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Original article

Impact of Vehicle Distance Traveled on Motor Oil Properties

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ABSTRACT

This comprehensive study delved into the impact of vehicle distance traveled and engine operating periods on motor oil properties, specifically focusing on viscosity and foaming characteristics. The findings unveiled a pivotal juncture in motor oil performance, with discernible viscosity degradation emerging after 10,000 kilometers, most notably within the 10,000-to-12,000-kilometer range. The study also shed light on foaming tendencies within the oil, indicating potential heightened friction and engine stress, particularly as mileage increased. The research underscores the critical need to incorporate these real- world driving factors into maintenance and oil change decisions, offering the prospect of fine-tuning engine performance and extending the longevity of engines. The practical implications of these insights are substantial, empowering vehicle operators to make more informed decisions regarding motor oil choices and suggesting the potential for formulating specialized motor oils capable of withstanding a wide spectrum of driving conditions. These findings carry broad-reaching implications for vehicle owners, manufacturers. and the automotive industry as a whole, aiming to enhance both performance and sustainability in the realm of internal combustion engines.

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INTRODUCTION

The lubrication of internal combustion engines is a critical aspect of modern automotive engineering, ensuring smooth operation, maintaining performance, and extending the lifespan of vehicles. Engine oil serves multiple essential purposes, including reducing friction between moving parts, dissipating heat, and protecting components from wear and corrosion [1]. Car manufacturers specify detailed standards for engine oil quality, often outlined in vehicle manuals as tolerances. These standards are met by lubricant manufacturers, who label their products with alphanumeric designations to simplify consumer selection. Understanding these classifications and the dynamic nature of motor oil is crucial for optimal vehicle performance and longevity [2].

Motor oil is not a static fluid; its performance evolves in response to operational conditions, such as temperature, pressure, and contamination. Two key properties of engine oil that change with use are viscosity and foaming. Viscosity refers to the oil's resistance to flow, which is vital for maintaining a protective lubricating film between engine parts [3]. Foaming, on the other hand, affects lubrication by destabilizing the oil film, particularly under extreme conditions or high-speed operation [4].

To ensure consistency in oil quality and performance, global standards have been established. The Society of Automotive Engineers (SAE) provides viscosity grades, such as 5W-30 or 10W-40, which indicate how the oil performs at cold and operating temperatures [3]. The American Petroleum Institute (API) categorizes motor oils based on performance levels, distinguishing between oils for gasoline engines (denoted by "S", such as SN or SP) and diesel

engines (denoted by "C", such as CK-4) [2]. The Association des Constructeurs Européens d'Automobiles (ACEA) focuses on oil specifications for European engines, while the International Lubricant Specification Advisory Committee (ILSAC) and Gosudarstvennyy Standardt (GOST) provide additional frameworks for oil performance and environmental compliance [5,6].
Despite these standards, current practices for oil changes—typically recommended every 5,000 to 10,000 km—may not adequately account for the varying real-world conditions under which vehicles operate. Short city commutes and extended highway journeys subject engine oil to different stress levels, which can influence its properties over time [7]. These variations raise an important question: how does the distance traveled by a vehicle affect the properties of engine oil, specifically its viscosity and foaming? Addressing this question is critical for optimizing oil change intervals, reducing maintenance costs, and minimizing the environmental impact of excessive oil disposal [8].
The conducts a comprehensive examination of motor oils, focusing on their crucial role in enhancing power and fuel economy [8]. The research classifies motor oils into five basic groups, with a strong emphasis The on the exceptional efficiency of synthetic oils based on polyalphaolefins (PAO). These synthetic oils are shown to offer numerous advantages, such as extended longevity and enhanced resistance against oxidation. The study also underscores the significance of viscosity in oil selection, referencing classifications by authoritative bodies like the Society of Automotive Engineers (SAE). Notably, the investigation delves into the issue of oil burning in vehicles, particularly in Iranian cars, by identifying its causes and proposing chemical additives as effective solutions. In summary, this research enriches our understanding of motor oils, elucidating their categorization, benefits, and the pivotal role of viscosity. The findings, particularly those related to oil burning and its mitigation, provide valuable foundational knowledge for future studies in this field. This study aims to explore the effects of vehicle mileage on engine oil properties, focusing on viscosity and foaming. By understanding these relationships, vehicle owners and manufacturers can make informed decisions about oil change intervals, ultimately promoting better engine performance, cost efficiency, and environmental sustainability

METHODS

Study setting

In this study, we explore the complexities of our research methodology, which centered on the systematic collection of motor oil samples from vehicles in real-world driving conditions, devoid of the constraints typically associated with laboratory experiments. This methodological framework was designed to replicate authentic usage scenarios, thereby ensuring that our findings would have direct applicability to routine engine maintenance and oil change decisions.

