Analysis of the use of hydraulic drives in the automotive industry

Alexander Rybak[1*], *Besarion* Meskhi[1], *Dmitry* Rudoy[1,2], *Anastasiya* Olshevskaya[1], *Svetlana* Teplyakova[1], *Ivan* Kolesnikov[1], *Alexey* Prutskov[1], and *Maxim* Romanov [1]

[1] Don State Technical University, 344003 Rostov-on-Don, Russia
[2] Agricultural Research Centre "Donskoy", 347740 Zernograd, Russia

Abstract. The article is devoted to the study of the use of hydraulic drives in the automotive industry, which is a promising direction in engineering practice. The paper examines the global implementation of hydraulic drives in various vehicle systems, such as steering, braking, suspension and clutch mechanisms. The main attention is paid to the analysis of the advantages and disadvantages of hydraulic drives in the automotive industry. The study includes a conclusion about the operating efficiency of hydraulic drives, their reliability, durability and economic feasibility. The results obtained during the study can be useful in choosing optimal solutions for the use of hydraulic drives. This can help improve the safety and performance of vehicles, as well as improve production processes in the automotive industry. The article represents a special contribution to the development of new technical solutions in the automotive industry and can serve as a basis for further research in this area.

1 Introduction

In the context of the rapidly developing automotive industry, a large number of innovations, the introduction of new technologies and the emergence of rapidly changing requirements for automobiles, the study of the use of hydraulic drives in the automotive industry is a promising area of research, the most relevant and capable of bringing innovation and new knowledge and solutions to the automotive industry.

This article also sets itself the task of determining optimal solutions for the selection of hydraulic drives for various vehicle systems in order to increase road safety, reduce production costs and improve technical characteristics.

The object of the study is the use of hydraulic drives in the automotive industry in order to improve the efficiency of various systems, such as steering, braking systems, clutch mechanisms, suspension systems, etc.

* Corresponding author: 2130373@mail.ru

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2 Material and research methods

Hydraulic drives are an important component of modern cars, providing power transmission and control of various mechanisms [1, 2].

The use of hydraulic technology has significant advantages, such as increased reliability, durability and economic feasibility. The advantages of hydraulic drives over other types of drives are efficiency (this type ensures fast and smooth transmission of force), reliability (hydraulic systems are rarely subject to breakdowns and have a long service life due to the simplicity of the design and the absence of a large number of vulnerable parts), durability (hydraulic drive able to withstand high loads and impacts, while providing trouble-free operation without loss of performance), controllability (high degree of precision and control, making the hydraulic drive ideal for applications with precise adjustments), comfort (providing a smooth and soft movement, which makes the vehicle move more comfortable and safe), adaptability (adaptation to different conditions and requirements), efficiency (the use of this type of drive can be cost-effective due to their durability and efficiency), safety (high reliability and the ability to remain operational in any conditions, which increases the level of safety) , power (the ability to transmit large force and torque while ensuring high performance and efficiency) [3, 4].

An example of the successful use of hydraulic drives in the automotive industry is the use of a combined electric power steering system. Electric power steering is an auxiliary system for lightweight steering with minimal effort, which significantly increases the comfort and control of the vehicle and improves driving safety. The benefits of using this system include reduced steering effort, improved handling, increased driver comfort and automatic correction. Reduced steering effort is due to the fact that the driver needs less effort to turn the steering wheel, which is especially important when maneuvering at low speeds or when parking. Improved handling is due to the fact that the electric power steering system allows you to more accurately track and control the direction of the vehicle, which improves safety on the road. Driver comfort in this case is realized by reducing driver fatigue during long trips, as the system ensures ease and smoothness of control. Automatic correction systems are able to automatically detect operating conditions and take actions to ensure a comfortable ride by adjusting the force transmitted to the power steering system.

