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Effect of Oil Viscosity over temperature on Gearbox Efficiency

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ABSTRACT: This research paper investigates the effect of oil viscosity on gearbox performance, paying particular attention to how temperature variations affects this relationship. The study was conducted by experimenting the gear box under different temperature and recording the current over time due to gradual fall in viscosity. The result indicate that viscosity has a significant effect on current consumed, thus improving the efficiency in terms of operating cost. The findings of this study shed important light on the connection between the viscosity of oil and gearbox efficiency and can inform the development of more effective lubrication strategies for gearbox.

KEY WORDS: Oil Viscosity, Current, Lubrication, Gearbox, Power Consumptions, VG320 Lubricant.

I. INTRODUCTION

Gearbox revolutionized mechanical systems, including automobiles, aircraft, and heavy machinery. It has a wide range of application from a basic power drill to advance robotic industries. These intricate machineries need the right lubricants to operate at their best. They are made to transfer power from a source to a load at a specified speed and torque ratio. Gearbox are protected from wear, friction, and heat generation by lubricants, which is essential. As a result, choosing the right lubricating oils and determining their proper viscosity levels are crucial for the effective operation of gearbox.

The ability of an oil to lubricate and protect the gearbox is significantly influenced by its viscosity, which is defined as its resistance to flow. Temperature, pressure, and shear rate are only a few of the variables that have an impact on an oil's viscosity. The most important element impacting oil viscosity may be temperature, as oil viscosity decreases as temperature rises. In order to maximize the performance of gearboxes, it is crucial to comprehend the impact of oil viscosity over temperature difference.

II. LITERATURE REVIEW

2.1 Nacer Tala-ighill, Ahcene Mokhtari1, Amine Brick Chaouche1, Kheireddine Bettahar, Michel Fillon

This Journal compares the viscosity effect of two different oils used as lubricant in a hydrodynamic journal bearing. The hydrodynamic journal bearing performance improvement passes by a friction torque improvement and minimum film thickness through an appropriate surface texturing. The used numerical approach in this analysis is finite difference method. It is found that in the hydrodynamic lubrication system, the improvement of the performances of the textured journal bearing depend strongly on the lubricant viscosity and journal bearing velocity.

2.2 I. C. V. M. Santos, P. F. Oliveira, C. R. E. Mansur

In oil extraction, the high viscosity of crude oil made some problems, it affecting the oil production rate. Crude oil property is different oil grades and their production techniques. The main causes of high viscosity are the presence of solids and high concentrations of heavy fractions and the formation of water-in-oil (W/O) emulsions. The mechanisms that seek to reduce the viscosity of oil containing high concentrations of heavy fractions, the mechanisms of formation and destabilization of emulsions, and the use of polymers in technologies to reduce viscosity, mainly by applying emulsion viscosity reducers (EVRs).

III. METHODS OF LUBRICATION

The purpose of lubricating gears is as follows:

1. Lubrication increase sliding between the teeth to reduce the coefficient of friction μ .
2. Temperature rise cause of rolling and sliding friction is reduced.

So the correct lubricant must be chosen to avoid difficulties such as tooth wear and premature failure.

Three major gear lubrication methods in general:

- (1) Grease lubrication.
- (2) Splash lubrication (oil bath method).
- (3) Forced oil circulation lubrication.

Lubricant choice depends upon the rotating speed(rpm) and tangential speed(m/s). Grease lubrication is a good choice for low speed gears. For high speed and medium speed gears Forced oil circulation and Splash lubrication is mostly used but there are exceptions. Sometimes, Grease lubricant also used for maintenance.

3.1 GREASE LUBRICATION:

Grease lubrication is mostly used for any gear system that is enclosed or open, this method is only for low speed gears.

Three major points regarding grease:

- Choosing a lubricant with suitable cone penetration.
A good fluidity lubricant property is especially good in an enclosed system.
- High load and continues operation is not suitable for this method.
The grease is not as good as lubricating oil for cooling method. So it become a problem with temperature increased in continues and high load operating conditions
- Proper quantity of grease
There must be sufficient grease to do the job. Lot of grease can be harmful to enclosed system. Excess grease will cause trouble and result in power loss.

3.2 SPLASH LUBRICATION:

Splash lubrication is used with an enclosed system. This method oil stored in reservoir when the gear is rotating oil is splash into gear system and bearings. Tangential speed at least 3m/s is effective in this method. However, splash lubrication has some disadvantages like oil level and temperature limitation.

1.Oillevel

If the oil level is too high there will be excess of agitation loss. if oil level is too low there is no effective cooling. Also, the oil level during operation must be monitored, as contrasted with the static level, in that the oil level will drop when the gears are in motion. This problem may be countered by raising the static level of lubricant in an oil level.

