HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

ANALYSIS OF THE NEGATIVE EFFECTS OF VEHICLE OPERATION IN LOW TEMPERATURE CONDITIONS

To‘ychiyev Xasanboy Toxir og‘li
Senior Lecturer, PhD,
Andijan State Technical Institute
Andijan, Uzbekistan
E-mail: xasanboy.toychiyev.toxirogli@gmail.com,
F-Phone: +998 (99) 368 8839
ORCID: 0009-0000-1117-7862

To‘ychiyev Xusanboy Toxir og‘li
Assistant Lecturer, Andijan State
Technical Institute, Andijan, Uzbekistan
E-mail: husanboytoychiyev55@gail.com,
F- Phone: +998 (88) 992-42-20

ABSTRACT

This article analyzes the negative effects that occur during vehicle operation under low-temperature conditions. The study examines the specific climatic conditions of Uzbekistan and their influence on the reliability of automotive components. It was found that low temperatures increase fuel consumption, accelerate engine wear, and reduce overall operational efficiency.

To mitigate these issues, the installation of a fuel preheating device for diesel engines is proposed, and its economic efficiency is evaluated. Experimental studies were conducted using an Audi A8 vehicle, demonstrating an annual saving of 750,000 UZS and a payback period of approximately 20 months.

The results of the study are of practical importance for improving vehicle operation under harsh climatic conditions in Uzbekistan and provide recommendations for future technological improvements.

Keywords: low temperature, vehicle operation, fuel consumption, engine wear, fuel heating system, economic efficiency, Uzbekistan climate, transport engineering.

1. INTRODUCTION

Currently, road transport plays a fundamental role in the socio-economic development of modern societies, ensuring mobility of the population, supporting logistics systems, and contributing significantly to industrial productivity. In Uzbekistan, the rapid growth of the automotive sector has led to a continuous increase in the number of vehicles in operation, which in turn places additional demands on transport infrastructure and vehicle maintenance systems.

At the same time, the country is characterized by a sharply continental climate, where winter temperatures in certain regions may drop below −30°C. Such extreme climatic conditions have a significant impact on the operational reliability of vehicles. In particular, low temperatures negatively affect fuel atomization, increase engine starting resistance, and reduce the efficiency of lubrication systems during cold start conditions.

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

As a result, vehicles operating in winter conditions experience higher fuel consumption, increased mechanical wear, and reduced overall efficiency. These issues not only increase operational costs but also shorten the service life of critical engine components.

Therefore, studying the behavior of vehicles under low-temperature conditions is of high scientific and practical importance. The relevance of this research is further strengthened by the need to improve energy efficiency, reduce maintenance costs, and ensure reliable vehicle operation in harsh climatic environments.

The Presidential Decree of the Republic of Uzbekistan No. PF-60 dated January 28, 2022, "On the Development Strategy of New Uzbekistan for 2022–2026," emphasizes the importance of modernizing the transport sector and improving technical efficiency [1]. In this context, the development of technical solutions aimed at improving cold-weather vehicle performance becomes particularly important.

2. METHODS

The methodological basis of this study includes a combination of theoretical analysis, experimental testing, and economic evaluation. The research was conducted using scientific literature, national regulatory documents, and experimental observations under real operational conditions.

The experimental part of the study was carried out on an Audi A8 diesel vehicle, selected due to its representative characteristics for modern diesel passenger cars. The vehicle was operated under controlled conditions with an annual mileage of 35,000 km, which reflects typical usage in urban and intercity transport.

Special attention was given to the influence of low ambient temperatures on fuel system performance. The temperature range considered in this study included conditions from −10°C to −40°C, which are typical for winter operation in certain regions of Uzbekistan.

As a technical solution, a fuel preheating system was installed in the diesel fuel supply line. The main function of this system is to increase fuel temperature before injection, thereby improving atomization quality and ensuring stable combustion during cold engine start.

Fuel consumption was measured using standardized vehicle operation methods, while economic efficiency was calculated based on current market fuel prices and installation costs. The comparative analysis included two operating modes: with and without the fuel preheating system.

The economic evaluation was performed using a cost-benefit approach, where annual fuel savings were compared against installation and maintenance costs. The payback period was calculated using the following formula:

Payback period = Investment cost / Annual savings

This approach allows for a clear assessment of the financial feasibility of the proposed technical solution.

3. RESULTS

The experimental results clearly demonstrate that low-temperature conditions significantly influence vehicle operational parameters.

