SELECTION OF ELASTIC SUSPENSION ELEMENTS FOR THE SPECIAL USE VEHICLE

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Abstract

The work analyzes the possibility of using a truck chassis in terms of installing a specific device. As part of work was selected the vehicle, identified the necessary geometric parameters and the mass allowing of modernization, with particular emphasis on the required structural changes in the front and rear suspension. To this were used, the developed two phase methodology of calculation of the metal elastic elements (springs) and mechanical lateral tilt stabilizers.
Results of numerical calculations are presented in the form of recommendations to redesign of the front and rear suspension. However, in the front suspension should be made a new spring and a mechanical lateral tilt stabilizer, while rear spring suspension meets the requirements in terms of elastic characteristics (adequate the coefficient of rigidity) is required only adjustment of the static deflection of the suspension for example by adjusting the radii of leaf of the spring. Because of the design solution of the driving rear axle (so called driving axle trolley) was not proposed mechanical lateral tilt stabilizer. Paper present diagram of the forces acting on a vehicle with special equipment, results of the calculation loads acting on the suspension components fitted to a lorry with a special device, results of the calculation loads acting on the base vehicle suspension components, the basic parameters of a lorry with special hull and performance graph of the front suspension leaf spring resilience.

Keywords: *special vehicle, suspension, spring, elastic element, lateral tilt stabilizer*

1. Introduction

The driving force of modernization and the creation of new military technology are the high demands of the modern battlefield. Saturation of the battlefield by various systems of recognition, identification and destruction significantly reduces the viability of special purpose vehicles. Determines the continuous analysis of threats, analysis of current techniques and technology in vehicles and the need to improve their quality. Mainly using modern methods of calculation. The problem relates specifically to vehicles equipped with special hall creating a significant threat to the enemy. In this paper, an attempt was made to improve the ability to overcoming terrain by a car with special equipment, which presents the base version of Fig. 1.

The main objective of the work is the analyze and the selection of the elastic suspension elements (springs), and lateral tilt stabilizer for lorry (national production) in terms of adapting it to the mounting of special equipment on it. An important element of work is also experimental verification, proposed in [1, 2, 3], car suspension design methodology. The study was conducted within the framework of a special purpose project pursued in IPM WAT. The scope of work included:

- analysis and selection of the elastic suspension;
- analysis and selection of lateral tilt stabilizer of the lorry.

To realize the theme were used the implementation of the available technical documentation of base lorry and the results of research of the same or similar class lorries, pursued by other teams.

Fig. 1. Vehicle base - Star 1366 [7]

In Fig. 2 and 3 were presented front and rear suspension of the vehicle base.

