



A Comparative and Analytical Study of the Energy Economy and Environmental Impacts of Engine Oils in Nigeria: An Examination of Thermophysical Properties

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Abstract

This study investigates the energy economy and environmental impacts of commonly-used engine oils in Nigeria by analyzing their thermophysical properties. Limited public literature on these oils has left several energy and environmental issues inadequately addressed by governmental regulators. Ten popular engine oils were selected: Master Super (SAE 40), Abro (SAE 20W-50), Sea Horse (SAE 20W-50), Oando Oleum Super (SAE 40), Climax Auto Lube (SAE 40), Conoil Golden Super (SAE 40), Total Classic (SAE 40), Tonimas ENEZ Heavy Duty (SAE 40), Mobil Super (20W-50 XUP), and Ammasco Vital 2000 SL (SAE 20W-50), coded as S1 through S10, respectively. Thermophysical testing revealed that dynamic viscosity decreased across all samples as temperatures rose from 40°C to 100°C, with S10 showing the highest viscosities (427 cP and 106 cP) and S1 the lowest (255 cP and 66 cP). The oils also showed variations in density (882.7–895.0 kg/m³), thermal conductivity (0.1430–0.1463 W/mK), specific heat capacity (1832–1921 J/kgK), and thermal diffusivity ($8.433\text{--}8.923 \times 10^{-9}$ m²/s), indicating discernible property relationships. Flash points ranged from 230°C to 262°C. Samples S2, S3, S4, S8, S9, and S10 demonstrated high wear protection under stressful conditions but tended to degrade more rapidly at elevated temperatures. In contrast, S1, S5, S6, and S7 exhibited balanced properties, optimizing engine performance, reducing fuel and energy consumption, and potentially minimizing toxic emissions. The findings underscore the need for further regulatory focus on engine oil standards to support energy efficiency and environmental protection.

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1.0 Introduction

Throughout human history, the development and use of engine oils have played a pivotal role in advancing technology and industry, contributing significantly to modern civilization. In today's transportation sector, engines are the core of vehicles, driving them forward with power and efficiency. The performance of these engines relies heavily on engine oils, which serve as lubricants to reduce friction, dissipate heat, and protect internal components from wear. These oils enhance overall engine productivity, performance, and longevity, supporting applications across automotive, farming, industrial, aviation, and marine sectors (Nagy et al., 2019). By lubricating moving parts, controlling contamination, reducing noise, and preventing corrosion, engine oils contribute to optimal engine operation and environmental sustainability (Klowak & Gracyalny, 2014; Puckace et al., 2015; Rawashdeh et al., 2020; Hasan-Zadeh & Poshtiban, 2021; Owunna & Ikpe, 2023).

The environmental implications of engine oils are gaining increasing attention, especially in light of modern standards for energy conservation, efficiency, and compliance with Environmental Protection Agency (EPA) guidelines. Variations in engine oil performance depend on factors such as properties, quality, composition, purity, and operating conditions, which have been extensively studied (Shahnazar et al., 2016; Wu et al., 2021; Adebogun et al., 2020; Pabsetti et al., 2023). With a projected rise in the demand for synthetic lubricants and functional fluids—estimated at 3% growth annually and projected to reach \$37.3 billion by 2030—the importance of efficient, high-performance oils becomes even clearer.

Nevertheless, the potential environmental impacts and energy-related drawbacks of engine oils, particularly in regions like Nigeria, remain insufficiently explored. Critical questions persist regarding the oils' long-term effects on soil, air,

and water, raising concerns from environmental regulators. This research aims to address this gap by evaluating the energy economy and environmental impact of several commonly-used engine oils in Nigeria, focusing on their thermophysical properties. Unlike prior studies that explored the effects of lubricants on soil properties (Nwite & Alu, 2015), urban health (Shehu et al., 2023), and certain rheological properties (Desai et al., 2021), this study pioneers an in-depth analysis of dynamic viscosity, density, thermal conductivity, specific heat capacity, thermal diffusivity, and flash point.

Understanding these thermophysical characteristics is essential for assessing the oils' efficiency in enhancing engine performance, reducing greenhouse gas emissions, and ensuring environmental safety. By filling this critical research gap, this study aims to provide insight into the suitability of various engine oils for sustainable energy practices in Nigeria, offering valuable information for both industry professionals and environmental policymakers.

