Analysis of procedures for assessing the technical condition of passenger car bodies after post-accident repairs

Michał Liss¹, Marcin Łukasiewicz¹*, and Aleksandr Dykha²

¹Bydgoszcz University of Science and Technology, Faculty of Mechanical Engineering, Al. prof. S. Kaliskiego 7, 85-796 Bydgoszcz, Poland
²Khmelnitskyi National University, 29016, Instytutska 11, Khmelnitskyi, Ukraine

Abstract. The rapid development of the automotive industry is associated with a large number of motor vehicles on public roads. As the number of active road users increases, the probability of a road accident increases. As a result of a collision, cars have minor or major damage, often related to damage to the vehicle's body structure. The paper discusses issues related to the assessment of the quality of post-accident repairs and their impact on the technical condition of the post-accident vehicle in further operation.

1 Introduction

In recent years, the automotive industry has been undergoing a period of rapid change, all because of one environmental paradigm that is still being lobbied and is becoming more and more widespread. At first, the direction seemed to be the right one, as it forced (through EURO standards) the development of technologies used in the broadly understood automotive industry, only to hit a wall at some point. The first such signal appeared in 2015, known as "diesel gate". It was in that year that one of the world's largest automotive concerns, known for the high quality and quality of its products, tarnished the image of the entire industry, thus setting the boundaries of conventional solutions for motor vehicles.

Less than a year later, in 2016, the first mentions of a ban on the sale of vehicles with internal combustion engines and the development of electromobility, and thus hybrid, electric and other vehicles powered by alternative fuels, appeared. Currently, the ban on the sale of conventional cars with combustion engines has been sealed in the EU and will probably be in force as early as 2035. This will be a huge challenge for the automotive industry, much greater than the one that was previously known in the form of regularly implemented increasingly restrictive exhaust emission standards.

The increasing environmental requirements for the automotive industry translated into a gradual reduction in the curb weight of the manufactured vehicles, for example through the use of technologies such as "downsizing", and later the technology of production of hybrid bodies [2,6]. While "downsizing" did not necessarily work, hybrid bodies along with all the technology have established themselves much more firmly in the automotive industry. The global direction set for the automotive industry results from many factors - smaller and larger, while the consequences related to it, while they are taken into account by vehicle manufacturers, are not necessarily regulated by legislation by the governments of individual countries. In many cases, the existing implementing rules are too general, and the procedures, methods and tools used are too outdated and inadequate to current technologies. The best example is the subjective methods of assessing the technical condition of a passenger vehicle, which are still used in vehicle inspection stations, depending mainly on the diagnostician's experience.

* Corresponding author: mlukas@pbs.edu.pl

© The Authors, published by EDP Sciences. This is an open access article distributed under the terms of the Creative Commons Attribution License 4.0 (https://creativecommons.org/licenses/by/4.0/).
Apparently, nowadays we cannot afford something more objective, reliable and certainly more reliable in terms of ensuring road safety than the trained eye and experience of a diagnostician at a vehicle inspection station. The case from 2015 and the events of the following years make us think hard about:

- national regulations, procedures, methods and tools used to assess the technical condition of passenger cars, which do not keep up with the technological development of the automotive industry,
- car companies for which economic indicators are important, thus questioning their intentions (repair technologies, regulations and maintenance activities proposed by them) regarding reliable methods and procedures of restoring the state of fitness and control tests verifying the technical condition of the vehicle,
- road safety and environmental safety, which is no longer as certain as it might seem, due to a number of cases that have been revealed by the press and journalistic investigations.

2 Vehicle body

Passenger cars are used in accordance with current regulations to carry up to nine passengers and their luggage. Nowadays, the car market is very wide and manufacturers, in response to market demand, offer a number of design solutions for car bodies [3,5]. The body is the external form of the vehicle, which binds its individual components together.

The basic function of the body of a passenger car is to ensure the transport of people and goods, ensuring an optimal level of comfort and safety of the transport process. To this end, there are a number of design solutions that increase the rigidity of the body by appropriate reinforcement or weakening of the structure – deliberately introducing, for example, crumple zones, absorbing energy during a road collision. Another way to increase the rigidity of the structure while reducing weight is the use of various construction materials, both steel and aluminum and magnesium alloys, or the introduction of plastic and composite materials [1,2,6].