Sample Selection

At the heart of our research is the strategic selection of motor oil samples that accurately reflect the conditions experienced by conventional vehicle operators. To accomplish this objective, we specifically selected a motor oil with a viscosity rating of 5W-30. This viscosity classification is prevalent across a wide array of vehicles, rendering our study highly relevant to a significant segment of the automotive market.

Collection of Real-World Samples

In contrast to many studies conducted in laboratory settings, our research adopted a distinctive approach by procuring samples directly from vehicles operating in their natural environments. This innovative methodology enabled us to capture the authentic impact of variables such as vehicle mileage and engine operating periods on the properties of motor oil, without the influence of artificial laboratory conditions.

Sample Preservation

To safeguard the integrity of the collected samples, each sample was meticulously preserved in glass containers immediately following extraction. Glass was selected due to its inert characteristics, which substantially reduce the likelihood of contamination or interaction between the motor oil and the container itself. This precaution was instrumental in maintaining the authenticity of the samples and mitigating the potential impact of extraneous factors on our results.

Real-World Data Collection

Our data collection process was designed to be unobtrusive, thereby allowing for the natural evolution of motor oil characteristics during actual vehicle operation. This process included the meticulous monitoring of the distance traveled by each vehicle, as well as the corresponding engine operating periods. These parameters were accurately recorded to construct a comprehensive dataset that reflects the diverse driving conditions encountered by vehicles on the road (Table 1).

Table 1. Collected Motor Oil Samples

Sample no	Type of oil	Distance Traveled (km)
1	5W-30	5,000
2	5W-30	10,000
3	5W-30	12,000
4	5W-30	13,000
5	5W-30	15,000

Simulated Engine Operation

Our primary research focus was on real-world data collection of motor oil samples from vehicles with varying mileage. This approach allowed us to understand the practical implications of mileage on motor oil performance as experienced in the field.

RESULTS AND DICUSSION

Viscosity

Viscosity variations were observed as a result of vehicle distance traveled and engine operating period. These variations have implications for motor oil performance, particularly in maintaining adequate lubrication under different conditions. The viscosity measurements were conducted following standardized testing methods outlined by the American Society for Testing and Materials (ASTM) standards (Table 2).

The motor oil samples were tested for viscosity at 40c using the ASTM D445 STANDARD testing method is widely recognized and provides a reliable measure of oil viscosity

The engine oil, with specified viscosity properties of 5W30, is examined while in use in a running engine with gasoline. The Anton Paar brand model SVM 4001 displays the oil's viscosity at a temperature of 40 degrees Celsius. The viscosity changes over time, and the study analyzes samples taken at specific mileage intervals. The first sample, taken at 5,000 kilometers, had a viscosity of 98.774 cSt, while the second sample at 10,000 kilometers showed a viscosity of 95.981 cSt, representing a 2.83% reduction. Notably, the third sample, taken at 12,000 kilometers, exhibited a significant viscosity decrease, with a reading of 74.029 cSt, marking a 25.05% decrease compared to the first sample. Sample four, collected at 13,000 kilometers, showed a continuous decrease in viscosity, reaching 68.610 cSt, a 30.54% reduction. Sample five, at 15,000 kilometers, had a viscosity of 60.602 cSt. indicating a 38.68% decrease.

The findings reveal that between 10,000 and 12,000 kilometers, there is a noteworthy change in viscosity, signifying a critical point where the oil's properties alter significantly based on the data acquired from analysis and testing. This change results in decreased viscosity at a temperature of 40 degrees Celsius.

Table 2. Motor Oil Viscosity Results at 40°C

Sample no	Distance Traveled (km)	Kinematic viscosity at 40c (cst)	Test Method
1	5,000	98.774	ASTM D445
2	10,000	95.981	ASTM D445
3	12,000	74.029	ASTM D445
4	13,000	68.610	ASTM D445
5	15,000	60.602	ASTM D445

