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PRE-REPAIR DIAGNOSTICS OF VEHICLE UNITS BASED ON TECHNICAL CONDITION

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Abstract
This article examines the organization of pre-repair diagnostics for vehicle units, focusing on assessments based on their technical condition. By identifying and evaluating the current state of various vehicle components before repair, this approach aims to enhance the accuracy and effectiveness of maintenance efforts. The study highlights the importance of advanced diagnostic tools and methodologies in detecting potential issues early, thereby preventing more significant problems and ensuring optimal vehicle performance. Key benefits of implementing condition-based diagnostics include reduced downtime, cost savings, and prolonged vehicle lifespan. This article provides a comprehensive overview of best practices and strategies for effectively organizing pre-repair diagnostics, aligning with the evolving technical requirements of modern vehicles.

Keywords: Pre-repair diagnostics, vehicle unit assessment, technical condition evaluation, maintenance strategies, condition-based diagnostics.

Introduction

In the realm of vehicle maintenance, ensuring optimal performance and safety is paramount. One essential aspect of this endeavor is the meticulous assessment of a vehicle's technical condition before initiating any repair work. This article delves into the critical practice of pre-repair diagnostics for vehicle units, emphasizing the significance of evaluating their technical state as a foundational step in the maintenance process [1].

The complexity of modern vehicles necessitates advanced diagnostic methodologies to accurately discern the condition of various components. By focusing on the technical condition of vehicle units, pre-repair diagnostics serve as a proactive approach to identify existing issues and potential vulnerabilities. This proactive stance not only aids in preventing future malfunctions but also contributes to the overall efficiency and reliability of the vehicle [2].

Throughout this discussion, we will explore the methodologies, tools, and best practices involved in organizing pre-repair diagnostics based on technical condition assessment. By shedding light on these fundamental aspects, we aim to underscore the importance of incorporating condition-based diagnostic frameworks into routine maintenance procedures [4,5].

Furthermore, the benefits of such an approach are multifaceted. From minimizing downtime and repair costs to extending the lifespan of vehicles, condition-based diagnostics offer a holistic solution to optimize maintenance outcomes. By adopting these strategies, mechanics and technicians can make informed decisions that prioritize safety, efficiency, and customer satisfaction.

In essence, the organization of pre-repair diagnostics based on technical condition assessment represents a proactive and preventive approach to vehicle maintenance. Through this article, we seek to provide insights and guidance to automotive professionals on implementing effective diagnostic practices that align with the evolving technical complexities of modern vehicles [6,7].

The Main Part

For the analysis and study of complex technical systems with fuzzy initial information, decision making and implementation, mathematical methods based on the theory of fuzzy sets, in which the behavior of the system is described by fuzzy algorithms, are widely used.

Automotive technology belongs to complex technical systems, the study of technical condition management of which is advisable to carry out using mathematical models.

The practice of automobile repair production shows that more than half of the units are received for major repairs with an underutilized resource of 40 to 70% for a significant number of connections. When carrying out a major overhaul, one assembly unit may contain new, serviceable without repair, and restored parts. Between 20 and 30% of their service life is lost during the running-in of impersonal parts.

Moreover, fault detection is one of the critical components of predictive maintenance; it is very much needed for industries to detect faults at very early stage [7]. Techniques for maintenance policies can be categorized into the following main classifications [9,10].

(R2F) Run 2 Failure: also known as corrective maintenance or unplanned maintenance. It is the simplest amongst maintenance techniques which is performed only when the equipment has failed. It may lead to high equipment downtime and a high risk of secondary faults and thus, create a very large number of defective products in production.

Preventive Maintenance (PvM): also known as scheduled maintenance or time-based maintenance (TBM). PvM refers to periodically performed maintenance based on a planned schedule in order to anticipate the failures. It sometimes leads to unnecessary maintenance which increase the operating costs. The main aim here is to improve the efficiency of the equipment by minimizing the failures in production [8].

Condition-based Maintenance (CBM): this method of maintenance is based on a constant machine or equipment monitoring or their process health that can be carried out only when they are actually necessary. The maintenance actions can only be carried out when the actions on the process are taken after one or more conditions of degradation of the process. CBM usually cannot be planned in advance.

PdM: known as Statistical-based maintenance: maintenance schedules are only taken when needed. It is based on the continuous monitoring of the equipment or the machine, as like CBM. It utilizes prediction tools to measure when such maintenance actions are necessary, hence the maintenance can be scheduled. Furthermore, it allows failure detection at an early stage based on the historical data by utilizing those prediction tools such as machine learning methods, integrity factors (such as visual aspects, coloration different from original, wear), statistical inference approaches, and engineering techniques.