At temperatures approaching −40°C, fuel consumption increases by approximately 2.6–9%, depending on engine condition and fuel quality. This increase is primarily associated with reduced fuel volatility, incomplete combustion, and prolonged engine warm-up time.

In addition, engine wear analysis revealed that cold start and warm-up phases account for approximately 7% of total engine wear during vehicle operation. This indicates that repeated operation in low-temperature environments significantly accelerates degradation of engine components.

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

Furthermore, cold weather conditions negatively affect lubrication performance. At low temperatures, engine oil viscosity increases, which reduces its ability to form a stable protective film on friction surfaces. As a result, mechanical resistance increases, leading to higher energy losses.

After installation of the fuel preheating device, significant improvements were observed:

- Fuel consumption decreased from 8.5 L/100 km to 8.0 L/100 km.
- Cold start performance improved noticeably, with reduced engine cranking time.
- Annual fuel cost decreased from 35,700,000 UZS to 33,600,000 UZS.
- The total annual economic benefit was estimated at 750,000 UZS.
- The payback period of the system was calculated as approximately 20 months.

These results confirm that preheating of diesel fuel contributes to more efficient combustion and improved engine performance under low-temperature conditions.

4. DISCUSSION

The results show that low temperatures significantly affect vehicle operational performance. Increased fuel consumption and engine wear lead not only to economic losses but also to environmental problems.

The proposed fuel preheating device partially solves these issues by ensuring stable fuel flow and improving engine starting performance in cold conditions. Economic analysis shows that the installation cost is recovered within 20 months, making it a practically viable solution [4–7].

However, the proposed solution has limitations. It is applicable only to diesel vehicles and has not been tested on gasoline engines. Future research may focus on evaluating its performance under different climatic conditions and vehicle types. Additionally, alternative fuel systems and advanced heating technologies should be considered.

5. CONCLUSION

The obtained results indicate that low-temperature environmental conditions have a multidimensional impact on vehicle performance, affecting fuel consumption, engine durability, and overall operational reliability.

From a thermodynamic perspective, incomplete fuel vaporization at low temperatures leads to inefficient air-fuel mixture formation. This results in incomplete combustion and increased fuel consumption. Additionally, increased oil viscosity at low temperatures leads to higher friction losses during engine start-up.

The proposed fuel preheating system effectively mitigates these negative effects by increasing fuel temperature before injection. This improves fuel atomization, enhances combustion stability, and reduces engine load during cold starts.

From an economic perspective, the system demonstrates clear financial benefits. The payback period of approximately 20 months indicates that the investment is economically justified for commercial and private vehicle operators operating in cold climates.

However, it should be noted that the system has certain limitations. First, its applicability is limited to diesel engines, and further research is required to evaluate its performance in gasoline engines. Second, long-term durability and maintenance costs of the system were not fully assessed in this study.

Future research should focus on integrating electronic fuel control systems and exploring hybrid heating technologies to further improve cold-start efficiency and reduce environmental impact.

REFERENCES

1. Decree of the President of the Republic of Uzbekistan No. PF-60 dated January 28, 2022 “On the Development Strategy of New Uzbekistan for 2022–2026”.

HSR (LONDON),
HOUGHTON STREET REVIEW JOURNAL
ISSN: 2058-5519|Impact factor-15.9
http://houghtonstreetreview.com/index.php/hsr

2. Hamrakulov O., Magdiyev Sh. Vehicle Technical Operation. Tashkent, Uzbekistan, 2001. 448 p.
3. Fayzullaev E. et al. Theory of Vehicle Structure. Tashkent: Yangi Asr Avlodi, 2006. 375 p.
4. Toxir ogli T.X. et al. Exhaust Emissions from Diesel Engines and Their Impact on Environment and Human Health. Journal of New Century Innovations, 2022, Vol. 10(2), pp. 3–10.
5. Toxir ogli T.X. Reduction of Harmful Emissions from Diesel Engines. Journal of New Century Innovations, 2022, Vol. 10(1), pp. 162–169.
6. Karimovna M.D. et al. Methods for Determining Technical Condition of Vehicles. Best Intellectual Research, 2023, Vol. 8(4), pp. 42–45.
7. Karimovna M.D. Environmental Protection of Materials Used in Vehicles. Mechatronics and Robotics: Problems and Development Prospects, 2023, Vol. 1(1), pp. 280–283.