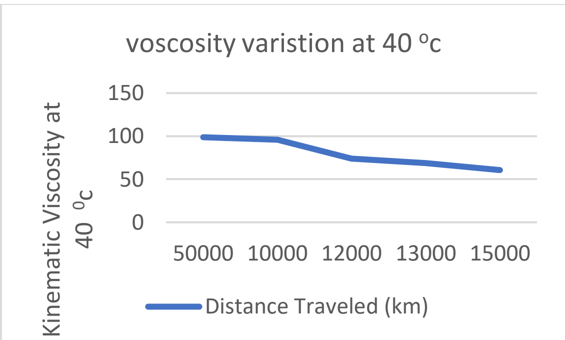

Figure 1. Viscosity Results at 40°C

Viscosity Results at 100°C

The viscosity test curve shows that the kinematic viscosity of engine oil takes a decreasing trend with increasing distance traveled. This trend can be analyzed in detail based on the data collected at 100.0°C and shown in the figure2. In the first sample with a mileage of 5000 km, a viscosity of 14.103 cSt was observed. According to what is shown in the drawing and data table 2.

In the second case, with a distance traveled of 10,000 km, we note that the wife's drop amount to 13,442 cSt, with a percentage of 4.68%. Compare together the first sample. As for the three samples with a mileage of 12,000 km, their viscosity was 12,583 cSt. It had a decrease in viscosity of 10.77% compared to the first sample, as shown in the drawing. As for the fourth sample, which had a mileage of 13,000 thousand kilometers, the oil records a decrease in viscosity 11,743 cSt. The oil recorded a decrease in viscosity, reaching 11,734 cSt. The percentage continues to decrease until it reaches 16.81%. As for the fifth and last sample, which traveled a distance of 15,000 km, the viscosity reached 11,270 cSt. The percentage of decline in this fifth sample amounted to 20.09%.

Table 3. Motor Oil Viscosity Results at 100°C

Sample No	Distance Traveled (km)	Kinematic Viscosity at 100 ºC (cSt)	Teast Method
1	5,000	14.103	ASTM D445
2	10,000	13.442	ASTM D445
3	12,000	12.583	ASTM D445
4	13,000	11.734	ASTM D445
5	15,000	11.270	ASTM D445

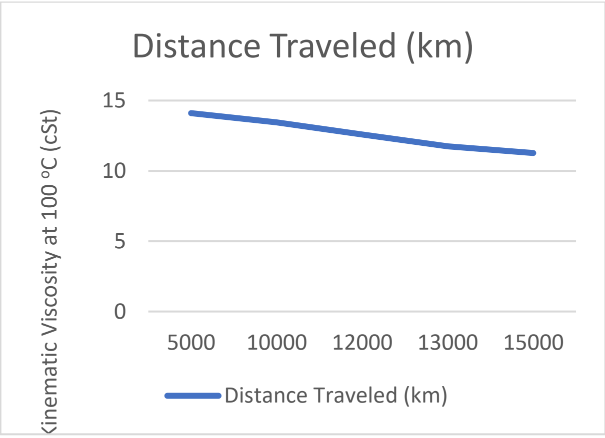

Figure 2. Viscosity Results at 100°C

Foaming Properties

Foaming properties displayed significant changes, highlighting the oil's ability to trap air bubbles. Excessive foaming can lead to reduced oil effectiveness or potential engine damage. The foaming capacity was assessed according to established testing standard.

Table 4. Foaming properties Results

Sample No.	Distance Traveled (km)	Foaming seq1 result -5 min(ml)	Foaming seq1 result -10 min(ml)	Test Method
1	5,000	0.0	0.0	ASTM D892
2	10,000	10.0	0.0	ASTM D892
3	12,000	20.0	0.0	ASTM D892
4	13,000	50.0	0.0	ASTM D892
5	15,000	80.0	10.0	ASTM D892

The foaming properties of the motor oil samples were evaluated using the ASTM D892 standard testing method, which includes different stages at varying temperature to assess the foaming characteristics of the oil.

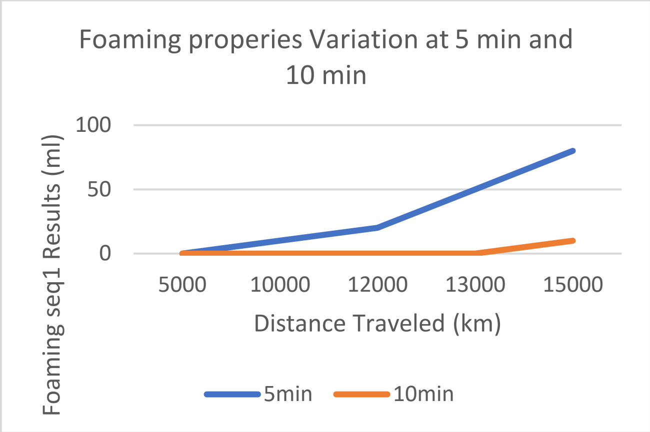

Figure 3. Foaming properties Variation at 5 min and 10 min

Both the graph and the table illustrate changes resulting from foam formation in engine oil samples. These observations reveal how different samples performed under test conditions. Here are the formation rates observed after 5 and 10 minutes:

Sample 1, with a mileage of 5000 km, displayed remarkable resistance to foaming. It showed no signs of foam formation, with 0.0 ml of foam both at 5 and 10 minutes. This implies a 0% foaming rate relative to the baseline.

