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SPOSOBY ZWIĘKSZENIA NOŚNOŚCI I TRWAŁOŚCI POJAZDÓW

Streszczenie: Celem pracy jest zbadanie stanu naprężenia i odkształcenia ramy przyczepy BMZ-887, a w szczególności zbadanie konstrukcji spawanego zespołu ramy, w celu zbadania wpływu rodzaju konstrukcji na trwałość ramy jako całości. Przeprowadzone analizy zostały dokonane za pomocą metodą elementów skończonych, używano pakietu oprogramowania ANSYS.

Słowa kluczowe: Stan naprężenia i odkształcenia, rama przyczepy, tensometr, konstrukcja spoiny

WAYS TO INCREASE THE RESOURCE CARRIER SYSTEMS VEHICLES

Summary: The purpose of the work is to investigate the stress-strain state of the BMZ-887 trailer frame, and in particular to study the design of the welded frame assembly, to study the influence of the type of construction on the durability of the frame as a whole.
The research method is a mathematical finite element method, expressed in the ANSYS software package.

Keywords: Stress-strain state, trailer frame, strain gauge, weld construction

1. Introduction

The most pressing issue facing modern engineering is the creation of equal-strength technical systems, which will reduce the material intensity of these systems.

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Therefore, the work has investigated the stresses that occur during various kinds of loads on two types of welded parts of the frame of the trailer BMZ-887, with a kerchief and without a kerchief. Using the ANSYS software package, two types of ramie nodes were modeled. For these nodes, simulated and applied loads that occur in actual operating conditions

According to the data obtained in the course of the calculation, it was found that the models of the nodes fully correspond to the real frame nodes. It was suggested that the ANSYS software package be further used to create an optimal profile of the spar that would allow redistributing the resulting stresses over the entire contour evenly.

This work is devoted to the problems of studying the stress-strain state of welded joints of a trailer car frame. This problem is relevant, since the frame is the carrier system of the vehicle, on which the main units, loads are installed and the efficiency of the vehicle as a whole depends on its performance. The main problem that confronts modern engineering is the creation of an equally strong structure that would be able to ensure reliable and trouble-free operation of all units, and at the same time not spend a large amount of metal, which in our time is very expensive. That is, to create such a construction that will allow the redistribution of the load, so that the resulting voltages would be the same throughout the circuit.

2. Analysis of the development of damage to various structures during operation and fatigue tests

To solve this difficult problem, it is necessary to carry out a large number of field tests, which in our time are an expensive pleasure. Therefore, modern scientists have developed a software package ANSYS, which allows you to simulate using a computer a design to which you can apply all the loads arising in actual operating conditions, and subsequently observe the stresses that arise in this design. Analyzing the voltage data, determine the dangerous cross sections of the model and, using the program, redistribute them so that the design is generally of equal strength [1,2].

Experience in operation and testing shows that each design has the prevailing types of damage, regularly occurring under certain conditions of use of machines and steady quality of manufacture. The study of the nature of damage to bearing structures showed that more than 95% of the damage is made either by fatigue cracks or in zones of stress concentration, which, in particular, include welds or zones of riveted joints made it possible to single out the following stages of destruction of complex statically indeterminable bearing systems:

1) the occurrence of the first crack in one element of the system (the simultaneous appearance of several cracks with water or several elements is possible);
2) the development of a crack to the destruction of one element without affecting the system's performance;
3) the development of a crack to the destruction of several elements without damaging the system;
4) the development of cracks in the elements to the violation of the performance of the carrier system and associated units.

From an analysis of the results of operating a trailer, it has been established that the majority of damage to the frames are fatigue cracks in the zones of connection of the spars and frame crossbars. The object of research of this work is the BMZ-887 trailer, which is a structure weighing 1.7 tons, consisting of a frame, platform, chassis, drawbar, turning device, braking system, tipping mechanism, electrical equipment towed device. The frame of the trailer is welded from two spars (1), three crossbars (2), a rear carriage (3), and rear body support brackets (4) (Fig. 1).