2.Temperature limitation

Friction loss due to gears, bearings and lubricant agitation is the reason for temperature rise. Rising temperature may cause some of the following problems

- Lower viscosity of lubricant
- Accelerated degradation of lubricant
- Deformation of housing, gears and shafts
- Decreased backlash

3.3 FORCED OIL CIRCULATION LUBRICATION:

Forced oil circulation lubrication oil pump applies lubricant to the contact portion of the teeth. There are three methods in this application drop, spray and oil.

- Drop Method
An oil pump is used to suck-up the lubricant and then directly drop it on the contact portion of the gears via a delivery pipe.



- Spray Method

An oil pump is used to spray the lubricant directly on the contact area of the gears.

- Oil Mist Method

Lubricant is mixed with compressed air to form an oil mist that is sprayed against the contact region of the gears. It is especially suitable for high-speed gearing.

In forced oil lubrication system pump, filter, oil tank, piping needed. Therefore, it is only used for special application like high speed and large gear box.

IV. VISCOSITY OF LUBRICANT

The correct viscosity is the most important consideration in choosing a proper lubricant. The viscosity grade of industrial lubricant is regulated in JIS K 2001.

Table1. ISO Viscosity Grade

ISO Viscosity grade	Kinematic viscosity center value 10 ⁻⁶ m ² /s (cSt) (40°C)	Kinematic viscosity range 10 ⁻⁶ m ² /s (cSt) (40°C)
ISO VG 2	2.2	More than 1.98 and less than 2.42
ISO VG 3	3.2	More than 2.88 and less than 3.52
ISO VG 5	4.6	More than 4.14 and less than 5.06
ISO VG 7	6.8	More than 6.12 and less than 7.48
ISO VG 10	10	More than 9.0 and less than 11.0
ISO VG 15	15	More than 13.5 and less than 16.5
ISO VG 22	22	More than 19.8 and less than 24.2
ISO VG 32	32	More than 28.8 and less than 35.2
ISO VG 46	46	More than 41.4 and less than 50.6
ISO VG 68	68	More than 61.2 and less than 74.8
ISO VG 100	100	More than 90.0 and less than 110
ISO VG 150	150	More than 135 and less than 165
ISO VG 220	220	More than 198 and less than 242
ISO VG 320	320	More than 288 and less than 352
ISO VG 460	460	More than 414 and less than 506
ISO VG 680	680	More than 612 and less than 748
ISO VG 1000	1000	More than 900 and less than 1100
ISO VG 1500	1500	More than 1350 and less than 1650
ISO VG 2200	2200	More than 1980 and less than 2420
ISO VG 3200	3200	More than 2880 and less than 3520

This image was taken from Khk Gears

4.1 SELECTION OF LUBRICANT:

Gear oils are categorized by usage: 2 types for industrial use, 3 types for automobile use, and also classified by viscosity grade.

Table2. Types of Gear Oils & the Usage

		Type	Usage
For Industrial Usage	1	ISO VG 32 ISO VG 46 ISO VG 68 ISO VG 100 ISO VG 150 ISO VG 220 ISO VG 320 ISO VG 460	Mostly used for lightly loaded enclosed-gears in general type of machines.
	2	ISO VG 68 ISO VG 100 ISO VG 150 ISO VG 220 ISO VG 320 ISO VG 460 ISO VG 680	Mostly used for middle or heavily loaded enclosed-gears in general types of machines or rolling machines.

This image was taken from Khk Gears

4.2 VG320 LUBRICANT:

Industrial lubricants like VG320 lubricating oil is frequently used in a various machinery and equipment. It is a high-performance oil with density of 320m²/s that is especially well suited for use in Industrial gearboxes and other heavy-duty applications and is created to offer good protection against wear, friction, and heat. The high viscosity of VG320 lube oil, which enables it to offer good protection against wear and tear even in challenging circumstances, is one of its main advantages.

It is also very oxidation resistant, which contributes to the oil's longer lifespan ad less frequent replacement requirements. Overall, it has been shown that using VG320 lubricating oil to increase a variety of machinery and equipment's performance and dependability is an efficient method. In demanding industrial applications where durability and performance are crucial, its high viscosity, superior wear protection, and resistance to oxidation make it the best option.

V. METHODOLOGY

The study was performed equipping a 150kW gearbox, lubricated using 120 liters of VG320 lube oil. The viscosity of the lubricant will be measured using a viscometer at various temperatures. RTD sensors and CT coils were used to detect Temperature and Current respectively. The data was collected by a PLC, and SCADA software was equipped to plot graphs for analysis. For each combination of viscosity and temperature, the gearbox will run at steady-state conditions during the tests. The data gathered from the experiments will be analyzed using statistical tools to determine the connection between oil viscosity, temperature, and gearbox efficiency.