The shape of the body is not only an aspect of travel safety, but also has an impact on the technical parameters of the vehicle – e.g. aerodynamic resistance, which translates directly into the operating costs of a given type of vehicle.

Due to a number of design solutions, the following division of bodies depending on the form [3,4,5] was introduced:

- closed bodies – with the roof permanently attached to the load-bearing part of the body. The basic design solutions include a sedan, limousine, coupe, station wagon,
- open bodies – with a folding roof. Popular design solutions in this segment include cabriolet, roadster, speedster, buggy,
- mixed body – depending on the results of marketing and styling research, manufacturers offer non-standard body solutions, which are a combination of different forms and types of bodies.
- body derived from passenger cars - types of delivery vehicle bodies based on passenger vehicles. We can distinguish here, for example: a pick-up body, a van.

The load-bearing structure to which all vehicle systems are attached can be the vehicle frame or the body itself. Vehicle bodies must meet a number of legal requirements, which present forms of body assessment in order to obtain approval for vehicle service, commonly referred to as homologation. During the homologation tests, the bodies are evaluated in the range of [3,4,5,6]:

- the way the lights are placed,
- type of glass,
- the method of fastening and the construction of the seats,
• air conditioning and ventilation equipment,
• the level of sound insulation,
• the location of the fuel tank,
• seat belt fasteners,
• number of airbags,
• additional equipment.

Therefore, the body of the vehicle is a very important structural element that obviously protects passengers against the negative effects of a road accident.

3 Research problem

Many would probably ask – why examine the body of the vehicle? The body of a vehicle is a unique structural element of every car, which, regardless of the road incident, has one important goal – to protect the driver and passengers from injuries, regardless of who is to blame for the incident, the type of incident (side impact, frontal collision, etc.), the duration of the vehicle's operation and the age of the people inside the vehicle. It is a construction in relation to which the following should be decisively assumed:

• clear limits on the possibility of modifying and repairing it,
• continuous development of procedures, methods and tools used to assess its current technical condition.

What for? In order to maximize the effectiveness of its operation and at the same time minimize the risk of losing one's life. The reasons why you should be interested in this area can be seen in the police statistics on the effects and consequences of road accidents and incidents.

In Poland and the European Union, in accordance with the Road Traffic Law, appropriate entities are appointed to carry out technical inspections of vehicles. Vehicle Inspection Stations operating in Poland are the last line of defence and the only bastion equipped with methods, procedures and tools to decide on the complete withdrawal or admission of vehicles to road traffic. The diagnostic tests carried out should assess the technical suitability of the vehicle in terms of both safety and environmental protection. It should be borne in mind that road safety depends not only on the technical condition of new vehicles, but also, if not to a large extent in particular, on the vehicles throughout their lifetime.

In the context of the upcoming changes in the automotive industry, the second part of this sentence is particularly important. At present, Poland ranks fifth among other European Union member states in terms of the number of passenger vehicles [7, 8].

According to current data, this number in December 2021 was 25,879,900 units and is still growing by an average of about 3% per year. Therefore, it is not surprising that the largest share in the annual reports of the National Police Headquarters [7] on road accidents falls on passenger vehicles. Statistic of the road accidents are introduced in table 1 and graphically introduced at figure 1.

Tab. 1. Statistics on the number of road accidents based on Polish police reports [7].

<table>
<thead>
<tr>
<th>Data range 2006 - 2021</th>
<th>Road Traffic Accidents</th>
<th>Participation</th>
<th>Fatalities</th>
<th>Participation</th>
<th>Injured</th>
<th>Participation</th>
</tr>
</thead>
<tbody>
<tr>
<td>total</td>
<td>36 508</td>
<td>100,0%</td>
<td>20 078</td>
<td>100,0%</td>
<td>28 324</td>
<td>100,0%</td>
</tr>
<tr>
<td>including the fault of the drivers of the vehicles</td>
<td>30 029</td>
<td>82,3%</td>
<td>16 309</td>
<td>81,2%</td>
<td>23 673</td>
<td>83,6%</td>
</tr>
<tr>
<td>bike</td>
<td>1 799</td>
<td>4,9%</td>
<td>978</td>
<td>4,9%</td>
<td>1 222</td>
<td>4,3%</td>
</tr>
<tr>
<td>moped</td>
<td>762</td>
<td>2,1%</td>
<td>404</td>
<td>2,0%</td>
<td>541</td>
<td>1,9%</td>
</tr>
<tr>
<td>motorcycle</td>
<td>929</td>
<td>2,5%</td>
<td>537</td>
<td>2,7%</td>
<td>676</td>
<td>2,4%</td>
</tr>
<tr>
<td>car</td>
<td>22 909</td>
<td>62,8%</td>
<td>12 406</td>
<td>61,8%</td>
<td>18 355</td>
<td>64,8%</td>
</tr>
</tbody>
</table>
Overall, in recent years, we have seen a situation in which fatal road accidents are becoming less and less frequent, which is of course encouraging. At the same time, however, it should be noted that out of all fatal accidents, as many as 62% of them involved a passenger vehicle, i.e. the largest group of vehicles in Poland [7].