An equally important example of the development of a hydraulic drive in the automotive industry is the development of a braking system designed for traffic safety. One of the significant achievements is the invention of the anti-lock braking system in car brake systems. Anti-lock braking system is a technology that prevents wheel locking during heavy braking, ensuring optimal traction and vehicle control. The benefits of using a hydraulic drive in an anti-lock braking system include increased safety, shorter braking distances, increased comfort and improved handling. Anti-lock braking system allows you to hold the car even under extreme braking, which significantly reduces the risk of losing control of the vehicle. Thanks to the ability of the anti-lock braking system to maintain wheel rotation at an optimal level, the control system allows you to shorten the braking distance and reduce the likelihood of collisions. Also, the anti-lock braking system provides smoother and more stable braking, which increases the level of comfort and safety for both the driver and passengers. The hydraulic drive in anti-lock braking systems allows the car to most effectively respond to changes in the road surface (including loss of traction) and effectively respond to various emergency situations, which improves controllability in difficult driving conditions. Thus, the use of a hydraulic drive in the anti-lock brake system is one of the striking examples of technological progress in the automotive industry, which helps to increase safety and comfort, as well as improve the technical characteristics of engines [5-7].

The next equally important achievement in the use of hydraulic drive is the adaptive suspension. This system uses hydraulic elements to adjust the suspension stiffness and height

(clearance) of the vehicle. This technology allows the car to change its suspension stiffness over a short period of time to suit different road conditions and driving styles. The benefits of use are improved comfort, improved handling, fuel economy and greater safety. Hydraulic suspension is able to soften road irregularities, absorbing impacts, shocks and vibrations, which increases driving comfort and safety. Adaptive suspension based on hydraulic drive improves vehicle handling by providing better grip on the road surface. Hydraulically adjusting suspension stiffness can reduce fuel consumption by optimizing suspension performance depending on the situation. Adaptive Control Suspension helps improve vehicle stability on the road and prevents loss of control in critical situations. Thus, the use of a hydraulic drive with adaptive control is an example of advanced solutions in the automotive industry that improve the level of comfort, vehicle driving efficiency and safety criteria [8,9].

An important achievement is the use of a hydraulic clutch. It plays a key role in transferring power from the engine to the transmission and ensures smooth gear shifting without jerking or wear. The benefits of a hydraulic clutch include smooth gear shifting, high reliability and durability, improved efficiency and quick response. This type of clutch provides more comfortable and smooth gear shifting compared to mechanical shifting, which increases driving comfort. Also, the hydraulic clutch system has high durability and reliability due to a smaller number of moving parts subject to wear and the ability to work under various operating conditions [9, 10]. There's no getting around the fact that a hydraulic clutch allows for more efficient power transfer, which can improve fuel economy and performance. An important characteristic is fast response: the hydraulic drive allows you to quickly respond to driver commands and ensures quick transfer of force from the clutch pedal to the gear shift mechanism. Trends in improving efficiency and safety through the introduction of hydraulic drives are shown in Figure 1.

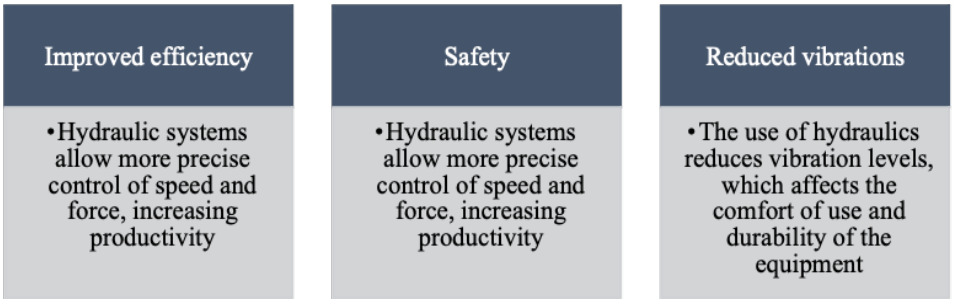

Fig. 1. Trends in improving efficiency and safety through the introduction of hydraulics