2.0 Materials and Methods

2.1 Materials

The primary materials used in this research consisted of various engine oil samples, each acquired in sealed containers directly from Oil Link Lubrication Limited in Uyo, Akwa Ibom State, Nigeria. These oils were chosen to represent commonly used types in Nigeria. An overview of the different engine oils examined in this study is provided in Fig. 1. For consistency and ease of reference, each oil sample was assigned a unique code, as detailed in Table 1.

In addition to the oil samples, specialized equipment was utilized to measure their thermophysical properties. This equipment included the KD2 Pro Thermal Analyzer, which was equipped with sensors and probes for thermal property measurements, density bottles

for consistent density assessments, and a viscometer for determining the dynamic viscosity of each sample. A digital weighing balance provided precise mass measurements, while a thermostatic bath ensured stable temperature control during testing. Furthermore, an automatic Open Cup Flash Point Tester was employed to determine each oil's flash point, a critical parameter for evaluating safety and

performance. This comprehensive setup enabled a systematic analysis of the oils' dynamic viscosity, density, thermal conductivity, specific heat capacity, thermal diffusivity, and flash point, yielding valuable insights into their thermophysical properties and potential environmental impacts. The different lubricants used are shown in Fig.1:



Fig. 1: Photos of the Engine oil samples used

Table 1: Engine oils and their code

Name of the engine oil sample	Sample Code
Master Super	S1
Abro	S2
Sea Horse	S3
Oando Oleum Super	S4
Climax Auto Lube	S5
Conoil Golden Super	S6
Total Classic	S7
Tonimas ENEZ Heavy Duty	S8
Mobil Super 1000	S9
Ammasco Vital 2000 SL	S10

2.2 Determination of Oils' Thermophysical Properties

2.2.1 Dynamic (Absolute) Viscosity

The dynamic viscosity of each oil sample was determined using a viscometer (Model PCE-RVI 8), which has an accuracy of $\pm 1\%$. Prior to measurements, the viscometer's operating handle was moved to its uppermost position, and the thumb screw on the viscometer shaft was loosened to insert the paddle spindle fully. The spindle's groove was aligned with the thumb screw hole, and the screw was then tightened. Each oil sample was placed in a 600 cm³ measuring cup and positioned under the viscometer. Measurements were taken in three trials, using a rotation speed of 200 rpm for each test. Viscosity readings were recorded at both 40°C and 100°C, after which the data were averaged and documented.

2.2.2 Density

Thirty identical 100.0 cm³ density bottles were thoroughly cleaned and dried under laboratory conditions. The mass of each bottle was measured with a digital scale and recorded. Three bottles were filled with a particular oil sample, ensuring no air bubbles were present, and each bottle was filled to approximately one-third of its neck. The filled bottles were placed in a thermostatic bath to reach a temperature of 20°C. Each density bottle's stopper and thermometer were carefully aligned and secured, and a capillary tube was used to top off the bottle. The stopper and outer surfaces of the bottles were then dried with a soft tissue. The mass of each filled bottle was measured, and from these data, the density of the oil was calculated.

$$\rho = \left(\frac{M-W}{V} \right) \quad (1)$$

where ρ = density of the oil, M = mass of the density bottle with its content, W = mass of the empty density bottle, and V = volume of the density bottle.

2.2.3 Thermal conductivity, Specific heat capacity, and Thermal diffusivity

The thermal conductivity, specific heat capacity, and thermal diffusivity of each oil sample were measured directly using the KD2 Pro thermal analyzer, based on the standard needle probe technique as documented in ASTM D5334 (2022). This thermal analyzer is designed for use with distinct sensor probes for specific applications. For this study, the KS-1 sensor probe was employed for measuring thermal conductivity, while the SH-1 sensor probe was utilized to determine volumetric heat capacity (from which specific heat capacity was derived) and thermal diffusivity of the samples. Each oil sample was placed in a separate, small, identical test container and conditioned in a thermostatic bath, which was pre-adjusted to a temperature of 20°C. This conditioning process lasted for 24 hours, ensuring the samples remained absolutely still relative to the sensor. After this period, the samples were removed from the bath for testing. The thermal analyzer was calibrated, equipped with the appropriate probe, and powered on, ensuring that the entire needle of the probe remained fully inserted in each oil sample during testing. This equilibration process lasted approximately 30 seconds. During each measurement cycle, the temperature was recorded as displayed on the analyzer's screen. Temperature stability in the oil samples was carefully maintained throughout the test session, and the entire probe was thoroughly cleaned before each new sample. The mean values of each oil sample's volumetric heat capacity and density were then applied to calculate its specific heat capacity given in equation 2:

$$C = \frac{C_v}{\rho} \quad (2)$$

where C_v = volumetric heat capacity, and C = specific heat capacity. The instrument measured thermal conductivity with uncertainty of $\pm 5\%$ whereas the specific heat capacity and thermal diffusivity were measured with uncertainty of \pm

10 % each as specified for the sensors employed for such measurements.