The test was conducted in two conditions. First, the oil was feed into gear box in ambient oil temperature. The second, the oil was preheated for 50°C using heater coil before feeding into the gear box. To find the trend and patterns, the data was platted as graphs of viscosity vs current, current vs time, temperature vs time, current vs temperature.

VI. INTERPRETATION OF RESULT

6.1 AMBIENT TEMPERATURE OIL:

Given that the current consumption of the motor is steadiest between 55°C and 60°C of gear box oil temperature, around 35A. The study's findings imply that this temperature range is also the best for gearbox efficiency. The current consumption decreases as the temperature rises at temperatures below this range, showing a progressive improvement in efficiency. The current consumption is steady at temperatures above this range, thus the power consumption is also stable.

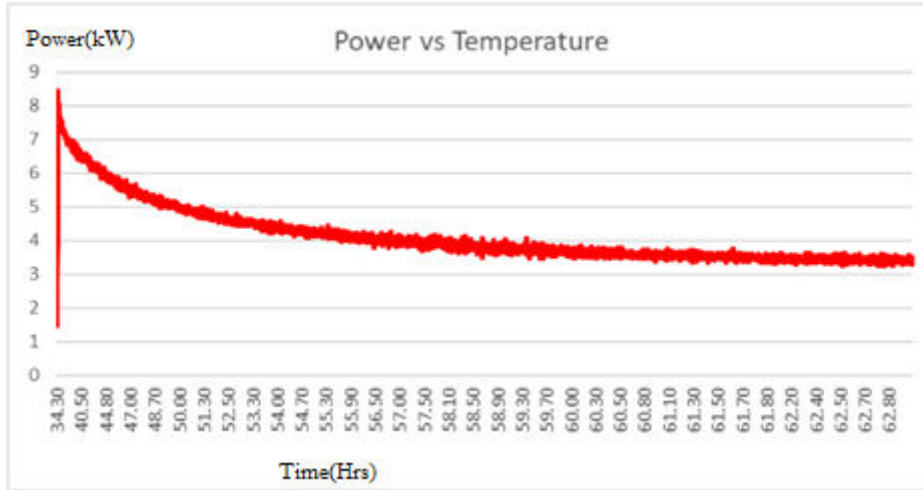


Fig1. Power Vs. Temperature of Ambient Temperature Oil

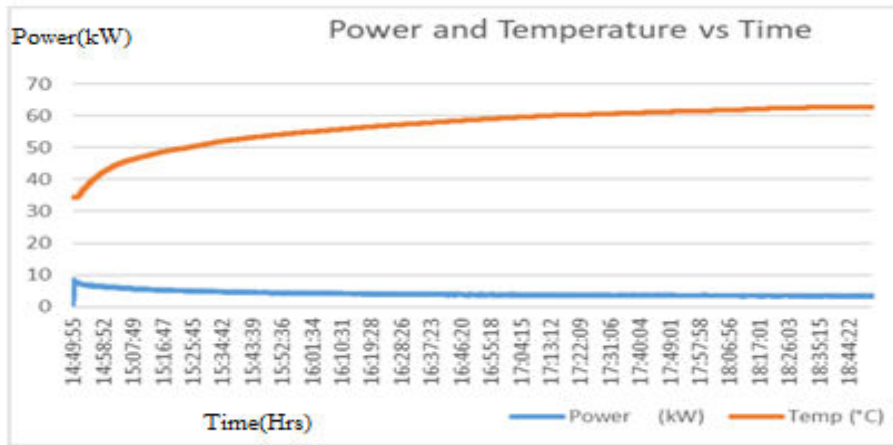


Fig2. Power & Temperature Vs. Time of Ambient Temperature Oil

6.2 PREHEATED OIL:

The oil was preheated to 50°C, where the current consumption is steadiest. The temperature of the oil decreases initially and rises along the working of gearbox. This leads the gear box to attain the stabile power in less time, than using the ambient temperature oil. There is a saving of 0.13KW and 0.53kWh of power and energy respectively for 4 hours of working. The energy consumed to preheat the oil to 50°C is 2.2kWh for 15mins of oil preheating.

