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Researching the influence of various factors on the superficial layer materials used in car body construction and protection

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Abstract. To carry out the restoration of the car body, in addition to modern equipment for body repair and painting, it is necessary the use of high-quality consumables for body repair and painting, which are selected for each brand of car, strict following the technology of repair car body, painting work and qualified specialists in body repair and painting, as well as knowledge of the factors affecting the degradation and condition of the body and its elements to improve the quality of final results. In average value, the thickness of the protective layer varies from manufacturer to manufacturer in the range of values 80-170 μm . The use of different materials for the manufacture of vehicle components and materials for protection against external factors of the body is a major interest for the vehicle industry and is the subject of this article.

1. Introduction

Factors affecting the safety of the car body: mileage, service life and seasonality, storage conditions, climate and care. They are all interconnected. But if such as the climate do not depend on us, then the seasonality, storage conditions and care are in one way or another up to us, and therefore, they allow us to influence the durability of the car.

With seasonality is simple. If you want to use a car longer - give up driving at an unfavorable time of the year.

The storage conditions mean ambient temperature, humidity, precipitation and other influences on the car, but care - washing the car body and engine compartment, treating the paint coating, cleaning the interior.

It seems that everything is clear with the storage and maintenance conditions: the better when the car is protected from precipitation, sun and wind, and when the car is washed more often. If we remember that with an annual mileage of 15,000 kilometers, it is in motion for only about 300 hours that means less than an hour a day! And the rest of the time it stands: in a warm or cold garage, under a tent, in an open area with or without a cover storage place.

The benefits of a warm garage don't need to be described. But disadvantages: the main one is the continuation of the advantages. The higher the all-year temperature, the worse. With its growth, the ageing of protective coatings and the process of metal corrosion, if damaged, are more intense. Externally, a dry car is not at all like that. In the overwhelming majority of cases, ventilation in such garages is insufficient to dry out all hard-to-reach car body parts in a short time. If you arrive at your garage during the rain or after a wash, it's safe to say that the interior surfaces of the car body parts will stay wet for days and weeks.



The car especially suffers when stored in such a garage in the winter after returning from the street. Due to the sharp temperature difference, both the outer and inner surfaces of the body are covered with dew, which falls out of the relatively humid warm air of the garage. The amount of condensed moisture directly depends on the temperature difference and can be very significant. In some cases, damp areas can be observed on the floor along the perimeter of the body after a few minutes, as if the car had been placed in the garage immediately after washing. Outside, it dries up in a few hours. And the water that has not flowed out of the hollow body elements remains there until the next trip. In addition, the smaller the area occupied by the wet area inside the body, the more intense the corrosion process. Only a very time-consuming, carefully thought-out anti-corrosion treatment, for various reasons inaccessible to most drivers, can neutralize the negative consequences of storing a car in a warm garage. If you do not regularly take special measures, the car body gets through corrosion damage already at the beginning of the third year of operation and serves four, maximum five years.

For these reasons, it is better not to leave a warm garage without extreme need in winter.

In this sense, a cold garage is even somewhat preferable. However, in the off-season, the processes proceed quite noticeably, since when the car enters a garage, the engine and body give off heat to the surrounding small volume of air and the garage becomes warm for some time. Until the car cools in it, a corrosive process will take place on wet surfaces. And therefore, in a cold garage, a car sometimes degrades in five years [6].

Of all possible storage locations, it is preferable to keep the car under a ventilated covered storage shed. Besides the fact that it is protected from precipitation there, this type of parking has the greatest advantages. A wet car dries out here relatively quickly, and in the cold season its heated parts cool down very quickly to below-zero temperatures, at which corrosion stops.

An open parking lot, especially in winter, looks terrible: cars covered in snow, cold and windy. But this is a very well place for long-term car storage. As well as under covered storage shed, in a parking lot, the car cools down quickly and is well ventilated. The paintwork and most of the exterior parts are designed to withstand long-term exposure to solar radiation and natural precipitation. The main disadvantage of an open parking lot is that the car is not protected from dew deposition on the body, containing harmful substances from the atmosphere, as well as freezing on glass and horizontal panels of snow and ice. The exterior plastic parts also suffer from the degradation of the exterior appearance to detachment and deformation. After heavy or prolonged rains, water may appear inside the car, which means that you need to constantly monitor the condition of the floor under the rugs and in other places, find and eliminate microleaks, the number of which increases with the age of the car.