2.2.4 Flash point

The flash point of each oil sample was measured in accordance with the standard testing method stipulated in ASTM D92 (2018). An automatic open cup flash point tester (Model PT-BWKS-109) was used for the measurement. For each sample, the oil was placed in the test cup one at a time and heated automatically to reach the flash point. This point was determined when an ignition source caused the vapour of the oil to ignite, producing a flame that instantaneously propagated over the entire surface and then extinguished momentarily upon reaching the critical temperature. The readings displayed on the digital unit of the tester were recorded. Each property was tested in triplicates per sample, and the mean of the readings was calculated and tabulated for each sample.

3.0 Results and Discussion

3.1 Thermophysical properties of the oil samples

The results (in Table 2) of the thermophysical properties evaluation conducted on the oil samples are summarized in Table 2. At 40°C, the dynamic viscosities of samples S2 and S9 are similar, both measuring 364.0 cP, while S1 and S6 exhibit comparable viscosities of 266 cP. The dynamic viscosity of sample S4 is very close to that of S8. Other oil samples show varying viscosities, either higher or lower. Comparing the results to previous studies, Obi et al. (2013) reported a viscosity of 265.69 mPa.s (265.69 cP) for A-Z (SAE 20W50) at 40°C and 363 cP for Oando Oleum at 28°C. The viscosity at 40°C obtained for sample S1 is similar to that of A-Z oil, while the viscosities of S2 and S9 can be considered comparable to Oando Oleum in terms of their resistance to flow at the reported temperatures. An important observation from the results is that the viscosity values at 40°C are significantly higher than those obtained at 100°C

for all the samples, with differences ranging from 74.81% for S6 to 77.45% for S5. This decrease in viscosity with increasing temperature is consistent with the findings of Ratiu et al. (2020), who observed a similar trend in their study of synthetic used oils (SAE 5W-30). Such a viscosity reduction at higher temperatures is crucial for engine performance, as it reduces friction and enhances fuel and energy efficiency, thus impacting both energy economy and the environmental footprint of engine operations. In terms of energy economy, oils with lower viscosities at higher temperatures may improve fuel efficiency by reducing the resistance to flow, leading to less energy required for engine operation. However, the viscosity must remain within an optimal range to ensure proper lubrication and prevent wear, highlighting the balance needed between energy efficiency and engine protection.

From an environmental perspective, oils with excessively high viscosities at lower temperatures may lead to increased fuel consumption, as the engine must work harder to overcome the internal friction. Additionally, the environmental impact of engine oil in terms of its degradation and disposal is another key consideration. Oils that maintain stable thermophysical properties across a wide temperature range are likely to have longer service lives, reducing the frequency of oil changes and minimizing the environmental burden associated with waste oil disposal.

From Fig.2, it is observed that the viscosity curves for the engine oils trend similarly in a polynomial manner, but the lower curve exhibits more pronounced spikes compared to the upper curve. This suggests that as the temperature of the oils increases, their cohesive forces gradually decrease, leading to a reduction in resistance to flow. In other words, an increase in temperature appears to cause the molecular bonds within the oil to loosen, resulting in a thinner, less viscous fluid. At 40°C, each of the

oils exhibits higher viscosity compared to when heated to 100°C, indicating that the oils are thicker at lower temperatures. For certain samples, such as S2, S3, S4, S8, S9, and S10, a significant difference in viscosity is observed between 40°C and 100°C. These oils show a marked decrease in viscosity with increasing temperature, which may have implications for their performance under varying operational conditions. The large differences in viscosity between the two temperatures for some oil

samples may lead to increased thermal degradation, especially with sustained high temperatures. The rapid decline in viscosity under higher temperatures can cause the oils to lose their effectiveness in lubricating engine parts, potentially increasing friction, wear, and energy consumption. This thermal breakdown can also lead to the production of harmful byproducts, contributing to environmental pollution and negatively impacting engine efficiency and the overall energy economy.