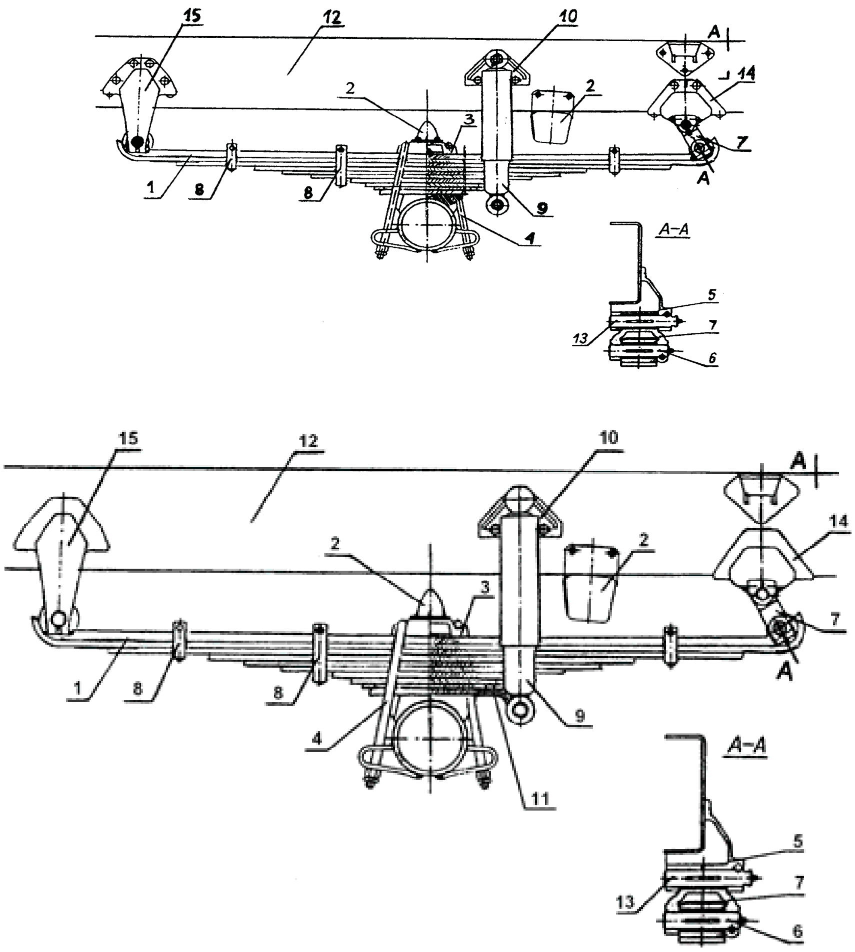

Fig. 2. Suspension front
1-master leaf of the spring, 2 - rubber bumpers, 3 - stirrup gap, 4 - stirrup of the spring, 5 – sleeve of the spring, 6 - pin of the spring, 7 - hanger of the spring, 8 - ferrule of the spring, 9 - damper, 10 - upper shock absorber bracket, 11 - the lower shock absorber bracket, 12 - frame, 13 - pin hanger, 14 - rear bracket of the spring, 15 - front bracket of the spring

