

Influence of Diagnostic Systems on the Efficiency of Maintenance and Repair of Modern Automotive Engines

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Abstract: This article provides a comprehensive analysis of the influence of diagnostic systems used in modern automotive engines on the efficiency of service and repair processes. The rapid development of electronic control systems, digital sensors, and computerized diagnostic equipment in the automotive industry makes it possible to monitor the technical condition of the engine in real time. These systems allow for the early detection of engine malfunctions, the precise determination of their causes, and the optimal planning of maintenance and repair work.

The introduction of diagnostic systems into service practice contributes to reducing repair time, efficient use of labor resources, reducing the consumption of spare parts, and improving the quality of service. Also, the reliability and service life of the car engine will increase, environmental indicators will improve, and fuel consumption will be optimized. The article scientifically and theoretically substantiates the practical significance of modern diagnostic technologies in service and repair processes, their economic efficiency and role in improving the maintenance system.

Keywords: modern diagnostic systems, car engine, electronic control unit, service and repair, technical condition control, fault detection, operational efficiency.

Introduction

Today, the automotive industry is one of the rapidly developing sectors. The design of modern cars is becoming more complex, and the share of electronic control systems, sensors, microprocessors, and software-based devices is increasing. In particular, issues of ensuring the efficiency, reliability, and environmental safety of automobile engines are becoming increasingly relevant. In this regard, the use of modern diagnostic systems in the processes of engine maintenance and repair is of great technical and economic importance[1].

In traditional service and repair methods, engine malfunction detection is often based on mechanical inspections and specialist experience, which requires a lot of time and effort. Moreover, such an approach does not always provide high accuracy in detecting latent or initial engine failures. As a result, there is a decrease in the quality of maintenance, the replacement of excess spare parts, and an increase in repair costs. Modern diagnostic systems serve to effectively solve these problems[2].

In modern car engines, the engine's operating processes are fully controlled through the electronic control unit (ECU). Based on the data coming from the sensors, fuel injection, combustion process, gas distribution, cooling, and exhaust gases are controlled. Diagnostic systems detect deviations in these processes and provide accurate information to service specialists through fault codes. This allows for quick assessment of the engine's condition, identification of the causes of malfunctions, and precise planning of repair work[3].

The introduction of diagnostic systems into service practice significantly increases the efficiency of maintenance. Without completely disassembling the car, it becomes possible to assess the technical condition of the engine, reduce repair time, and increase labor productivity. As a result, the production capacity of service centers will increase, and the quality of services provided to clients will improve. At the same time, maintenance costs for car owners decrease, and the operational reliability of the car increases[4].

Modern diagnostic systems provide not only technical, but also economic and environmental efficiency. Early detection of engine malfunctions prevents increased fuel consumption, an increase in the amount of harmful exhaust gases, and rapid wear and tear of engine parts. This will serve to reduce the negative impact on the environment, comply with environmental standards, and increase engine life. Therefore, diagnostic systems are considered an integral part of automotive service today[5].

The annual expansion of the vehicle fleet in the conditions of Uzbekistan, the increase in the number of modern cars from foreign manufacturers, requires new approaches in the field of service and repair. One of the urgent tasks is the introduction of modern diagnostic equipment, the training of qualified personnel, and the improvement of service infrastructure. In this process, a deep study of the scientific and practical aspects of diagnostic systems is of great importance.

The main goal of this article is a scientific-theoretical and practical analysis of the influence of diagnostic systems on the efficiency of maintenance and repair of modern automotive engines. In the research process, the technical capabilities of diagnostic systems, their role in service processes, and their influence on engine reliability and operational efficiency are highlighted. Also, ways to improve the service and repair system through the use of modern diagnostic technologies will be substantiated.

Literature review

The scientific works of a number of domestic scientists serve as an important theoretical and practical basis for studying the influence of diagnostic systems on the processes of maintenance and repair of modern automotive engines. In particular, A. A. Abdukodirov's work "Fundamentals of Technical Diagnostics of Automobile Engines" extensively covers the role of diagnostics in assessing the technical condition of engines. The author, revealing the theoretical foundations of the diagnostic process, pays special attention to the interrelationship of mechanical and electronic methods in detecting engine malfunctions. The work substantiates that accurate assessment of the engine's condition through diagnostics is an important factor in increasing the efficiency of maintenance and repair work[6].