We can also see cars covered with various tent covers in open parking. This seemingly obvious protection measure has more disadvantages than advantages. The latter is that the car cover tent protects the body from precipitation, freezing of snow and ice. However, after some time, the car cover tent may be the cause of the appearance of indelible colored spots on the outer coating. This happens because the car cover tent itself, after prolonged use and repeated humidification, is impregnated with chemicals deposited from the atmosphere. The concentration of these substances in the moisture impregnating the fabric of the tent when it gets wet changes and as the water evaporates, it necessarily reaches such a value that even automobile paint cannot resist this evil solution. The whole question is only how long the car cover tent stays in this state. If it is long enough, the texture of the tent is printed on the most prominent places of the car body and this pattern can only be removed mechanically or by repainting.

In windy weather, the car cover tent scratches the paint and can cause blistering of the paint, which is especially readily formed in summer. Imagine a thunderstorm has passed on a hot summer day. Naturally, the car cover tent and the car under it got wet, then the sun reappear. Soon, the temperature under a wet and, especially, a dark case, at 100% humidity, rises by several tens of degrees. In these conditions, moisture penetrates to the metal through any smallest damage to the coating, which is always on the surfaces of the body. A localized area of corrosion occurs between the paint layers and the metal, and since the products of this process take up more space than the components from which they were formed, the body coating bubble up [5].

A particular interest is the processes associated with the drop of various kinds of chemicals from the atmosphere, which affect the durability of the paint coating and the car body as a whole.

Most often, the red rash makes itself felt. Having found small rusty spots and drips on the paintwork of the car body, many believe that "local corrosion" of the car body, associated with the poor quality of the metal, has begun to break through the paint. These fears are completely unfounded.

An attentive observer will notice that the rash is located only on the horizontal surfaces of the car body.

The rash is caused by metal particles falling out of the atmosphere. Having settled on the surface of the body, they begin to corrode and stick tightly to the body when dew or light rain falls. The rash usually disappears after a few good washes. If not, you can wash it off with a 5% solution of oxalic acid.

Corrosion of the outer seams of the car often appears. After some time of operation, the mastic that seals the outer side of the joints of body parts cracks, and corrosion products protrude from there. This is most often seen in white cars, where the leaking rusty moisture is more noticeable. The reason is winter driving on uneven roads, not cleared of ice. Due to the mutual movement of car body parts, cold mastic cracks appear. This in itself is harmless. But salt solution gets into the cracks, causing corrosion. You can deal with this by smearing the seams with a heated special compound and then wiping the surface with a rag.

Also, some studies have shown that the change in color was caused by exposure to nitric acid from the atmosphere with acid rain or fog. As the moisture evaporated, its concentration changed to such an extent that it burned through the synthetic paint.

Under the influence of sulfurous precipitation, especially the red pigment of the paint loses its color, and the blue, which is more resistant to similar influences, appears. The color change occurs to a depth of ten microns, and it could be removed mechanically. Their appearance in the future will mean a deterioration of the ecological situation in terms of sulfur emissions into the atmosphere.

The order and frequency of maintenance are of great importance for the safety of the car.

There is an opinion that the car should be washed before putting it in the garage. But during washing, water penetrates between the glass and the seals into the cavity of the doors and other joints of the body. In addition, in almost any, especially a used car, due to the loss of elasticity of the seals during washing, accompanied by a large influx of water, leaks and microleaks occur, which do not occur during driving and in the heaviest rain. No matter how dirty the car is during the trip, the hollow body cavities, which necessarily have drainage holes, are blown through by air pressure. In a garage, under a cover shed or in a parking lot, such a car dries out faster than after washing, since the bulk of the water is removed from it during the movement. In the garage, to speed up drying, it is advisable to put it with the door glasses down. From the above, it is clear that it is necessary to wash the car before the trip, and the longer the trip, the better.