Table 2: Thermophysical properties of the tested oil samples

Oil sample code	Mean values of each investigated property						
	Viscosity (cP)		Density (kgm ⁻³)	Thermal conductivity (Wm ⁻¹ K ⁻¹)	Specific heat capacity (10 ³ Jkg ⁻¹ K ⁻¹)	Thermal diffusivity (10 ⁻⁸ m ² s ⁻¹)	Flash point (°C)
	40 °C	100 °C					
S1	266.0	66.0	882.7	0.1430	1.921	8.433	230.0
S2	364.0	91.0	891.0	0.1447	1.866	8.661	230.0
S3	341.0	84.0	889.3	0.1443	1.879	8.618	250.0
S4	332.0	82.0	888.3	0.1440	1.886	8.595	230.0
S5	285.0	72.0	886.0	0.1437	1.900	8.495	238.0
S6	266.0	67.0	882.7	0.1430	1.921	8.433	232.0
S7	276.0	68.0	885.0	0.1433	1.907	8.473	229.0
S8	330.0	83.0	888.0	0.1440	1.887	8.594	262.0
S9	364.0	91.0	891.3	0.1450	1.865	8.726	239.0
S10	427.0	106.0	895.0	0.1463	1.832	8.923	236.0

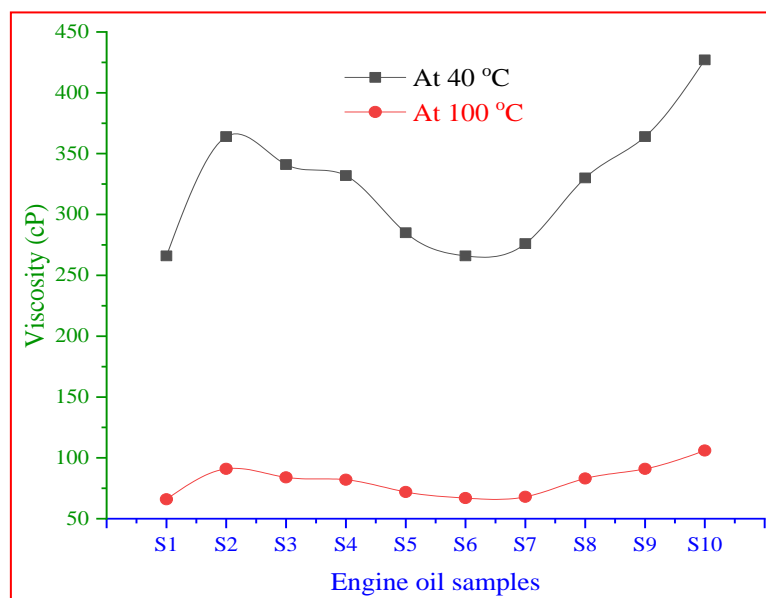


Fig. 2: Plots of the Viscosity of the samples

Density is a critical thermophysical property of engine oils, providing insight into their mass-to-volume relationship. This property influences several characteristics of engine oils, including their viscosity and ability to carry contaminants. From the results presented in Table 2, it is evident that as the density of engine oils increases, the oils become thicker, thereby increasing the time required for particles to settle out of suspension. The density values of the engine oil samples in this study were determined at 20°C and range from 882.7 kg/m³ (for S1 and S6) to 895.0 kg/m³ (for S10). Notably, samples S1 and S6 have nearly identical density values. Similarly, samples S2 and S9, S4 and S8, and S5 and S7 also exhibit comparable densities, which could indicate that these pairs have similar heaviness at low temperatures. However, it is important to note that density varies with temperature, so the relative heaviness of the oils may differ at higher temperatures.

The density values obtained for the oil samples in this study align reasonably well with values reported by other researchers, particularly when rounded to the nearest hundred. For instance, Iboh et al. (2023) reported density values for 20W-50 engine oils such as Mobil Super, Sea Horse, and Oando in Nigeria, which were 856.0 kg/m³, 872.0 kg/m³, and 879.0 kg/m³, respectively, at 20°C. These values corroborate the findings in this study, where the density values of the engine oils generally fall within the range of 850.0 kg/m³ to 900.0 kg/m³ for petroleum lubricating fluids (Obi et al., 2013). Moreover, as observed by Iboh et al. (2023), the density of engine oils decreases as their temperature increases, a trend that was also noted in this study.

Thermal conductivity, another key thermophysical property, defines an oil's ability to transfer heat and is crucial in applications where heat dissipation is essential. Engine oils play a significant role in cooling engine parts, such as piston assemblies, cylinder heads, and valves, by

absorbing heat from contact surfaces and transporting it to areas where it can be safely dissipated. In this study, S4 and S8 exhibited identical thermal conductivity values, which were slightly lower than the thermal conductivity of S3. The highest thermal conductivity was observed for S10, while S1 and S6 recorded the lowest values, indicating that these oils are the most effective at insulating against heat transfer. S1 and S6 were found to be 2.05% more thermally-insulating than S10.