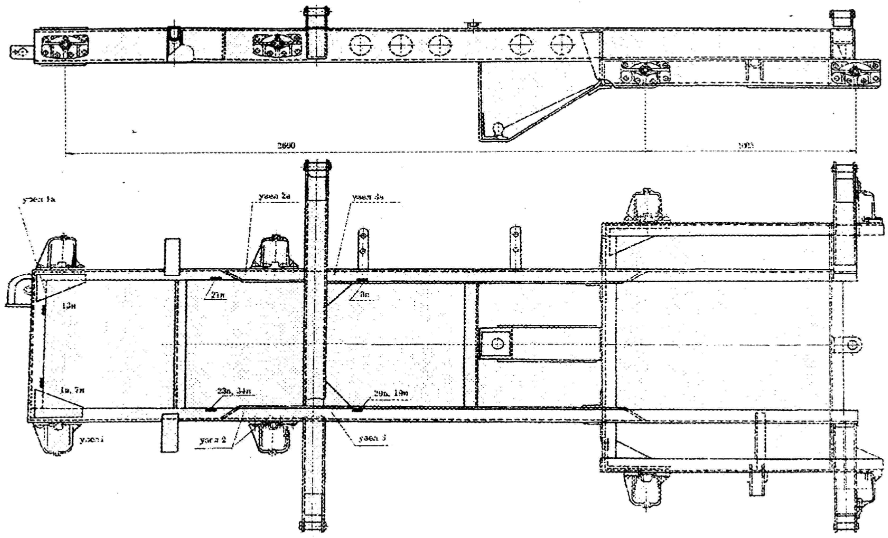

Figure 1. Appearance and layout of the strain gauges for the BMZ-887 grip frame

In the middle part of the side members have a closed profile formed by a channel and a closing plate, the ends of which go out to the rack of the channel. The first cross member of the frame is made of channel and welded to the rack and the edges of the flanks of the spar. The joints with the side member are reinforced with plates welded from above and below. The second cross member "П" - of the shaped section is welded to the side member and is covered with a sheet on top. The connection of the side members with the third cross bar of the open profile is reinforced with kerchiefs. The ends of the frame side members are welded to the rear carriage consisting of two crossbars and two longitudinal open profile beams. The connection of the beams and crossbars of the rear carriage is reinforced with sheet kerchiefs, and the connection of the frame side members with the front cross member of the rear carriage is enhanced by special brackets. Thus, in the welded frame construction, we observe two types of welded units.

3. Strain testing frame

Therefore, the purpose of this work is to study and compare the behavior of welded nodes of frames of 2 types of structures during the field testing of a trailer, the assessment of stress changes in various frame elements of the BMZ-887 trailer as the damage develops and develops in them.

Therefore, when carrying out strain-gauge studies of the frame, the magnitudes of stresses from static and dynamic loads in the zones of appearance and development of fatigue cracks during field tests and during operation are determined.
Landing tests were carried out on the track of the Mobile Technology Institute-Polygon test site (INPOMT).
Strain gages, located on the frame of the trailer BMZ-887, for the intended purpose can be divided into the following groups (Fig. 2)

1. Strain gages, covering the trajectory of the cracks of a node in conjunction with the control gages of other nodes. The purpose of this group of strain gauges is to register changes in the levels of stresses in a node depending on the appearance of cracks in it, as well as the effect of these cracks on the level of stresses in other nodes. Those the connection unit of the first cross member with kerchiefs of the left side member of the frame, the connection unit of the left side member of the frame and the insert near the front end, the connection unit of the left side member, insert and the second cross member kerchief are examined.
2. Strain gages designed to measure the voltage level along the length of the spar For the analysis, we chose two knots that have a different design, but the same cross section: the first cross member of the frame, which has a welded structure with a kerchief (node 1) and the frame spar - insert-structure without a kerchief (node 2). (Figure 2).

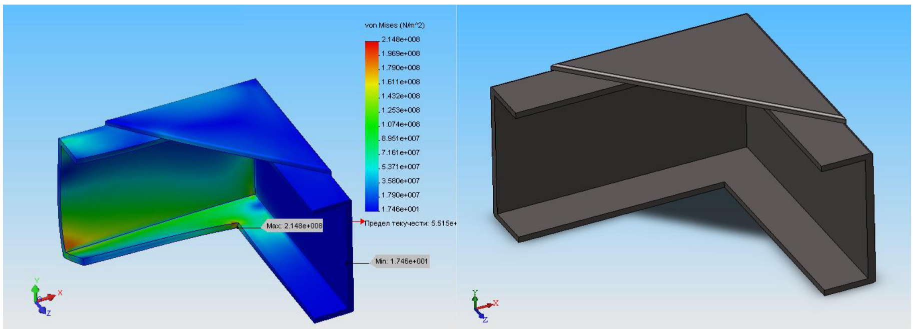

Figure 2. Structures 1 of the type of welds of the trailer frame units and stress distribution under load

3. For convenience, the assembly that represents the joint of the cross member of the frame, which has a welded construction with a kerchief, was conventionally designated as assembly 1, and the assembly joint of the frame side member — insert — a welding construction without kerchief (assembly 2).

The paper considers three states of nodes:
1 state - node 1 and node 2 are intact;
2 state - node 2 is not damaged, node 1 is damaged;
3 state - node 2 is damaged, node 1 is damaged.
In the conditions of the landfill on the frame, experiments were conducted on the selected test modes:
Experience a - lift the left front wheel 160 mm;
Experience b - lifting the right rear wheel 160 mm;
Experience in - simultaneous lifting of the right rear and left front wheels by 50 mm;

Experience g - load in the back of 5 tons.
During the experiments, the trailer speed was 10.5 km / h, the tire pressure was nominal, the length of the section was 620 m. [1].