![Road accidents, fatalities, injured in Poland](image)

**Fig. 1.** Polish police data on the number of accidents and casualties [7].

The most common causes of road accidents involving passenger vehicles are also available in reports prepared by the National Police Headquarters, but in how many cases the poor technical condition of the body was behind the mortality is difficult to determine for several reasons. Firstly, in police reports, this information is presented as the cause of the accident and not the cause of the fatality. As a result, malfunctions very often concern such elements of passenger vehicles as: defects in the steering, braking and driving systems and, in the vast majority of cases, defects in the lighting system. So, what systems are important from the point of view of mortality? Certainly, those concerning the passive safety of the vehicle [3,4,5,6,7]. As a result, malfunctions very often concern such elements of passenger vehicles as: defects in the steering, braking and driving systems and, in the vast majority of cases, defects in the lighting system. So, what systems are important from the point of view of mortality? Certainly, those concerning the passive safety of the vehicle [3,4,5,6,7].

There are two types of safety in vehicles: passive and active. Active safety as a set of factors that significantly reduces the likelihood of a collision or road accident fits perfectly into the systems mentioned above. On the other hand, a set of vehicle features aimed at minimizing the effects of a collision or road accident concerns passive safety.

The elements that have a significant impact on the level of this safety are:
- in particular, the body structure with side reinforcements, crumple zones, roll cage, etc.,
- glued glazing,
- seat belts,
- seat belt pretensioners,
• airbags,
• the structure of the chair, including headrests,
• folding steering column,
• child car seats, etc.

Therefore, in order to properly assess the technical condition of the vehicle body, which is so important from the point of view of the survivability of its users, it would be necessary to first determine the factors that negatively affect this condition. From the point of view of completely new vehicles that have been in use for some time, we can talk about various types of wear and tear. It is a certain process of changes taking place in the surface layers of the vehicle's load-bearing structure, which in turn leads to unfavourable changes in the values of structural features (geometric, material and dynamic).

One of the most popular types of wear and tear in the context of passenger vehicle bodies is certainly corrosion, the harmful effects of which are very often wrongly assessed by diagnosticians, not as a result of lack of experience, but mainly due to the lack of reliable tools to assess their impact on the technical condition of the vehicle.

In the second case, these will be post-accident vehicles, which in Poland are repaired much more often than in the "West of Europe". Some EU countries have additional and separate rules on the road clearance of vehicles after "severe" road accidents. But are additional diagnostic tests worth anything if there are still no adequate methods and tools to assess the technical condition? The answer is obvious.

There is also the following issue in the case of accident vehicles, i.e. the quality of the repair. The bodywork repair process, because this part of the bodywork and paint repair is definitely more important from the point of view of the passive safety of the vehicle, is usually carried out in accordance with the vehicle manufacturer's instructions. However, looking through the prism of the situation from 2015 and the car companies in its centre, one should ask ourselves what benefit they have in restoring the technical fitness of the vehicle in this way?

After all, in the vast majority of cases, body repairs are carried out by so-called unauthorized workshops. Even if they carry out repairs in accordance with the manufacturer's recommendations, the level of trust decreases proportionally with each subsequent automotive scandal. This trend applies in particular to those unauthorized establishments that carry out post-accident repairs of vehicles, sometimes after very "serious" road incidents.

