CASE STUDY ON THE DETERIORATION OF PIVOTS IN OPERATION

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Abstract: *The case study focuses on the analysis of wear and damage to automotive pivots, an essential component of suspension and steering systems, influencing the safety and performance of the vehicle. The pivots were monitored throughout the operation of 12 vehicles, and the main causes identified that led to their replacement were bellows damage, wear and corrosion. Bellows damage was common in most vehicles, leading to increased friction and steering instability. Wear was influenced by road conditions and driving mode, and corrosion, caused by bellows rupture, was more common on roads with high humidity. The study shows that well-maintained pivots can exceed 80,000 km, while those subjected to difficult conditions or improper use have a much lower durability.*

Keywords: *pivots, wear*

1. Introduction

The pivots a component of a vehicle's suspension and steering system that plays a critical role in the movement and direction of the wheels. It allows the wheels to rotate around a fixed point and absorbs vibrations and road bumps, contributing to the comfort and stability of the vehicle and have been the subject of a considerable amount of research and development since 1950 when they were designed and used in MacPherson suspensions in Ford Consul cars,[Rob Siengel,2017].

The pivot is of considerable importance for the performance, safety and comfort of a vehicle:

The steering pivot is essential to the maneuverability of a vehicle. A faulty steering pivotcan lead to loss of control of the vehicle, which poses a major risk of accidents. A faulty or worn pivotcan make the steering wheel imprecise or difficult to steer, thus affecting safety.

The suspension pivot helps absorb shocks and vibrations from the road. This helps maintain optimal passenger comfort and vehicle stability, especially on uneven roads. A damaged suspension pivot can lead to unstable vehicle behavior, such as poor handling or a feeling of instability when cornering.

The pivot has a direct impact on the durability of the entire suspension and steering. If the pivot is not properly maintained or wears out over time, it can cause premature wear of other components, such as the steering arms or shock absorbers, leading to higher maintenance and repair costs.

2. Case study

Case study on the analysis of wear and damage of automotive pivots in operation.

Objective of the study.This study analyzes the behavior and durability of 8 pivots and 14 bar ends used on various vehicles, aiming to identify the main causes that led to the need for their replacement. The pivots were recovered from a car service, as the vehicles presented themselves to the service for overhauls, repairs or technical inspection.

8 pivots and 14 bar ends from various vehicles were analyzed, according to the following table:

Table 1: *Analyzed pivots*

Nr. crt	Car brand	Year of manufacture of the car	Number of kilometers on the board	Ball joint type	Number of kilometers traveled with the joints subject to analysis	Observations
1.	A	2008	239.500	bar ends	35.000	
2.	B	2006	188.500	pivots	188.500	original pivots
3.	C	2008	243.500	bar ends	56.300	
4.	D	2012	101.200	pivot	18.400	
5.	E	2009	309.890	pivots	80.000	original pivot
6.	F	2003	296.300	bar ends	38.500	
7.	G	2005	263.000	bar ends	24.000	
8.	H	2000	328.400	bar ends	45.000	
9.	I	1999	289.318	bar ends	50.000	
10.	J	2005	331.200	pivot	40.000	
11.	K	2008	259.400	pivots	100.000	original pivots
12.	L	2001	387.215	bar ends	60.000	

Discussions.

Considering that the ball joints are manufactured by specialized companies. The brand of the vehicles from which they were recovered will not be specified in this study, as there is a probability that they are manufactured by one and the same manufacturer, even if they are mounted on vehicles of different brands. This study was based on the assumption that the pivot manufacturers respect (and are obliged to respect) the ball joint design and manufacturing standards and thus the respective pivots have common elements even if they come from different brands of vehicles.

The AK-LH 14 specification is considered as a reference document for both manufacturers of pivots and users and covers the functional and strength tests required for acceptance of pivots.

Next, we will analyze the main causes that led to the need to replace the ball joints.

3.1 Dust cover damage

The dust cover is an essential component of the pivot, protecting the internal parts from dirt, dust, water and other contaminants. The dust cover damage that **occurred in 10/12 cases in the analyzed vehicles** has significant effects on the functioning of the pivot.

Dust cover damage can occur due to low-quality rubber, natural wear and tear from long-term use, or exposure to extreme environmental conditions (very low or high temperatures). A worn dust cover can also lead to lubricant loss, which will accelerate pivot wear.

If the dust cover is damaged, the ball joint may be exposed to contaminants which will increase friction and prevent proper operation. This can cause loss of steering stability and imprecision in vehicle handling.

The "H" vehicle from the year of manufacture 2000 had bar ends with damaged dust cover, which led to replacement of the ball joints after 45,000 km in operation.

Figure 1: *Damaged bar ends due to the dust cover cut of vehicle "H"*

Vehicle "A" from the year of manufacture 2008 had bar ends with damaged dust cover after 35,000 km of use.