The graphs in Fig.3 further illustrate the strong correlation between density and thermal conductivity across the oil samples. For instance, S10, the densest oil, also had the highest thermal conductivity, while S1 and S6, with the lowest density, displayed the lowest thermal conductivity values. The thermal conductivity of each oil sample followed a similar trend to its respective density. These observations suggest that denser oils are better at restricting heat transmission. This is particularly important because thermal conductivity directly impacts the temperature distribution within engine systems, influencing their heat dissipation capabilities. Oils with high thermal conductivity are more efficient at transferring heat, helping to maintain optimal operating temperatures and prevent engine overheating.

Moreover, the density of engine oils serves as a reliable indicator of their thermal conductivity, which in turn affects the efficiency and performance of engines. Understanding the thermophysical properties of engine oils—specifically density and thermal conductivity—can offer insights into their potential for energy savings and environmental impact, as oils with better heat dissipation capabilities may contribute to reduced engine wear and lower fuel or energy consumption. Therefore, predicting engine oil performance based on density could be a valuable tool in selecting oils that enhance engine efficiency and minimize negative environmental impacts.

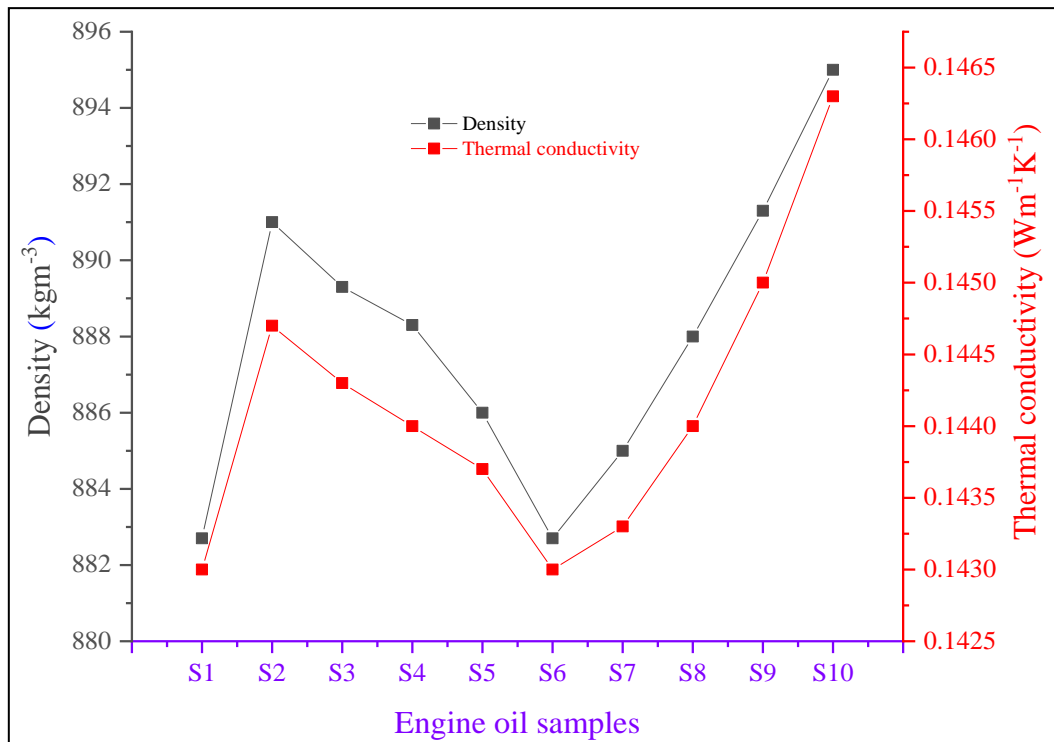


Fig. 3: Variation of Density and Thermal conductivity of the samples

The specific heat capacity of engine oils is a critical thermophysical property that determines the amount of energy required to raise the temperature of a unit mass of the material. Oils with a larger specific heat capacity will require a smaller temperature increase to absorb more heat, which can have significant implications for their energy economy and cooling performance. The specific heat capacities of the oil samples investigated in this study revealed that S1 and S6 shared the same value, while S2 and S9 differed by only 1 Jkg⁻¹K⁻¹ (Fig.4). Among all the samples, S1 and S6 exhibited the highest specific heat capacity, while S10 demonstrated the lowest. These findings align with similar studies, such as Kanu *et al.* (2018), who reported specific heat capacities of 2096.6, 1156.8, and 2125.0 Jkg⁻¹K⁻¹ for different SAE 20W-50 engine oils (Amasco, Oando, and Total, respectively). The variation in specific heat capacities observed in this study compared to those of similar oils can be attributed to differences in the grade and quality of the engine oils, as well as variations in experimental methodologies used. For instance, in this

