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Improving safety and reliability of Gazelle series vehicles by upgrading frame structures

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Introduction. The cargo frame is a load-bearing element of the car, since the body and chassis are installed on it. Therefore, high strength requirements are imposed on this node. For safe and reliable operation of the truck, the frame must be adjusted and balanced, since even minor changes in the geometry can negatively affect the overall condition and safe operation of the equipment. This article discusses methods for lengthening the load-bearing elements of trucks on the example of a light-duty car "GAZelle".

Problem Statement. Car frame extension is a high-tech process that requires high precision, knowledge, and the use of a wide range of equipment. The extended frame adds a number of advantages to the car, which in turn makes it possible to transport cargo with larger dimensions. The main goal of this work is to enable the car to transport bulky cargo. Also, in the process of extending the frame, it is checked for cracks, breaks and corrosion foci and, if necessary, repairs are made, which increases the reliability, safety and service life of the entire structure as a whole.

Theoretical Part. When extending the standard support, all attachments are removed from the car: fuel tanks, body, transmission, drive shaft. All that remains is the cab, the bridge, and the engine. Then the frame is cut in three places. Two cuts are made at a distance of 80 cm in the direction from the cab to the rear bridge, and the last one is made at a distance of 40 cm from the rear bridge in the direction of the rear overhang. Then a longer channel is installed on the frame. It is secured with rivets, bolts, or lap welding. After that, the structure is assembled back. This takes into account the redistribution of loads and the need for high-quality performance of all types of work.

Conclusion. The frame is an integral part of not only trucks, but also an important component of passenger cars, as well as light-duty vehicles. Its technical condition is just as important as the condition of, for example, the braking system, as it also ensures the safety of both the driver and pedestrians. The lengthening of the frame in the conditions of repair and mechanical enterprises allows you to increase the load capacity of serial cars of the GAZelle series while ensuring their reliability and safety.

Keywords: safety, reliability, load-bearing elements, car frame, welding joint, strength, load capacity, durability.

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Introduction. The car frame is the basic element that takes the load transmitted to the suspension. It is designed for mounting the main units and mechanisms. Cars with a short frame are in less demand than cars with an extended design of this basic part. Since most cargo transportation is designed for large-sized cargo, there is a need for cars with a longer body. Many of these needs are not met by manufacturers, so extending the frame in repair companies is the best technical solution.

The designs of such units can be divided into two types. The first is in the form of an elongated car body, used for passenger cars. The second — in the production of frame machines that transport bulky cargo. There are several types of car frames: ladder frame, backbone frame, fork-backbone frame and tubular frame. The advantages of such structures include uniform load distribution at road obstacles, ease of assembly, repair and maintenance of such vehicles, and increased passive safety [1].

The main goal of this work is to improve the operational capabilities of the car, as well as to increase the reliability and safety of the structure by lengthening the serial small-sized frame. The frame is the most important part of the car, so high quality is required when upgrading it.

The lengthening of the frame does not lead to an increase in its load capacity, so interference with other vehicle systems (chassis, brake system, springs, and wheels) is not required, and the safety and reliability of these systems are preserved. The upgraded frame will allow you to install a longer body on it, as a result of which the car will be able to transport large loads [2].

During the lengthening process, the geometry is maintained, all threaded connections are checked for integrity, and welded joints are subjected to thermal and mechanical treatment. The complex of these measures significantly increases the reliability and safety of the car as a whole.

Problem Statement. On many light trucks, the body is a supporting structure. It combines a number of powerful side panels that transmit the entire load. But on Russian cars of the GAZelle series, the load goes to the frame. In the last century, passenger cars designed on a frame were very popular. This was a classic assembly configuration [3]. But over time, the popularity of cars mounted on a load-bearing frame decreased due to the increase in the cost of such structures. Currently, only some SUVs and commercial vehicles with a load capacity of one and a half tons or more are equipped with frames. In this article, the modernization of frames is considered in relation to cars of the GAZelle series, the characteristics of which are shown in table 1.

Table 1

Characteristics of GAZelle cars

Car model	Capacity, kg	Basic frame length, mm	Car weight, kg	Wheelbase, mm	Rear overhang, mm
GAZ 3302-216	1500	4800	2980	2900	1580
GAZelle NEXT	1700	4920	3400	3145	1670
GAZ 33023	1800	4800	3200	2900	1550

Figure 1 shows a general view of the frame of the GAZelle car. It is made of thick-walled steel and combines two longitudinal channels. To give the structure rigidity, especially for torque effects, it has transverse elements made of pipe. In addition, the frame has two subframes. The first is for engine safety; the second contains rubber buffers and serves to support the gearbox [4]. Buffers are designed to dampen vibrations that are transmitted to the frame and body during vehicle operation. The frame design includes a suspension for the power take-off shaft. The frame has holes that serve to fix the interior on rubber shock absorbers, fixing the fuel tank, brake lines and other suspension elements. A wooden beam is placed as a buffer between the frame and the bottom of the cab body. It effectively dampens the impact that occurs when driving on uneven roads, and also does not allow the body to move on the surface of the frame. Otherwise, the body will wear out quickly [5].