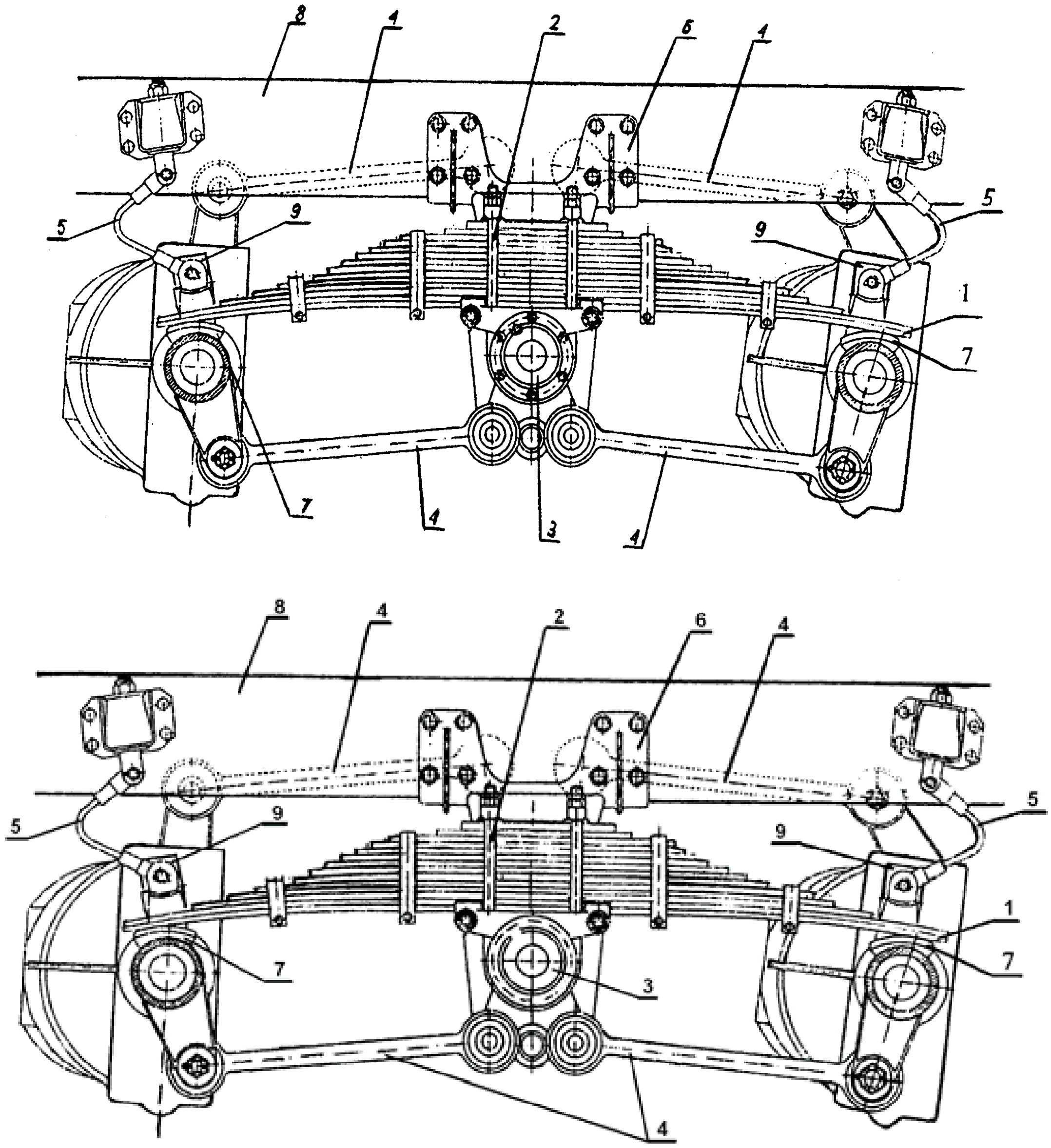

Fig. 3. Rear suspension

1- master leaf of the spring, 2 - stirrup of the spring, 3 - springs hub axle, 4-poles reaction, 5 - axles suspension link, 6 - axle springs bracket, 7 - speed-boat, 8 –frame side-members, 9 - rubber bumpers

2. Forces acting on a vehicle with special equipment

The system of forces acting on the lorry was set after the removal of the carrier box of the vehicle and mounted the hull with the special device shown in Figure 4 a and b. While the basic assumption that the device will be located on the chassis the same way as the test vehicle on the chassis of production abroad. Also assumes that the most adverse load acting on the frame and suspension of traffic occurs during a lorry with a full load under field conditions.

Table 1 compares the results of calculations for the two angles of raising a special device (α_1 and α_2). Distribution of forces is given for the unloaded and loaded device.

For comparison, in Table 2 compares the values of forces for the base version of the lorry platform. Designated distribution of forces acting on a vehicle with fitted the special device is different from the distribution of forces acting on the base vehicle. The resulting need for the calculation of a framework resistance and selection of springs, especially for the front suspension.

Fig. 4a. The vehicle with the special

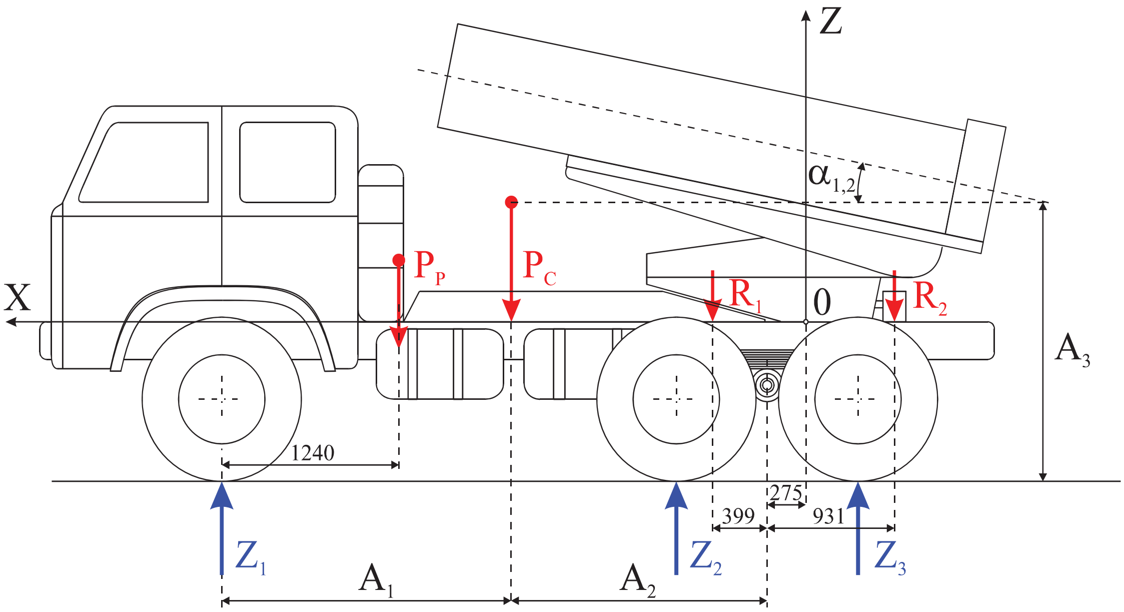

Fig. 4b. Diagram of the forces acting on a vehicle with special equipment: Pp - the force of gravity of the body without the box body; Pc - the force of gravity of a car with a special device; $R_{1,2}$ - force of the assembled device; $Z_{1,2,3}$ - normal reaction acting on the wheel axles; $A_{1,2,3}$ - the centre of gravity distance from the axis of the drive axes and from the ground

3. Calculation of suspension elastic elements

Calculation methodology for springs [1, 2, 3] was developed based on the original software that was used in the calculation of mechanical elastic elements.