Based on the above, we can say that the hydraulic drive in the automotive industry has a large number of advantages compared to other types of drives, for example, mechanical or electrical [7]. Some of the main advantages of hydraulic drive include high power and torque, smooth and precise control, versatility, high reliability and durability. Hydraulic systems are capable of delivering high power and torque in a relatively small size and weight, making them effective for transferring large loads and performing tough tasks. Hydraulic actuators have the ability to provide smooth, precise control, which is especially important for precision adjustments and complex movements in the automotive industry. Also, such systems quickly respond to changes in input signals, while providing quick response and high speed of operations, which is extremely important for the safety and efficiency of the vehicle. The versatility of using hydraulic systems is fundamentally important. They can be used for a variety of automotive functions, such as adaptive control of brakes, suspension, steering, clutch and other systems, making them a versatile solution for a variety of applications. Thus, the hydraulic drive in the automotive industry is a durable and reliable solution that has a number of advantages that make it widespread and in demand in the automotive industry.

But, despite the obvious superiority of hydraulic drives in the automotive industry, their use is also associated with certain disadvantages, namely: difficulty in maintenance, the possibility of leaks of working fluid and pressure losses in the system, high energy costs and limited application in some areas. Hydraulic systems require enormous experience and special knowledge for maintenance and repair, and this increases the complexity of maintenance of units and components. Hydraulic drives are also at risk of fluid leaks and loss of pressure, which can lead to decreased operating efficiency and failure of units. In addition, the use of hydraulic drives can consume more energy due to the need to operate pumps and other system components, which can affect the overall energy efficiency of the vehicle. In some cases, hydraulic systems cannot be used in some units and assemblies due to special requirements and restrictions, which can subsequently create difficulties when integrated into certain vehicle designs. Thus, despite a number of advantages, it is necessary to take into account the disadvantages when choosing specific tasks and operating conditions [10-12].

Based on the results of the study, we can conclude that hydraulic drives have a significant potential in new inventions of vehicle components and assemblies. The use of this type of drive opens up new prospects for improving the technical characteristics of vehicles. Figure 2 shows the main directions of development of hydraulic systems in the automotive industry. Namely, the most advanced area of development of modern technologies in hydraulic systems at the moment is based on the development of electronic hydraulics, the development of hydraulic systems with improved energy efficiency and their further integration into cars.

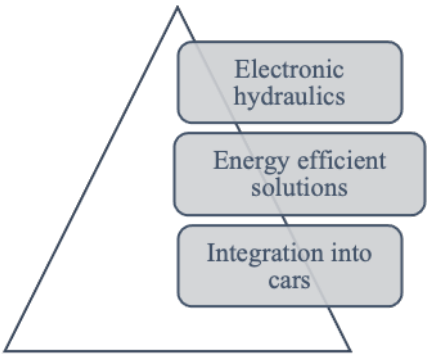

Fig. 2. Directions for the development of hydraulic systems in the automotive industry

The advantages of hydraulic drives, such as smooth control, high power transmission efficiency, fast response, and precise operation, contribute to increased productivity and driving comfort. These factors play a key role in creating more modern and efficient automotive solutions [8].

However, there are a number of disadvantages that also need to be taken into account: difficulties in maintaining hydraulic systems, high production costs, as well as the possibility of breakdowns and leaks of working fluid. Further research will be aimed at solving these problems and technological improvement of hydraulic drives in general.

3 Results and discussion

In summary, hydraulic drives represent an important element of technological progress in the automotive industry, which can significantly improve the overall performance of vehicles and provide a comfortable, convenient and safe driving experience. Further development, optimization and implementation of new, improved hydraulic systems will unlock the

potential and create even more innovative and modern vehicles that meet the requirements of the modern market and the dynamically changing needs of consumers.

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