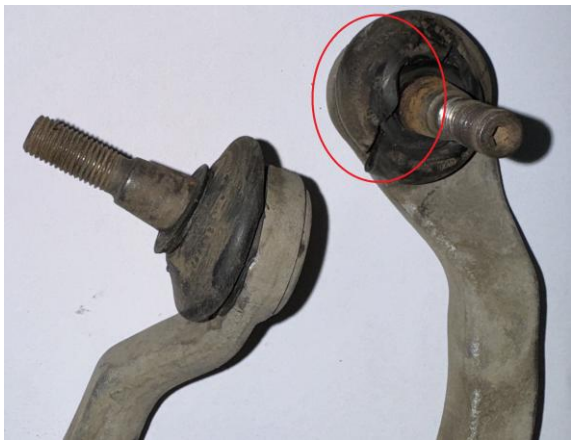


Figure 2: *Damaged bar ends due to the dust cover cut of vehicle "A"*

3.2 Wear

Ball joint wear is an inevitable process during the use of a vehicle. It occurs due to the constant friction of the internal components of the pivot and can be accelerated by several factors, such as road conditions, vehicle weight and driving style.

As a result of tribological tests carried out on the coupling of carbon steel material and plastic material of the spherical part, the friction in the spherical and ball joint couplings of the contact between the ball of the pivot pin shaft and the spherical locating bushing was studied [Watrin,2017] and the variation law of the dry contact wear coefficient at different sliding speeds and loads was identified. The determined wear coefficient is approximately.

Ball joint wear is influenced by road conditions, maintenance measures and operating conditions. Ball joints that are subjected to greater stress (e.g. on rough roads or with heavy loads) wear out more quickly. In addition, lubrication deficiencies can lead to rapid wear of the pivots.

Wear caused by friction can lead to the pivot becoming loose and steering stability will become inaccurate. Worn pivots can also lead to vibrations while riding, reducing comfort.

Vehicle "B" from the year of manufacture 2006, had original pivots that were subjected to significant wear after 188,500 km of use, which led to the need for their replacement.

Figure 3: *Worn ball joints of vehicle "B"*

Vehicle "E" from the year of manufacture 2009, after 80,000 km of use, there were signs of wear on the pivots which affected the vehicle's performance.

Figure 4: *Worn ball joints of vehicle "E"*

3.3 Corrosion (rusting) after dust cover rupture

After the dust cover are damaged, the ball joints are directly exposed to environmental conditions, and humidity, water and road salt can cause them to rust and corrode. Corrosion leads to degradation of the metal and affects the integrity of the ball joint.

Corrosion occurs more quickly when the dust cover ruptures and allows water, dirt, and chemicals to enter the ball joint. This is a major factor in areas where roads are salted in the winter.

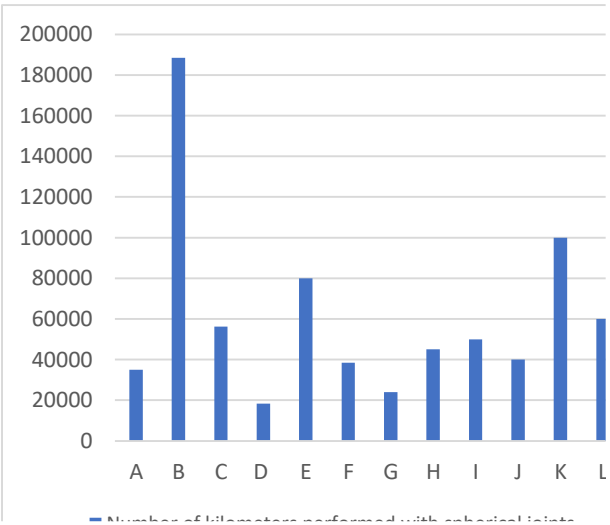
It can be estimated that if the degree of wear is more advanced, then we are in the situation of a pivot that has been operated with a dust cover broken for a longer period of time

The "F" vehicle from the year of manufacture 2003, used on rough roads, showed signs of corrosion of the pivots after 38,500 km of use, especially in conditions of increased humidity and dust, which led to the need for their replacement.

Figure 1: *Ball joint of vehicle "F" with broken dust cover*

4. Conclusions

The study conducted on the 8 ball joints and 14 bar ends on various vehicles shows that the pivots that lasted more than 80,000 km demonstrated superior performance, being considered reliable and durable ball joints.



Examples of vehicles that have recorded a longer life span of the ball joints, such as vehicle "B" from the year of manufacture 2006 with 188,500 km traveled, "K" from the year of manufacture 2008 with 100,000 km and "E" from the year of manufacture 2009 with 80,000 km, indicate that these components, in the case of correct maintenance and favorable conditions of use, can exceed a significant period of use.

On the other hand, ball joints that did not exceed 100,000 km or that failed for various reasons such as difficult road conditions or improper use recorded a lower number of kilometers traveled, which suggests a lower durability. For example, ball joints that failed faster, such as those on "D" vehicles from 2012 with 101 200 km on board, the pivot being replaced at only 18 400 km or "G" from 2005 with 263 000 km on board where the bar ends were replaced at 24 000 km, highlight the fact that factors such as the age of the vehicle, the type of road traveled and the type of use significantly influence the lifespan of the pivots.

Therefore, it can be concluded that the performance and longevity of automotive pivots depend to a large extent on the quality of original parts, regular maintenance and the conditions of use of the vehicle.

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