![Fig. 2. Age structure of vehicles at the end of 2021 in Poland [8].](image)
Despite a number of changes and doubts, everything indicates that the bodywork and painting industry and the second-hand vehicle aftermarket will continue to grow in the coming years. And this, in turn, will contribute to an even greater increase in the number of vehicles used for some time, which at the moment constitutes a very large part of all passenger vehicles—especially in Poland. Interestingly, data from 2021 shows that four out of five Polish passenger vehicles have been in use for more than 10 years. Out of about 26 million passenger cars in Poland, it is about 21 million [8]. The age structure of car park at the end of 2002 year in Poland were introduced at figure 2.

Some manufacturers give a 7-year warranty and what deserves attention only under certain strictly defined conditions, but it is still less than 10 years, is it really the scale of the problem with bodies in vehicles used for more than 10 years that such a problem? Marketing has been a very tough rival in recent times. Corporations will do anything to sell (DIESELGATE, 2015), and customers will believe anything to buy (cars that offer up to 7 years of warranty, 2010).

It seems that the aesthetic functionality of the body nowadays is something that in the case of many bodywork and painting works is too important for the customer. Very often it is the paint coating that becomes the main element in the assessment of the correctness of body and paint repairs in the customer's opinion, and few people are able to verify the correctness of the bodywork work.

It is difficult for the customer of bodywork and painting services, during the acceptance of the vehicle after the repair works, to objectively verify whether the repair process allowed for the restoration of the original mechanical properties of the body, which are so important in the context of passive safety.

What's more, appraisers, court experts, experts in the automotive industry and even diagnosticians would also face a similar problem. To a large extent, we rely on the opinions of other customers or we rely on the certificates that the plants have, indicating at the same time our level of preparation to carry out vehicle repair works. This knowledge often lags behind the latest trends introduced in the world, and the human factor becomes extremely important.

4 Conclusion

In Poland, police officers have the first contact with a vehicle involved in a road accident. A police officer may be the first to decide to seize the registration certificate if he considers that the damage to the vehicle may pose a threat to the safety of other road users. Of course, whatever condition the vehicle is in, it is still in the possession of the owner, who undertakes the repair or not. Not being a specialist in this field in most cases, he gives the vehicle to the appropriate body and paint shop, authorized or not.

Regardless of the type of body and paint shop, the basic parameters for assessing and restoring the condition are the geometrical features of the body and the symmetry of the vehicle. In this case, there is little to do with the strength or rigidity of the body, which is extremely important not only from the point of view of safety, but also from the point of view of the further process of its operation. Also in this case, we have to trust the body shop to take responsibility for the repair, which in this case may, but not always, comply with the vehicle manufacturer's recommendations.

So we have a second uncertain piece of the puzzle. The first is the manufacturer's procedures, and the second is the activities of body shops and paint shops. In both cases, it is not possible for diagnosticians to verify the technical condition of the body, as well as the correctness of its repair. And yet, very often, a superficial repair of a vehicle can perfectly hide serious damage caused during a road accident, and what is worse, it can hide several such damages that occurred even earlier, in other previous road incidents or accidents. Among policemen, appraisers, court experts, diagnosticians and sheet metal workers, only
the metal sheet and body workers use any tools to assess the technical condition of the bodywork.

Insurance companies are also involved in this entire repair process. However, on the basis of a cursory inspection, they are mainly guided by financial issues, very often underestimating the real costs of repair. Also in this case, there is no question of assessing the scale of the weakening of the load-bearing structure of the body, as well as its crumple zones or other reinforcements taken into account by the vehicle manufacturer. In its activities, the insurer mainly pays attention to restoring the appearance of the vehicle to its original condition, without investigating whether the reduced valuation of the cost of repairing the vehicle may contribute to the deterioration of the level of safety of the vehicle, which will return to the roads after repair.

After the introduction of the Central Register of Vehicles and Drivers (CEPiK) in Poland, diagnosticians have access to the vehicle's history, but in the context of accident vehicles and the technical condition of the body, it has not changed anything.

Perhaps we should consider restricting the admission of vehicles that have been involved in more than three serious road accidents in order to ensure an adequate level of road safety? Certainly, like any other idea, it has its advantages and disadvantages. Unfortunately, however, this does not in any way fill the gap in the reliable and fair assessment of the technical condition of the vehicle body for all road users.

The presented material is an introduction to a broader discussion on road safety and the quality of applied procedures for assessing the condition of passenger car bodies.

References