It is required that any maintenance strategy ought to minimize equipment failure rates, must improve equipment condition, should prolong the life of the equipment, and reduce the maintenance costs. An overview for the maintenance classifications is shown in Figure 1. PdM turned out to be one of the most promising strategies amongst other strategies of maintenance that has the ability of achieving those characteristics [2], thus the strategy has been applied recently in many fields of studies. PdM captivates the attention of the industries, hence it has been applied in the era of I4.0 due to it is capability of optimizing the use and management of assets [3].

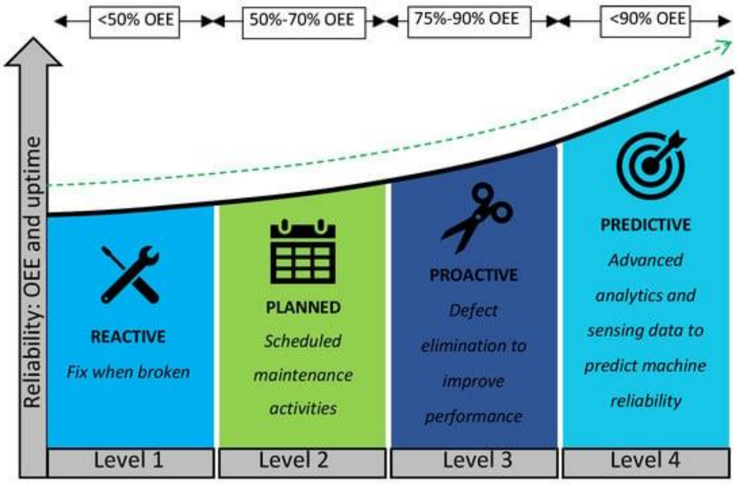

Figure 1. Maintenance types [1].

ML, within the contexts of artificial intelligence (AI) (Figure 1), lately, has appeared to be one of the most powerful tools that can be applied in several applications to develop intelligent predictive algorithms. It has been developed into a wide field of research over the past decades. Major repairs, in which the volume of disassembling a product and defect detection of its components is the same for a fleet of similar products, depending on the operating time since the start of operation, and the list of restoration operations is developed taking into account the results of defects in the components of the product, does not take into account the patterns of changes in the technical condition of cars and does not ensure effective maintenance of them in readiness for their intended use. To solve problems aimed at improving the organization and technology of repairs, it is necessary to use probabilistic models, since random physical quantities characterizing the actual state of machines are used as control parameters.

Research by many scientists has established that the most effective repair strategy is a repair strategy based on technical condition, in which the list of technological operations is determined based on the results of technical diagnostics at the time the repair of the product begins, taking into account the reliability of its components.

The technical condition of the unit is determined directly on the car during its intended use or at the stand of a car repair company. When performing disassembly work, the technical condition of the units is clarified based on structural parameters during instrumental fault detection.

The scientific problem is the lack of theoretical justification for technological repair processes based on the technical condition of automotive transmission units, the implementation of which ensures a reduction in the labor intensity of disassembly and assembly work and repair costs.

Automotive transmission units coming in for repair have a large number of values of various parameters that characterize their actual technical condition.

To effectively restore the serviceability (operability) of automotive transmission units, it is necessary to develop adequate models that represent the formalization of fuzzy information and techniques that will take into account the uncertainty of the technical condition for making decisions about repair actions.

The basis of the technical policy at car service enterprises is a planned preventive maintenance system for motor vehicles and repairs as needed - current repairs. Maintenance is a preventive measure, which is a set of works aimed at preventing failures and malfunctions, ensuring the full functionality of the vehicle unit, component or system. Maintenance is carried out as planned after certain miles or a certain period of operation of the vehicle. A vehicle with faulty units, components, systems and parts that pose a threat to traffic safety should not be allowed on the line. Other malfunctions that do not affect traffic safety and are not associated with intense wear due to premature destruction of parts can be eliminated after completion of the trip.

Requirements for the technical condition of a vehicle are established by the current Rules for the Technical Operation of Mobile Transport and the Rules of the Road. The range of maintenance work includes: cleaning and washing, inspection and diagnostic, fastening, adjustment, filling, lubrication and tire work. If during maintenance it is not possible to verify the complete serviceability of individual components, they should be removed from the vehicle for diagnostics on stands and special devices.