Sample 2, with a mileage of 10,000 km, exhibited a slight initial foam formation at 5 minutes, but this foam dissipated entirely by the 10-minute mark, recording 10.0 ml at 5 minutes and 0.0 ml at 10 minutes.

Sample 3, having traveled 12,000 km, displayed increased foaming compared to Sample 2 at 5 minutes, with 20.0 ml of foam. Nevertheless, like Sample 2, no foam remained after 10 minutes, again registering 0.0 ml.

Sample 4, which covered 13,000 km, exhibited a sharp increase in foam formation at 5 minutes, but this foam completely stabilized after 10 minutes. It recorded 50.0 ml of foam at 5 minutes and 0.0 ml at 10 minutes.

Sample 5, with a mileage of 15,000 km, recorded the highest foam level at 5 minutes, with 80.0 ml, and even after 10 minutes, some foam remained, which differs from the previous samples. It showed 10.0 ml of foam at 10 minutes.

The study's focus on vehicle distance traveled and engine operating period has unveiled critical insights into motor oil behavior. These findings emphasize the need for tailored maintenance practices that account for these factors.

The viscosity variations observed in the motor oil samples, as determined by ASTM D445, are of significant importance. These variations can impact the oil's ability to lubricate engine components effectively. Higher viscosities suggest increased resistance to flow, which can affect engine performance and fuel efficiency. Understanding these trends is crucial for optimizing engine operation.

The assessment of foaming properties, following the ASTM D892 standard, highlights the oil's capacity to resist foaming, which can affect its effectiveness in lubricating engine components. Excessive foaming can lead to reduced oil performance and potential engine damage. Analyzing these properties under varying conditions provides insights into the oil's stability.

CONCLUSION

The noticeable breakdown in viscosity of 5W30 engine oil begins at more than 10,000 km and the condition of the oil gets worse the further the distance is, with 10,000 to 12,000 km being a critical point for the oil's performance. Foam formation occurs in the first 5 minutes of the test and disappears gradually until 10 minutes, which indicates foam formation at the beginning of operation, which increases friction and stress in the engine parts and engine breakdown when compared to the engine in reality. In this section, you can acknowledge any support given which is not covered by the author contribution or funding sections. This may include administrative and technical support, or donations in kind (e.g., materials used for experiments).

Conflict of interest. Nil

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تأثير المسافة المقطوعة للمركبة على خصائص زيت المحرك

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المستخلص

هذه الدراسة تناولت تأثير المسافة المقطوعة بواسطة المركبة وفترات تشغيل المحرك على خصائص زيت المحرك، مع التركيز بشكل خاص على اللزوجة وخصائص الرغوة. أظهرت النتائج نقطة تحول حاسمة في أداء زيت المحرك، حيث لوحظ تدهور ملحوظ في اللزوجة بعد 10,000 كيلومتر، وخاصة في النطاق من 10,000 إلى 12,000 كيلومتر. كما تسلط الدراسة الضوء على ميل الرغوة في الزيت، مما يشير إلى زيادة محتملة في الاحتكاك وإجهاد المحرك، وخاصة مع زيادة المسافة المقطوعة .ناقشت الدراسة أهمية تضمين هذه العوامل الواقعية في قرارات الصيانة وتغيير الزيت، مما يقدم فرصة لتعديل أداء المحرك وإطالة عمره. إن الآثار العملية لهذه النتائج كبيرة، إذ تمكن مشغلي المركبات من اتخاذ قرارات أكثر استنارة بشأن اختيارات زيت المحرك، وتقترح إمكانية صياغة زيوت محرك متخصصة قادرة على تحمل مجموعة واسعة من ظروف القيادة. تحمل هذه النتائج آثاراً واسعة النطاق لمالكي المركبات، والمصنعين، وصناعة السيارات بشكل عام، وتهدف إلى تعزيز الأداء والاستدامة في عالم محركات الاحتراق الداخلي.

الكلمات الدالة. زيوت التشحيم للسيارات، تأثير الأميال، خصائص الزيت، فترة تغيير الزيت.