite grease**

Figs.17 to 20 show the SEM images of pure oil, oil / 15% graphite grease, oil / 20% graphite grease and oil / 25% graphite grease. Good mixing of graphite grease with oil lead to homogenize distribution of the mixture, as shown in the pictures, which works to conduct heat well between the oil molecules.

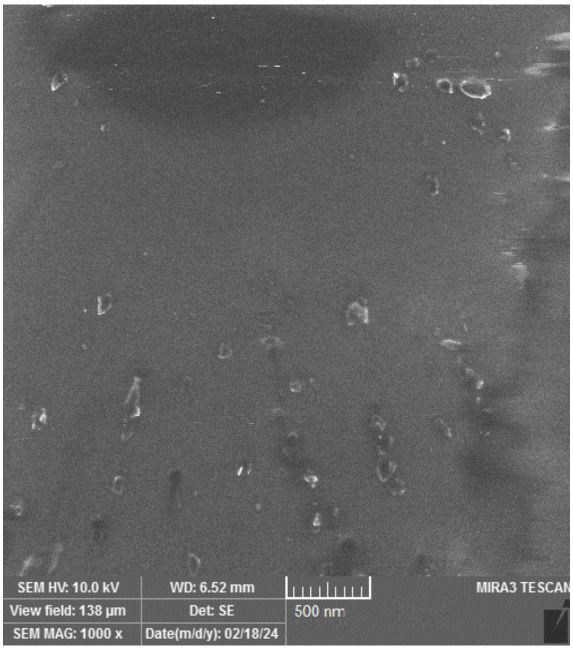


Fig. 17. SEM image for pure oil

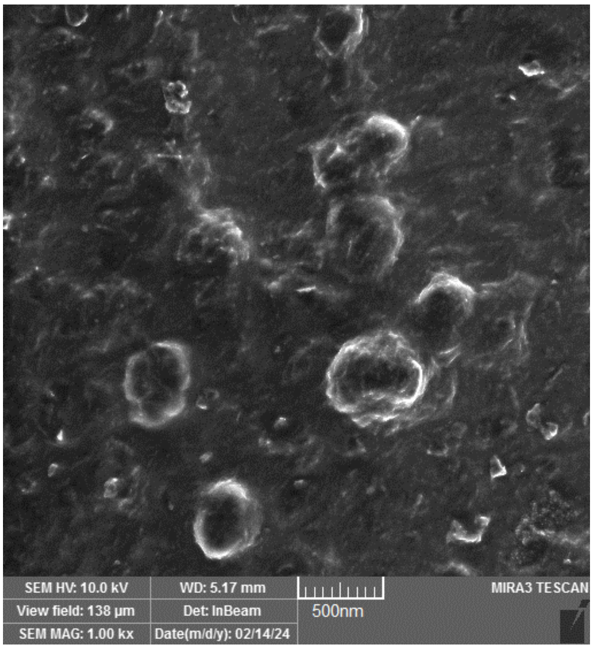


Fig. 18. SEM image for oil / 15%wt. of graphite grease

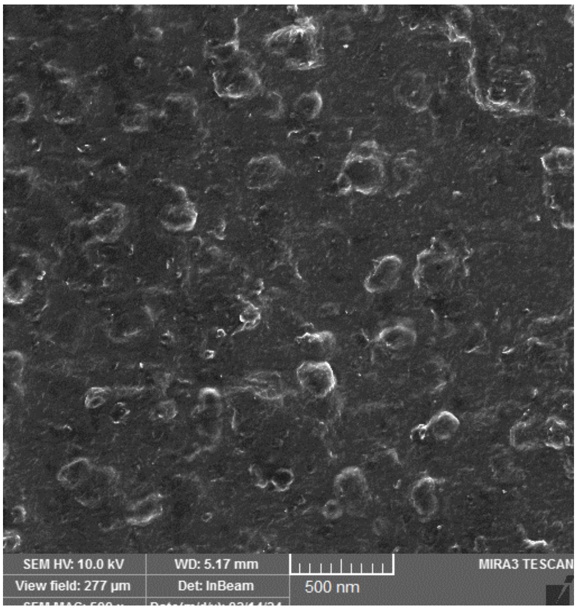


Fig. 19. SEM image for oil / 20%wt. of graphite grease

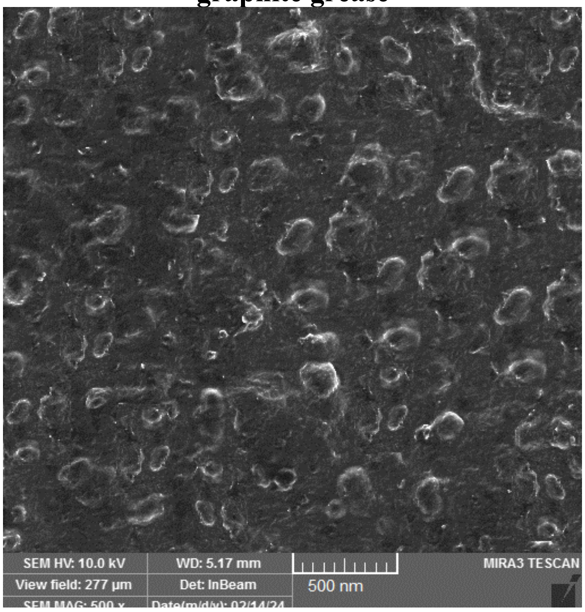


Fig. 20. SEM image for oil / 25% of graphite grease

## 4. CONCLUSIONS

From the results, it can be concluded that the thermal conductivity, viscosity, and density of the oil increase with increasing graphite grease concentrations. In the cement plant, it was found that there is no effect of adding the graphite grease on the temperatures of both the roller and tire in the journal bearing. Also, the shaft temperatures at the oil inlet, oil outlet, and mixture of graphite /oil temperature is clearly affected by the addition of graphite grease to the oil, as it is the closest area in contact with heat on the body of the rotary kiln. The SEM images show a homogeneous distribution of graphite grease for all mixture ratios.

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