However, not everything is clear here either. If the car is used all year round, is kept warm and does not have time to dry out or freeze to freezing temperatures for the next trip, it is better to wash it before putting it in the garage in order to remove dirt that retards the drying of individual cavities and parts, and in winter - salt adhering to snow.

The development of the automotive industry demands increased requirements for quality and safety, demand formation and use of new forms and materials. Carbon fiber materials most fully meet modern requirements, as they have a number of unique characteristics and demonstrate the best cost value [1].

Composite materials for cars have noticeably pushed the usual metal on the market. And not only steel, but also aluminum alloys, which until recently were considered the best in all aspects. Currently, composite materials are used to create almost any car assembly. Even concept cars are produced, the body of which consists entirely of composites.

Composite materials and products based on continuous fibers and reinforcing fabrics are widely used for the production of external car parts. Most often they do:

- Load-bearing structures - of doors and seats, protective elements of the bottom.
- Fastening elements for bumpers and radiators.
- Decorative items - interior decorative panels, external decorative panels.
- Trunk lids, body panels, brake discs, body elements, thermal and sound insulation.

Increasingly, the bodies of many types of cars (including heavy trucks) are entirely made of lightweight, durable and inexpensive carbon fiber reinforced plastics.

Composite materials for the automotive industry are primarily carbon fiber products. It has been used in the automotive industry for many years, and its use is growing every year. The most important advantage of carbon fiber is its light weight and high strength. Carbon-fiber-reinforced polymers (CFRP) is 5 times lighter than steel and 1.8 times lighter than aluminum. The use of composites in the automotive industry can reduce vehicle weight by 20-25%. This significantly increases the efficiency of the engine and reduces fuel consumption.

Carbon fibers are made from synthetic and natural polymer-based fibers. Depending on the processing mode and feedstock, materials of different structures and properties are obtained. This is the main advantage of composite materials. They can be created with initially specified properties for a specific task.

Carbon is 12.5 times more durable than steel. When we say "carbon", we remember, of course, the hoods of tuning cars. Today there is not a single body part that is not made of carbon fiber. Not only hoods are made from it, but also fenders, bumpers, doors and roofs. The weight savings are obvious. The average weight gain when replacing the hood with a carbon fiber one is 8 kg. However, for many, the main thing will be the fact that carbon parts look very stylish on almost any car.

Car carbon fiber is widely used in racing clothing. These are carbon helmets, boots with carbon inserts, gloves, suits, back protectors, etc. etc. Such equipment not only looks good, but also increases safety and reduces the weight of the suit (very important for a helmet). Carbon is especially popular with motorcyclists. The most advanced bikers dress themselves in carbon from head to toe.

The development of technology in the automotive industry is primarily associated with the development of motorsport. Observing technical progress in the development and application of composite materials, we can confidently say that in the near future there will be production cars with a fully composite body and many components and assemblies [2].

2. Methodology

Today, there are many methods for identifying the condition of the car body, which make it possible to find out not only about the damage and abnormal condition of the paintwork, but also about the areas where metal deformations have been fixed, to consider welds and any additional body reinforcements.

Car body diagnostics consists of the following steps:

- it is necessary to determine the VIN-cod of the body and compare it with the manufacturer's sample;
- second, is need to determine the actual age of the body (the exact date of the car's release) and changes in the VIN-cod of the car body;
- at the third stage, a step-by-step check of the body parameters in problem areas.

If the thickness of the paint-and-lacquer coating is scanned repeatedly and everywhere (this is possible with the help of ferromagnetic materials, aluminum and brass), then it is possible to determine the zones of corrosive destruction of the integrity of the body. This makes it possible to identify the following parameters:

1. The thickness of the paint;
2. Places of partial or complete repainting;
3. Renovates in the paintwork;
4. Deformation in the load-bearing elements of the body frame;
5. Cracks, corrosion;
6. Traces of restoration after repair.

It is now possible to carry out such an examination, since there are many modern high-tech and mobile equipment.

After collecting the data, it is necessary to analyze them by statistical methods [3].

For example, below, table 1 shows the thicknesses of the coating surfaces for different vehicle manufacturers.

Table 1. Thickness of coating for different manufacturers [7].