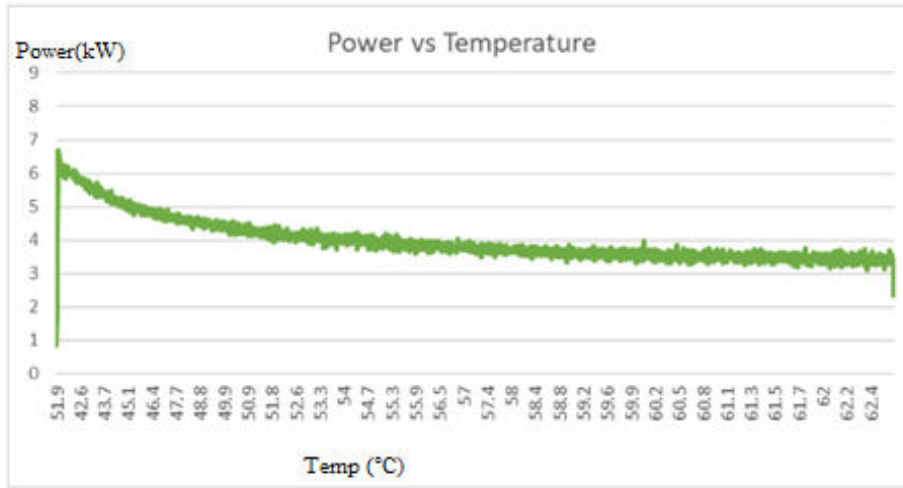


Fig3. Power Vs. Temperature of Preheated Oil

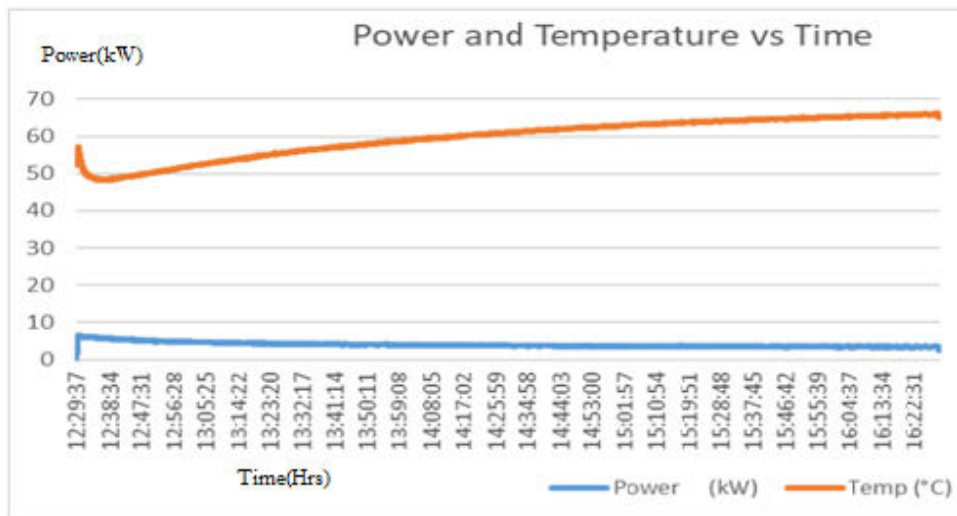


Fig4. Power & Temperature Vs. Time of Preheated Oil

VII. DISCUSSIONS

In this study a comparison of using ambient temperature oil and preheated 50°C was made. The efficiency of the gearbox is also significantly influenced by the oil's viscosity. Lower viscosity oils tend to have low efficiency at hot temperatures whereas higher viscosity oils typically perform worse at low temperatures.

It is crucial to choose an oil whose viscosity is suitable for the gearbox's anticipated working temperature range. The results from this experiment shows using preheated oil does not affect the power or energy consumed by the gearbox to work.



Table 3. Preheated Oil Vs. Ambient Oil

Mode	Pre Heating Condition	Ambient Condition	Heater Power Consumption
Time	04:00:06	04:01:39	0:25:00
Power kW	3.99	4.12	8.8
Energy(kWh)	15.94	16.47	2.2
Difference	0.53		2.2
Per Unit cost	6.00		
Total cost	95.64	98.82	13.2
Total Economy		3.17	13.2

From this Table3.Comparing Pre heating condition and ambient condition, Pre heating condition is very economy.

VIII. CONCLUSION

In conclusion, our study has shown that the viscosity and temperature of the oil are significant determinants affecting gearbox efficiency. According to research, the ideal operating temperature range for gearbox efficiency is between 50°C and 60°C, and the recommended oil viscosity should be chosen depending on the gearbox's anticipated working temperature range.

These discoveries could have a significant impact on how gearboxes are built and maintained, which could increase their effectiveness and durability. And changing the temperature of the lubricant at early stage does not affect the power consumed by the gearbox to work. Lastly, we explored the significance of our findings for the design of better gearbox lubrication systems and point our areas that require more study. With the help of this research, we seek to shed light on the connection among oil viscosity, temperature, current, efficiency of gearbox over the operating time.

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