The experiments were carried out using electrical tensometry. Strain gages were glued in places of suspected cracks at a distance of 10-15 mm from the edges of the welds. In intact nodes, the strain gages were glued in the zone of the alleged crack, and in the damaged ones - also in the zone of its end. In order to accelerate testing, cracks were induced with a hacksaw blade. The magnitude of the artificial incision was chosen taking into account the maximum possible damage to the node, for the possibility of operation and subsequent repair.

4. Analyze the stress-strain state of the trailer frame

When conducting the experiment "A", when lifting the left front wheel by 160 mm, it was observed that in the first node (in the lower part of the cross member in the area of the end of the channel) the maximum compressive stress
is concentrated max〚 σ〛_сж and the minimum voltage mix $\sigma_{\text{сж}}$ concentrated in the lower middle part of the channel. The maximum tensile stress is observed in the second node (spar) max〚 σ〛_рас in the lower part of the channel. Experience "b", "c", i.e. when lifting the right rear wheel by 160 mm or while simultaneously lifting the right rear and left front wheel by 50 mm, it shows that in the side member and cross member in the same section elements a similar pattern of stress distribution is observed as in the “a” experiment The difference is only in the numerical values of these quantities.
In the experience of "g", i.e. with a load in the body of 5 tons of a trailer, the following picture of stress distribution is observed: in the spar in its upper part, both compression and tension are observed. The same pattern is observed in the lateral region of the spar. At the bottom of the spar, an increase in voltage from sensor 33 to sensor 34 is observed, where it reaches a maximum value max $\sigma_{\text{рас}}$ In the cross section of this experience, stresses do not arise at all. Thus, in the case where the nodes 1 and 2 are not damaged, it is established that the lowermost part of the cross section and the cross member is the most dangerous element.
When conducting a series of experiments, when knot 2 is not damaged, knot 1 is damaged (the cross member and spar are trimmed in the lower parts of the knot). As a result, in the “a” experiment, we observe the following picture of the stress distribution: the maximum tensile stress on the spar and the compressive stress on the cross-beam are concentrated in the area of notches. In the upper part of the cross member, compression is observed, which is almost unchanged in magnitude. In the upper part of the spar, the following voltage distribution occurs: the compression stress is minimal.
We observe the same pattern of stress distribution in experiments “b” and “c”.
In the experiment in the “g” of the lower part of the spar, we observe the following picture: to the point of incision of the cross section, the stress is zero, and together with the end of the incision, the tensile stress sharply increases. In the upper part of the spar, a gradual decrease in the compressive stress is observed. In the lower part of the cross, there is a contraction, which is maximal at the beginning of the undercut,

and decreases towards the end of the notch. In the upper part of the cross member, there is a compression stress that does not vary in length.

From this analysis it can be seen that the lower section element of the spar and cross member remains the most dangerous, and the place of the cut end is a stress concentrator and may lead to further destruction of the section element.

In a series of experiments, when knots 1 and 2 are damaged, the cross member and the spar are cut so that the lower part of the spar and the cross member are practically cut. In this case, the following is observed: in experiments "a" - "b", compression is observed in the upper part of the spar. The lower part of the spar is observed stretching, which dramatically increases at the installation site of the sensor 22 and slowly increases towards the sensor 33 in the experience "a", "b", and vice versa gradually decrease in the experience.

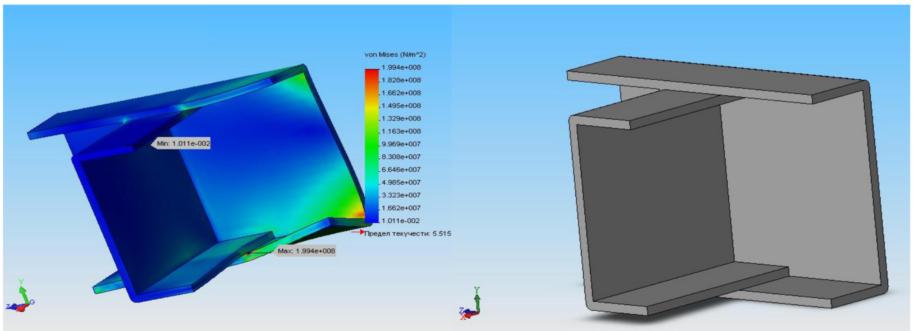

Figure 3. Structures 2 types of welded joints of the trailer frame and stress distribution under load

The voltage from sensor 34 to sensor 22 is 0 in all three cases. In the “g” experiment, in the upper part of the spar, compression is observed which gradually decreases from sensor 23 to sensor 35. In the lower part, the same picture is observed as in experiments “a”, “b”, only the voltage has a larger numerical value. In the experiments "a" - "b" for the cross member, an almost invariable picture of the stress distribution occurs.