	Manufacturer	Min. μm	Max. μm	Avr. μm	St.dev. μm
1	Audi	90	147	118.5	9.50
2	BMW	89	165	127.0	12.67
3	Chery	105	120	112.5	2.50
4	Chevrolet	75	150	112.5	12.50
5	Citroen	75	130	102.5	9.17
6	Daewoo	95	115	105.0	3.33
7	Fiat	111	130	120.5	3.17
8	Ford	119	160	139.5	6.83
9	GAZ	80	105	92.5	4.17
10	Honda	87	145	116.0	9.67
11	Hyundai	70	130	100.0	10.00
12	Infiniti	114	147	130.5	5.50
13	Lada	60	100	80.0	6.67
14	Lexus	125	150	137.5	4.17
15	Mazda	85	130	107.5	7.50
16	Mercedes Benz	90	250	170.0	26.67
17	Mitsubishi	53	125	89.0	12.00
18	Nissan	75	150	112.5	12.50
19	Opel	110	157	133.5	7.83
20	Peugeot	58	115	86.5	9.50
21	Renault	55	140	97.5	14.17
22	Skoda	99	125	112.0	4.33
23	SsangYong	100	110	105.0	1.67
24	Subaru	110	140	125.0	5.00
25	Suzuki	77	115	96.0	6.33
26	Toyota	77	130	103.5	8.83
27	Volkswagen	70	105	87.5	5.83
28	Volvo	95	130	112.5	5.83
	Average, μm	87.46	136.29	111.88	8.14
	Standard deviation, μm	19.84	28.37	19.41	

3. Results and discussions

Today, there are many methods for identifying the condition of the car body, which make it possible to find out not only about the damage and abnormal condition of the paintwork, but also about the areas where metal deformations have been fixed, to consider welds and any additional body reinforcements. Thickness for different parts of the car is shown in table 2.

Table 2. Thickness for different parts of the car.

	Part of body	Min. μm	Max. μm	Avr. μm	St.dev. μm
1	Hood	128	142	118.5	2.33
2	Wing	125	132	127.0	1.17
3	Roof	119	135	112.5	2.67
4	Front door	108	129	112.5	3.50
5	Back door	128	136	102.5	1.33
	Average, μm	121.6	134.8	128.2	2.20
	Standard deviation, μm	3.33	2.17	2.75	

When comparing the reference and actual values of the coating layer thickness, small discrepancies of tens of microns are normal, which is associated with uneven material deposition. If the difference is hundreds of microns, then we can say that in this place the body was painted again, and an even greater increase in discrepancies indicates large-scale repair work, which includes straightening and a set of subsequent measures. A decrease in the layer thickness by several tens of microns indicates polishing with the use of abrasive materials.

The primer surfacer provides a measure of corrosion protection. The usual dip priming system is [4]:

- Anti-corrosive dipping primer: 12-18 μm ;
- Primer surfacer: 40-50 μm ;
- Finish: 45-55 μm .

4. Conclusions

The thickness of the protective layer can have a wide range of formation, especially in the second-hand vehicles market, from almost zero layer to values that exceed the maximum level provided by special measurement devices. It was noticed that the producers choose different fields depending on the possibilities they have and the market demands. In average value, the thickness of the protective layer varies from manufacturer to manufacturer in the range of values 80-170 μm . Typically, the factory paint layer on steel auto parts is no more than 200-250 microns. Readings above 250 microns indicate re-painting. Readings up to 300 microns are possible if a cosmetic defect is painted over, for example, a scratch from a key. Readings closer to 1000 microns indicate that there is still filler under the paint. The body element with such readings definitely received a strong deformation in an accident and was putty during repairs. If the work is done poorly, the paint on the putty may crack and fall off over time. More than 1000 microns is a sign of serious body repair, which means participation in a serious accident. It is better not to buy a car with a coating layer of more than 1000 microns. The maximum value is 2000 μm which the thickness gauge can display. If the layer is thicker, the device will show nothing. This means that there is a lot of putty at this point or another material is used. Carbon fiber materials most fully meet modern requirements, as they have a number of unique characteristics and demonstrate the best cost value. The body car is and will remain the basic and most important component for the car industry, so it is important to find effective design solutions and new materials to cover the demanding needs of environmental protection and the customer needs.

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