research, engine oils such as Amasco Vital 20W-50, Oando Oleum Super (SAE 40), and Total Classic 5 SP-CF (SAE 40) were analyzed using the KD 2 Pro analyzer, which could yield slightly different results from those obtained by calorimetric methods employed by other studies.

Furthermore, a comparison with density-specific heat capacity data for lubricants (Engineering Toolbox, 2023) shows a similar trend. Specifically, oils with a density of 884 kgm⁻³ exhibited a specific heat capacity of 1910 Jkg⁻¹K⁻¹, and oils with a density of 896 kgm⁻³ had a specific heat capacity of 1830 Jkg⁻¹K⁻¹ (Fig.4). These values closely correspond to those observed in S7 and S10, which had densities of 885.0 kgm⁻³ and 895.0 kgm⁻³, respectively, with corresponding specific heat capacities of 1907 Jkg⁻¹K⁻¹ and 1832 Jkg⁻¹K⁻¹. The implication of these values is that oils with lower specific heat capacities, such as S2, S3, S4, S8, S9, and S10, would cool faster than oils like S1, S5, S6, and S7, assuming equal conditions of use.

As noted by George *et al.* (2010a), engine oils serve not only as lubricants but also as coolants.

Based on the specific heat capacities obtained, S1 and S6 would retain more internal energy, making them potentially more effective at maintaining engine temperature stability over time. This characteristic could be advantageous for engines requiring sustained high temperatures, whereas oils like S2, S3, S4, S8, S9, and S10 would lose heat more quickly, potentially lowering their cooling efficiency under prolonged high-load conditions.

Thermal diffusivity, which quantifies the rate at which heat spreads within a material, is influenced by thermal conductivity, density, and specific heat capacity. In this study, the thermal diffusivities of the engine oil samples ranged from $8.433 \times 10^{-8} \text{ m}^2\text{s}^{-1}$ to $8.923 \times 10^{-8} \text{ m}^2\text{s}^{-1}$ (Fig. 4). A strong positive correlation was observed between thermal diffusivity and thermal conductivity (George *et al.*, 2010b), while the relationship between thermal diffusivity and specific heat capacity was negative. This is consistent with the principle that high thermal conductivity enhances heat transfer, which in turn reduces the specific heat capacity, thereby increasing thermal diffusivity.

Interestingly, S1 and S6 exhibited the lowest thermal diffusivity despite their relatively low densities and thermal conductivities, which can be attributed to their larger specific heat capacities. On the other hand, S10, which had the highest density and thermal conductivity, demonstrated a higher thermal diffusivity than expected based on its specific heat capacity. This suggests that under comparable operating conditions, oils like S2, S9, and S10 would experience faster heat diffusion, while oils such as S1, S5, S6, and S7 would show slower temperature propagation. Oils like S3, S4, and S8 might show intermediate heat diffusion characteristics, depending on their unique combination of thermophysical properties.

Generally, the specific heat capacity and thermal diffusivity of engine oils play crucial roles in

their energy economy and cooling capabilities. The findings suggest that S1 and S6, with their higher specific heat capacities, may be more efficient in retaining heat, whereas oils like S2, S3, S4, S8, S9, and S10 would cool faster, which could affect their long-term performance in high-temperature engine conditions. The differences in these thermophysical properties in Fig. 4 should be considered when selecting engine oils for specific operational environments, as they impact not only the energy consumption and thermal management of engines but also the environmental footprint of the oils in terms of energy efficiency and cooling capacity.