The calculation is made up of two main phases:

- Stage I “Preliminary calculations” related to the so-called free spring.
- Stage II "Final Calculation" include non-linear analysis of work suspension of subsidiary with in the spring as calculated in Stage I, using the method of finite elements.

Tab. 1. Summary results of the calculation loads acting on the suspension components fitted to a lorry with a special device

The angle of the device settings	The unit charged yes / no	The load axis of the front springs R_p [daN]	The load springs rear trolley R_t [daN]	Normal reaction acting on the front axle Z_1 [daN]	Normal reaction to the rear trolley $Z_t=Z_2+Z_3$ [daN]
$\alpha_1=11^o$	yes	2580	7310	3590	9155
	no	2714	4594	3724	6438
$\alpha_2=53^o$	yes	1949	7942	2959	9786
	no	2750	4557	3760	6402

Tab. 2. Summary results of the calculation loads acting on the base vehicle suspension components

Base vehicle	The load of front axle springs R_p [daN]	The load of rear axle springs R_t [daN]	Normal reaction acting on the front axle Z_1 [daN]	Normal reaction to the rear trolley $Z_t=Z_2+Z_3$ [daN]
With the load	3413	7236	4522	9182
Without the load	2889	1890	3998	3836

4. Initial calculation of multi leaf springs

For the calculation of the initial (Stage I) uses the so-called free spring, which sets out the parameters of its design and optimization of static characteristics. It uses the classical method of calculation based on the theory of bending of straight bars. Data input for the calculation multi leaf springs is determined by the mass and geometric parameters of the vehicle and assumed the characteristics of elastic suspension. To find the optimal solution uses the method of systematically searching the area of the variables of decision, taking into account objective function - the proposed minimum weight of the spring.

The optimization methodology presented in [1], adopted the following assumptions:

- the number of leafs in the proposed spring should not exceed 20,
- thickness of leafs corresponds to the current steel industry range (PN-90/H-93219),
- long of leafs must be chosen so as to be evenly loaded,
- stress in spring should not exceed the limit established for the safety coefficient for forward spring $x=1.5\div1.7$ and for rear spring $x=1.3\div1.5$ respectively.
- pre-stress level must be chosen in such a way that showed the same fatigue life of the individual leafs,
- cross-sectional area of master leaf (so-called security) must ensure the transfer of complex loads such as during rapid braking;
- stiffness coefficients of springs should not differ from the assumed ± 10% (according to PN-90/S - 47250).

Table 3 compares the basic parameters of the mass and dimensions of a vehicle with a special device. These data provide the basis for the initial calculation of the elastic suspension of the lorry. On the basis of the mass and geometric of the vehicle (Tab. 1, 2, 3) and assumed the characteristics of elastic suspension is defined inputs to the numerical calculations of springs. In addition, the following parameters were assumed:

— stiffness coefficient,
— static deflection,
— dynamic load factor,

- spring length, the width of the leaf,
- type of material.

As fundamental for the calculation of the springs adopted load of lorry with a special device, fully loaded and set at an angle α1. Preliminary results of numerical calculations are summarized in Table 4. The results indicate that in the modernized vehicle rear springs may remain unchanged, while the front springs have to be reconstructed in order to obtain the less rigid suspension. Calculated pre-springs, you'll want to check other options for the load.

Tab. 3. The basic parameters of a lorry with special hull

No.	The name of STAR 1366 lorry parameter in accordance with the special device	Unit	Value
1	Mass of unloaded special equipment	Kg	3090
2	Mass of loaded special equipment	Kg	5690
3	Total mass of the vehicle with the unloaded special equipment	Kg	10360
4	Total mass of the vehicle with the loaded special equipment	Kg	12960
5	Overall length of vehicle	Mm	7533
6	Total width of vehicle	Mm	2484
7	Track of the front axle	Mm	2047
8	Track of the rear axle	Mm	2033
9	Wheelbase front and middle	Mm	3309
10	Wheelbase front and rear	Mm	1368
11	The distance from the front wheel axle to hub rear springs	Mm	3990
12	The radius of the static wheel	Mm	570

Tab. 4. The selected size of the proposed multi leaf springs in 1366 STAR lorry equipper with the special device