Fig. 1. General view of the frame of the GAZelle car

Let us consider the structure of the standard frame (Fig. 2), which is installed on the GAZelle since 1994. The most loaded elements of the frame are the frame rails 5 and 17, connected by crossbars 1, 3, 7, 8, 11, 12, 14, 15. Fastenings of crossbars, especially with the use of angle braces 9 and 10, provide rigidity of the structure. The rear crossbar is provided with a brace 13. There are brackets 2, 4, 6, 18-22 on the frame to mount car components: power unit, front suspension, shock absorber, radiator, and buffer. The equalizing beam suspension supporting bracket is provided with a gasket 16.

Frame length is 4.84 m; width is 1.12 m;height is 0.29 m; and weight is 128 kg. The frame is designed for installation of a three-seat cab and a three-meter body. The maximum length of the body superstructure is 3.2 m. However, most car owners ignore the last parameter and install a 3.5-meter body on the frame without extending it. As a result, a longer body forms an additional load not only on the frame, but also on the car as a whole, the load on the rear axle increases, the car becomes less stable and safe on the road, and the car's maneuverability decreases [6]. To install a 4-meter body, you should install the factory frame with a length of 5.85 m.

Theoretical Part. The principle of lengthening a short standard frame is quite simple. All attachments are removed from the vehicle: tanks, body, gearbox, and driveshaft. All that remains is the cab, the bridge, and the engine. Then the frame is cut in three places (Fig. 3). Two cuts are made between the rear axle and the cab, and the last one is made in the rear of the frame. Then the lengthening channel is fixed to the frame using rivets, bolts, or lap welding. After that, the gearbox, fuel tanks, and specially extended driveshaft are re-installed [7].

Figure 4 shows the frame of the GAZelle NEXT car after its extension. The most appropriate solution is to upgrade the factory frame. Its width and length remain unchanged, and the thickness of the spars increases. The essence of the reinforcement is to install additional rolling profiles on the factory element. Various types of compounds can be used [8].

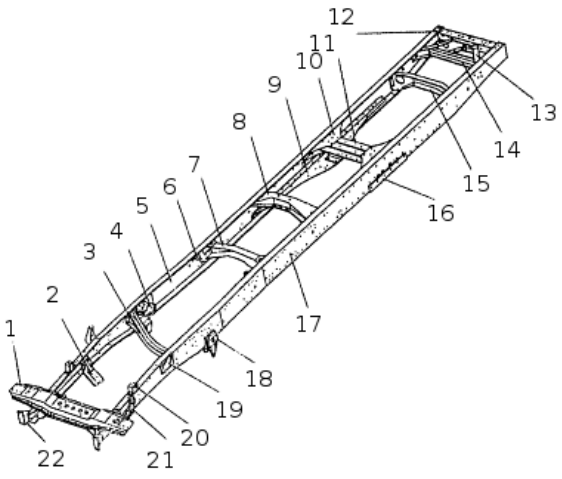

Fig. 2. Frame structure of the GAZelle car

Fig. 3. Places, where the frame of the GAZelle NEXT car is cut

Fig. 4. Lengthened frame of the GAZelle NEXT car

Often, one of the most common causes of frame deformation is the following errors in its design:

— steel grade mismatch to vehicle operating loads;

— plant savings on additional materials that strengthen the frame structure;

— mismatch of the thickness of the structural elements of the frame (spars, traverses, belts, etc.) to the working loads.

The usual GAZelle car, for example, GAZ 3302-216, has a load capacity of one and a half tons. The purpose of reinforcing the frame is to increase this parameter. Car owners expect that the GAZelle will be able to carry 2.5 or more tons, while the frame will withstand such a load. However, it is necessary to take into account the load-bearing capacity of other elements, especially the rear axle, suspension and clutch. The standard gearbox of the GAZ 3110 car, which is installed on the GAZelle, is not designed for the increased load capacity. The clutch disc may also fail in this case. In this situation, the transmission wears out, the bridge is overloaded, and the wheels fail when driving with obstacles. From this we can conclude that even with a reinforced frame the GAZelle is not able to carry more than specified in the manufacturer's specification. This is also confirmed by the fact that on the extended industrial versions of the car, the standard load capacity is 100-150 kg less than for conventional structures, since the lengthening of the body increases the vehicle's own weight. Therefore, lengthening the frame by welding is a dubious choice, and if you transport loads, they are light and bulky. The customer pays a significant surcharge for the transportation of high-volume cargo. Often, the extended GAZelle accepts cargo of the foam type at 5-ton tariffs.

Conclusion. The frame is an important part of not only trucks, but also passenger cars. Its technical condition is just as important as the condition of, for example, the braking system, as it determines the safety of both the driver and pedestrians. Now it is becoming more and more relevant to strengthen and lengthen the frames of trucks. The principle of lengthening a standard frame is quite simple. All attachments are removed from the vehicle: tanks, body,

gearbox, driveshaft, etc. All that remains is the cab, the bridge, and the engine. Then the frame is cut in three places and a lengthening channel is installed. However, its installation is accompanied by welding or the use of additional fastening elements. It should be noted that such units can be attributed to stress concentrators, so, when performing such work, due attention should be paid to the strengthening of these units.

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M. S. Dolmatov — collection of source material, preparation of the text, formulation of the theoretical part of the work, correction of conclusions; S. A. Ivanov — participation in production research, processing and registration of results; A. G. Isaev — scientific supervision, formulation of the main concept, goals and objectives of the study, formulation of conclusions.