The thermophysical properties of the studied engine oils, such as low density, thermal conductivity, and thermal diffusivity, in conjunction with high specific heat capacity, suggest that these oils can effectively mitigate thermal degradation and reduce the likelihood of machine failure. Oils with these properties are less prone to overheating, thus ensuring optimal performance under high-temperature operating conditions (Akpabio *et al.* 2010 a, b). The trends observed in the plots reveal that oil samples S4 and S8 exhibit nearly identical specific heat capacities, indicating that they could be used interchangeably in engine systems without significantly affecting performance. Similarly, the thermophysical behavior of samples S2 and S9 suggests that they could also serve as suitable alternatives for one another. If the priority is to prevent overheating, enhance engine efficiency, reduce fuel consumption, and prolong engine life, oils such as S1, S5, S6, and S7 stand out as preferable choices. These samples demonstrate favorable thermophysical characteristics, making them ideal for high-performance engine systems that require stable thermal management. Regarding the flash point, sample S8 exhibits the highest value, while sample S7 shows the lowest flash point (Fig. 4).

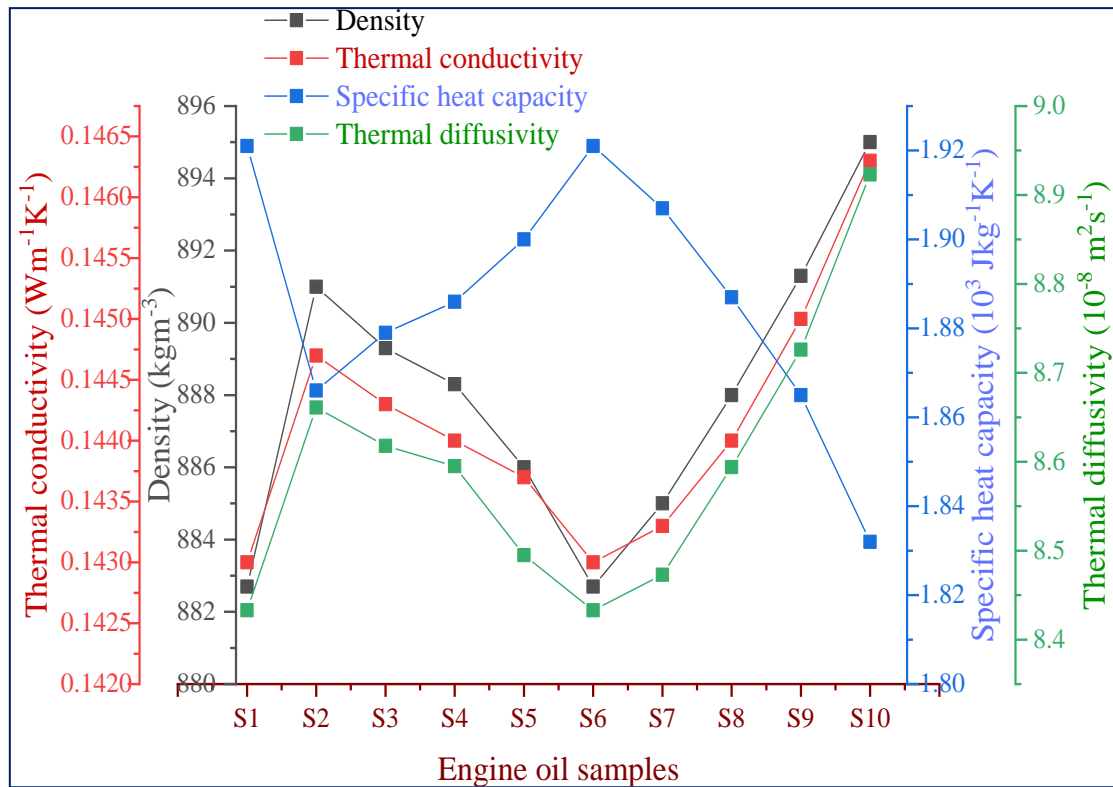


Fig. 4: Relationship among the heat transfer properties of the samples

Samples S1, S2, and S4 share the same flash point, indicating that they can potentially ignite instantaneously in air when exposed to an external heat source under standardized conditions. The flash points for samples S3 and S8, although higher, fall within the range of 220°C to 240°C, which aligns with the findings of Mansur et al. (2022) for synthetic oils of the 20w-50 viscosity grade. Specifically, S3 and S8 would require an increase in temperature of 4.17% and 9.17%, respectively, to reach the flash point where vapors capable of ignition in the presence of heat are released. Overall, the oils selected for this study exhibit high flash points, indicating that a substantial amount of time would elapse before ignition becomes a concern, further enhancing their suitability for safe and reliable engine performance.