Compression is observed in its upper part, which gradually decreases from sensor 1 to sensor 2. At the lower part, the voltage from sensor 7 to sensor 9 is equal to zero, then at the installation site of sensor 9, the compression voltage increases sharply and gradually decreases towards sensor 5 In the experiment "g" there is almost the same picture as in experiments "a" - "c", only the compressive stress in the lower part from sensor 9 towards sensor 5 remains unchanged, and the magnitude of the voltages themselves is much less.

From the analysis of the experiment it was established that despite the fact that the sections were cut, the lower elements of the section of the spar and the cross member remain the most dangerous and do not depend on the cuts made in this experiment. This means that if the frame is damaged in the direction of the cuts, it will not affect its further operation.

5. Conclusion

The same pattern is observed in the lateral region of the spar. At the bottom of the spar, there is an increase in voltage from sensor 33 to sensor 34, where it reaches its maximum value. In the cross section of this experience, stresses do not arise at all.
Thus, in the case where the nodes 1 and 2 are not damaged, it is established that the lowermost part of the cross section and the cross member is the most dangerous element. When conducting a series of experiments, when knot 2 is not damaged, knot 1 is damaged (the cross member and spar are trimmed in the lower parts of the knot). As a result, in the “a” experiment, we observe the following picture of the stress distribution: the maximum tensile stress on the spar and the compressive stress on the cross-beam are concentrated in the area of notches. In the upper part of the cross member, compression is observed, which is almost unchanged in magnitude. In the upper part of the spar, the following voltage distribution occurs: the compression stress is minimal.

We observe the same pattern of stress distribution in experiments “b” and “c”.
In the experiment in the “g” of the lower part of the spar, we observe the following picture: to the point of incision of the cross section, the stress is zero, and together with the end of the incision, the tensile stress sharply increases. In the upper part of the spar, a gradual decrease in the compressive stress is observed. In the lower part of the cross, there is a contraction, which is maximal at the beginning of the undercut, and decreases towards the end of the notch. In the upper part of the cross member, there is a compression stress that does not vary in length.
From this analysis it can be seen that the lower section element of the spar and cross member remains the most dangerous, and the place of the cut end is a stress concentrator and may lead to further destruction of the section element.
In a series of experiments, when knots 1 and 2 are damaged, the cross member and the spar are cut so that the lower part of the spar and the cross member are practically cut. In this case, the following is observed: in experiments "a" - "b", compression is observed in the upper part of the spar. The lower part of the spar is observed stretching, which dramatically increases at the installation site of the sensor 22 and slowly increases towards the sensor 33 in the experience "a", "b", and vice versa gradually decrease in the experience "c".
The voltage from sensor 34 to sensor 22 is 0 in all three cases. In the “g” experiment, in the upper part of the spar, compression is observed which gradually decreases from sensor 23 to sensor 35. In the lower part, the same picture is observed as in experiments “a”, “b”, only the voltage has a larger numerical value.
In the experiments "a" - "b" for the cross member, an almost invariable picture of the stress distribution occurs. Compression is observed in its upper part, which gradually decreases from sensor 1 to sensor 2. At the lower part, the voltage from sensor 7 to sensor 9 is equal to zero, then at the installation site of sensor 9, the compression voltage increases sharply and gradually decreases towards sensor 5 In the experiment "g" there is almost the same picture as in experiments "a" - "c", only the compressive stress in the lower part from sensor 9 towards sensor 5 remains unchanged, and the magnitude of the voltages themselves is much less.
From the analysis of the experiment it was established that despite the fact that the sections were cut, the lower elements of the section of the spar and the cross member

remain the most dangerous and do not depend on the cuts made in this experiment. This means that if the frame is damaged in the direction of the cuts, it will not affect its further operation.

From the analysis done, it can also be concluded that the design of a welded joint with a kerchief is the most durable, since stresses in the cross section are more permanent or do not arise at all.

Consequently, the stress-strain state of the BMZ-887 trailer frame, and in particular two types of welded assemblies (with and with kerchief), was studied. With the help of strain tests, stresses arising in these nodes were found, the stress pattern was analyzed, and on the basis of them it was found that the greatest stresses in the nodes arise in the zone of the lower flange of the spar, the most optimal performance of the welded unit is a welded unit with a scarf, as it is more evenly distributed.

Further study of welded units was carried out using the ANSYS software package. With the help of this program, two nodes were modeled, loaded with real loads and installed, the resulting models of nodes and the distribution of voltages in them fully correspond to real objects.

Thus, in this work, methods of studying the stress state in complex rod systems were used, and it was established that they can be used to further solve this kind of problems, since they fully correspond to the experimental data

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