Repair is a set of works or operations to eliminate any failures or malfunctions that have arisen and to restore the full functionality of a vehicle, unit, system, or unit within the operating characteristics established by the manufacturer.

Technical diagnostics is the process of establishing the technical condition of units, components, systems and mechanisms of a vehicle with established accuracy using instruments and devices without disassembling the diagnostic object. Diagnostics makes it possible to identify faults that require adjustment or repair work to eliminate. Based on the purpose, scope of work, place and time of implementation, diagnostics are divided into continuous and periodic. Continuous diagnostics are carried out by the driver while operating the vehicle. Periodic diagnostics are performed after a certain mileage. In addition, diagnosis can be general (D-1) and elementary (D-2). During D-1, the technical condition of the vehicle components and assemblies that ensure road safety is determined and their suitability for use is assessed. D-1 is performed before TO-1. D-2 is intended to identify hidden faults, failures, causes and nature of faults. Based on the results of D-2, an in-depth diagnosis of the technical condition of the car is made, the volume of repair work necessary to restore the performance and maintain the good technical condition of the car is established. D-2 is carried out 1–2 days before TO-2. When carrying out maintenance-2, the service life until the next maintenance is predicted.

Control and diagnostic inspection can be carried out on production lines or at individual posts. Technical diagnostic posts can be equipped with stationary stands, mobile stations, portable instruments with the necessary measuring devices. On the production line, the main diagnostic posts are located at the TO-1 and TO-2 areas. Separate posts are organized in areas for routine repair of vehicle units and components, for example, gearbox repair and engine repair. This arrangement of posts allows for diagnostic measurements to be carried out before and after repairs, thereby ensuring guaranteed quality. Stands with running drums allow you to simulate driving conditions and vehicle loads. The diagnostic stand is equipped with a brake system and a fuel flow meter, which allows you to check the main characteristics of the vehicle components and parts and compare them with the passport data. The stand allows you to adjust sensors and instruments on the vehicle's instrument panel and identify faults.

At the engine diagnostic stations there is special vibroacoustic equipment, stethoscopes and other instruments, which, based on the characteristics and level of noise and knocking, make it possible to determine the technical condition of the gas distribution and crank mechanisms.

To carry out maintenance and repair of vehicles, mobile repair and repair and diagnostic workshops are used. Such workshops have special equipment for diagnostics, as well as equipment for metalworking, drilling, turning and other work.

Conclusions

In conclusion, the organization of pre-repair diagnostics based on the technical condition of vehicle units is a crucial component of effective vehicle maintenance strategies. Throughout this article, we have explored the importance of conducting comprehensive diagnostic assessments before initiating any repair work, emphasizing the necessity of accurately evaluating the technical state of vehicle components.

By focusing on the technical condition of vehicle units, pre-repair diagnostics enable automotive professionals to identify existing issues and potential vulnerabilities proactively. This proactive approach not only helps prevent future malfunctions but also contributes to improved vehicle performance, efficiency, and safety.

The title, "Pre-Repair Diagnostics of Vehicle Units Based on Technical Condition," encapsulates the essence of our discussion, highlighting the proactive nature of assessing vehicle units' condition before undertaking repairs. This approach acknowledges that the success of subsequent repair efforts relies heavily on the precision and thoroughness of the initial diagnostic phase.

Throughout our exploration, we have examined various methodologies, tools, and best practices involved in organizing pre-repair diagnostics based on technical condition assessment. From advanced diagnostic technologies to condition-based diagnostic frameworks, these strategies offer holistic solutions to optimize maintenance outcomes and ensure the longevity of vehicles.

Moreover, the benefits of implementing condition-based diagnostics extend beyond mere cost savings and downtime reduction. By enhancing vehicle reliability, extending lifespan, and ultimately improving customer satisfaction, these practices contribute to overall operational efficiency and business success.

As the automotive industry continues to evolve, the role of pre-repair diagnostics in maintaining vehicle health and optimizing repair outcomes becomes increasingly significant. By incorporating these practices into routine maintenance procedures, automotive professionals can make informed decisions that prioritize safety, reliability, and performance.

In essence, the proactive organization of pre-repair diagnostics based on technical condition assessment represents a cornerstone of effective vehicle maintenance. Through this article, we have provided insights and guidance to automotive professionals on implementing and refining diagnostic practices aligned with the evolving technical complexities of modern vehicles.

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