No.	Name of parameter	Unit	Spring suspension lorry STAR 1366 with the special equipment		Spring suspension of base lorry STAR 1366	
			front	rear	Front	rear
1.	Stiffness coefficient (c)	N/m	120100	280700	144000	287000
2	Number of leaf	No.	7	14	9	14
	Including master	No.	2	3	2	3
3.	Thickness of leaf	mm	12	10	12	10
4.	Static deflection of springs fs	mm	104	113	118	126

5. Final calculations

The calculation of the final (Stage II) - includes non-linear analysis of suspension of work with the spring selected in the Stage I of calculations [2, 3]. The main objective of analysis is to optimize the characteristics of the suspension through the selection of the geometry with special emphasis on springs models (MES) to calculate distribution of stress (strain) for different conditions of vertical load and the specific operating conditions (for example braking or acceleration). There are possible also adjustments of dimensions of leafs of the springs, calculated in Stage I, and designation of distribution of stresses and movements in all leafs of the springs. Fig. 6 presents selected results of final calculations for the front suspension.

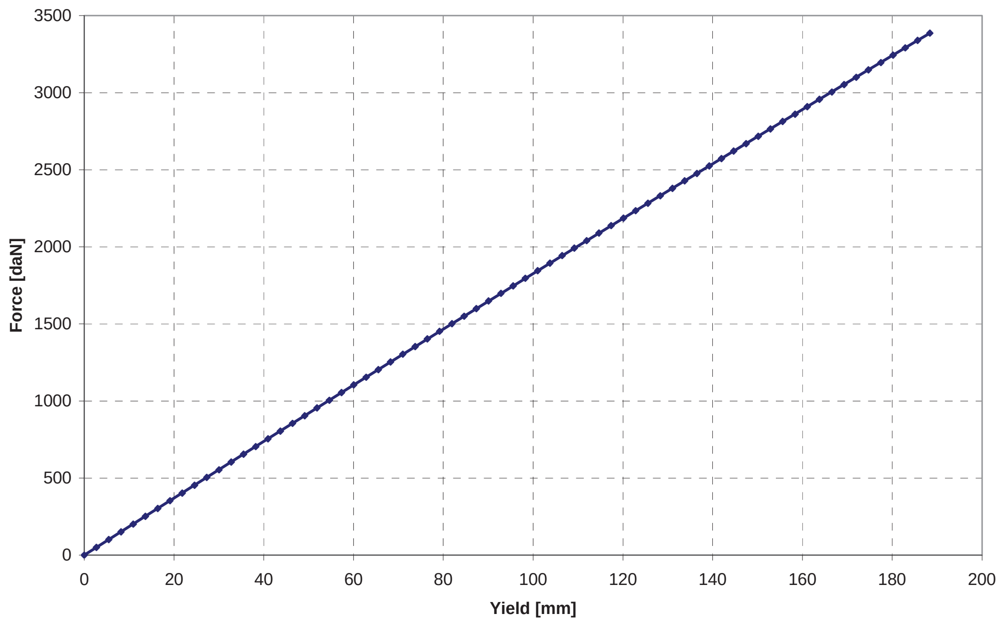

Fig. 6. Performance graph of the front suspension leaf spring resilience

6. The calculation of the tilt lateral stabilizer

Given the structural details underlying the suspension of the base lorry (front suspension equipped with conventional multi leaf springs with rockers, while the rear suspension fitted with a so-called oscillatory suspended axle trolley and equipped with reaction rod) dropped from the calculation of lateral tilt stabilizer for rear suspension. For the calculation of mechanical stabilizer tilt side were used methodology presented in [4]. As a selection criterion adopted by the limit of the lateral tilt angle of vehicle (β_{max}=0.2 rad.) for a given value of lateral force (the maximum value was adopted by the lateral acceleration a_y = 0.3 – 0.4 g, where g - acceleration of gravity).

Tab. 5. The calculation results of mechanical stabilizer of the lateral tilt of the front suspension of lorry equipped with a special device

Lp.	Name of parameter	Unit	Options	
			I	II
1.	Diameter of rod	mm	43	38
2	Length of arm	mm	450	350
3.	Distance between bearings	mm	790	860
4	Arm spacing	mm	865	1040
3.	Length	mm	790	860

7. Final comments

On the basis of carried out numerical calculations were designed and constructed springs for a vehicle with a special device. Springs have been tested on the stand than experimental studies on the real object were carried out. The obtained test results fully confirm the usefulness of the proposed methodology for the selection of the elastic suspension for vehicles.

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