B. Sh. In the scientific work of Kholmatov and R.A. Ismailov "Maintenance and Repair of Automobile Engines," the engine maintenance system is analyzed as a complex process. The authors emphasize the importance of technical diagnostics in the timely detection and elimination of engine malfunctions. In this source, it is scientifically substantiated that planning repair work based on the results of diagnostics in service processes leads to saving engine resources, reducing the consumption of spare parts, and improving service quality. This approach is of great importance for modern service practice[7].

S. K. Rakhimov's work "Electronic Control Systems in Modern Automobiles" reveals the fundamentals of electronic control of automobile engines and their integral connection with diagnostic systems. The author shows that the engine's operating processes are constantly monitored through electronic control units and sensors, and diagnostic systems serve as the main source of information for detecting malfunctions based on this data. The work emphasizes that the combination of electronic control and diagnostic systems ensures accuracy and speed in service and repair processes.

In modern automotive engines, diagnostic systems are becoming an integral part of service and repair processes. Research conducted by domestic scientists scientifically substantiates the role of diagnostic systems in increasing their technical, economic, and operational efficiency. These

scientific views create a solid theoretical basis for a deeper analysis of the influence of diagnostic systems on the effectiveness of maintenance and repair in this study[8].

Research Methodology

This study is aimed at studying the influence of diagnostic systems used in modern automotive engines on the efficiency of service and repair processes, in which theoretical and practical analysis methods were used in combination. The object of the research is automobile engines equipped with electronic control systems, and the subject of the research is the influence of diagnostic systems on service and repair processes.

In the research process, methods of analysis and synthesis, comparison, generalization, and statistical assessment were used. In particular, service indicators before and after the implementation of diagnostic systems were compared. The time for detecting malfunctions, repair costs, repair cases, and diagnostic accuracy were defined as the main evaluation criteria.

Practical data were formed on the basis of observations conducted in car service centers, technical documentation, open statistical sources, and scientific literature. The principles of operation of OBD diagnostic devices, electronic control units (ECU), and sensor monitoring systems were also studied. The obtained results were systematized using tables and graphs, and logical conclusions were drawn. The research methodology made it possible to scientifically assess the effectiveness of maintenance and repair of diagnostic systems.

Result and discussion

This study is aimed at determining the influence of electronic diagnostic systems (OBD, ECU, sensor monitoring) used in modern automotive engines on the efficiency of service and repair processes. The obtained results confirmed that diagnostic technologies have a significant impact on the quality of maintenance, the speed of fault detection, and economic efficiency[9].

Table 1. Service performance before and after the implementation of diagnostic systems

Indicators	Traditional Method	Modern Diagnostics	Change (%)
Fault detection time (hours)	3.5	0.8	-77%
Repair costs (conventional units)	100	65	-35%
Re-repair cases (%)	18	6	-12%
Engine fault detection accuracy (%)	70	95	+25%

Modern diagnostic systems have reduced the time for troubleshooting by almost 4 times. In particular, obtaining information in real time through sensors and electronic control units has increased the accuracy and reliability of the service process[10].