3.2 Energy Economy and Environmental Impact of the Oils

The energy economy and environmental impact of engine oils are significantly influenced by their thermophysical properties, particularly viscosity, density, specific heat capacity, and

thermal diffusivity. Viscosity is a critical factor affecting fuel economy, as it governs the formation of lubricating films that reduce friction within engine components. Oils with lower viscosity, such as S1, S5, S6, and S7, spread more easily across engine surfaces, providing effective lubrication during startup and improving cold-weather performance. These oils reduce internal resistance, which results in less energy demand from the engine, thus decreasing fuel consumption and greenhouse gas emissions. On the other hand, high-viscosity oils like S2, S3, S4, S8, S9, and S10 offer better protection under high-stress conditions, but their increased resistance to flow, especially during cold starts, can hinder fuel economy. This leads to higher fuel consumption and increased emissions due to the greater effort required for the engine to overcome the resistance.

Density also plays an important role in energy economy, influencing the compatibility of oil with the engine's oil pump system. Oils with suitable density ensure efficient pump

performance and contribute to effective thermal management. While the dependency of density on temperature changes is relatively low compared to viscosity, it impacts thermal conductivity and overall heat transfer. Oils with higher thermal conductivity, such as S2, S3, S4, S8, S9, and S10, are effective at dissipating heat, which can reduce friction losses, enhance engine performance, and improve fuel economy by preventing overheating.

Specific heat capacity, which dictates the ability of oils or materials to absorb and release heat in a medium (Etuk et al., 016) or engine, influences the medium/engine's ability to manage temperature fluctuations. Oils with higher specific heat capacity, such as S1, S5, S6, and S7, can store and release more thermal energy, helping the engine reach optimal operating temperatures more quickly, particularly during cold starts. This ability reduces the need for excess fuel to maintain operational temperatures, leading to improved fuel economy. In contrast, oils with lower specific heat capacity may cause the engine to heat up and cool down more quickly, potentially resulting in higher fuel consumption and emissions due to increased engine stress.

Thermal diffusivity, which measures how quickly heat spreads through the oil, is inversely related to fuel economy. Oils with lower thermal diffusivity, such as S1, S5, S6, and S7, retain heat more effectively, reducing the need for additional fuel to maintain the engine's internal temperature. This not only enhances fuel efficiency but also contributes to reducing emissions. Additionally, oils with higher flash points help maintain stable internal energy retention, which further supports energy efficiency and minimizes the environmental impact.

More generally, oils with a balanced set of properties—such as S1, S5, S6, and S7—are optimal for improving fuel efficiency and minimizing environmental impact. Their

combination of low viscosity, efficient thermal conductivity, high specific heat capacity, and low thermal diffusivity contributes to reduced friction, effective heat management, and enhanced thermal stability. These oils help optimize fuel consumption and reduce emissions, making them more eco-friendly and cost-effective in engine performance.

4.0 Conclusion

In conclusion, this study examined the thermophysical properties of various engine oils and revealed several important findings relevant to energy economy and environmental impacts. The dynamic viscosity of the engine oil samples was observed to decrease with increasing temperature. Among the samples, Ammasco Vital 2000 SL (SAE 20W50) exhibited the highest viscosities at both 40°C (427 cP) and 100°C (106 cP), while Master Super oil (SAE 40) recorded the lowest viscosities at 40°C (266 cP) and 100°C (66 cP). Oils such as Master Super (SAE 40), Climax Auto Lube (SAE 40), Conoil Golden Super (SAE 40), and Total Classic 5 SP-CF (SAE 40) displayed a balanced set of thermophysical properties, suggesting their potential for enhanced performance under typical engine operating conditions.

The engine oils with low viscosity, thermal conductivity, and thermal diffusivity, yet high specific heat capacity—such as Master Super (SAE 40), Climax Auto Lube (SAE 40), Conoil Golden Super (SAE 40), and Total Classic 5 SP-CF (SAE 40) demonstrated better heat retention capacity. This trait suggests that these oils could result in less wear on engine components compared to oils like Abro (SAE 20W-50), Sea Horse (20W50), Oando Oleum Super (SAE 40), Tonimas ENEZ Heavy Duty (SAE 40), Mobil Super 1000 (20W-50 XUP), and Ammasco Vital 2000 SL (SAE 20W50) under similar operating conditions. Furthermore, oils like Master Super (SAE 40), Climax Auto Lube (SAE 40), Conoil Golden Super (SAE 40), and Total Classic 5 SP-CF (SAE 40) are likely to have better

environmental acceptability, as they could enhance fuel efficiency, improve engine performance, and reduce the emission of harmful gases into the environment, contributing to a more sustainable energy economy.

Conflict of Interests

The authors declare no known conflict of interest that could influence the consideration or publication of this paper.

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