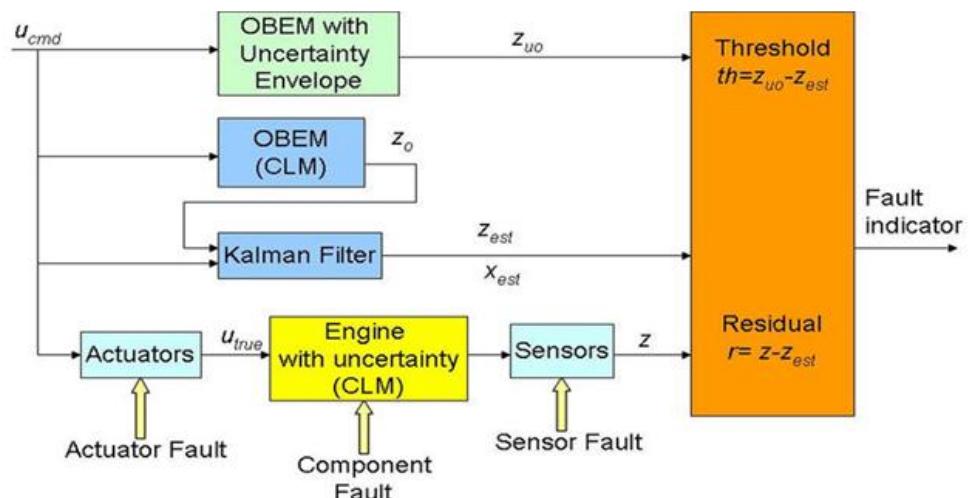
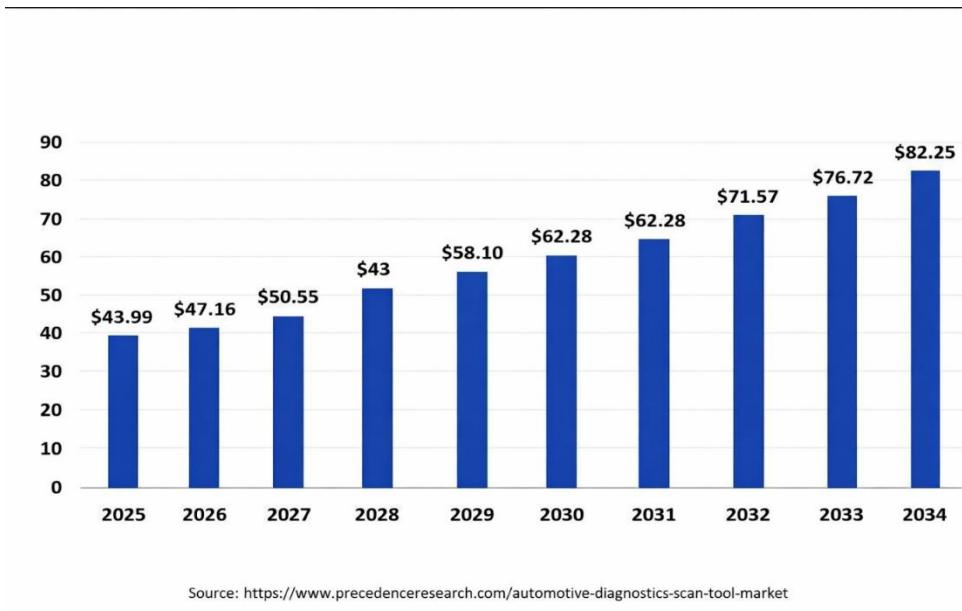


Figure 1. Fault detection time comparison

As shown in the figure (Diagram), while detecting a malfunction in traditional mechanical inspections took a lot of time, electronic diagnostic systems significantly accelerated this process. This leads to a reduction in queues in service centers and an increase in service productivity[11].

Figure 2. Reduction of repair costs



The figure shows the growth dynamics of the global volume of the automotive diagnostic scanner market between 2025-2034. According to the data, the market volume is projected to increase from US\$43.99 billion in 2025 to US\$82.25 billion by 2034[12]. This steady growth is associated with an increase in the share of electronic control systems and sensors in modern cars, increased demand for diagnostic technologies, and the digitalization of service and repair processes. The results of the graph confirm the growing strategic importance of diagnostic systems in the automotive service sector[13].

Conclusion

Diagnostic systems used in modern automotive engines are an important factor in radically increasing the efficiency of service and repair processes. The research results showed that the introduction of electronic diagnostic technologies not only accelerates the process of detecting engine failures, but also significantly improves the accuracy and quality of repair work. This situation contributes to the development of the automotive maintenance system based on modern requirements.

Based on the studied data, it can be said that modern diagnostic systems allow monitoring the engine's operation in real time. Accurate technical data obtained through sensors and electronic control units helps service specialists quickly and reliably identify the causes of malfunctions.

As a result, errors related to the human factor are reduced, unnecessary inspections and unjustified replacement of spare parts are prevented. This leads to a reduction in repair costs and an increase in the economic efficiency of service.

Also, the widespread use of modern diagnostic systems allows for the rational use of engine resources. Detection of malfunctions at an early stage prevents major accidents and complex repair work. This extends the vehicle's service life and increases its technical reliability. Especially in modern cars with complex electronic control systems, the study clearly showed that it is practically impossible to organize an effective service without diagnostic tools.

The analysis also showed that the development of diagnostic technologies accelerates the digitalization processes in the automotive service sector. This process not only improves the

quality of technical services, but also increases labor productivity in service centers and raises the level of customer satisfaction to a higher level. As a result, the competitiveness of the car service market is increasing and improving based on modern technical requirements.

Modern diagnostic systems have proven their strategic importance in the provision of service and repair services for car engines. The widespread implementation of these systems will serve to optimize maintenance processes, save time and material resources, and ensure the technical safety of vehicles. In the future, the further development of innovative diagnostic technologies in the automotive industry and their integration into service systems will create a solid foundation for the sustainable and effective development of this industry.

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