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Investigation on distribution of stresses in steel and aluminium alloy arms of a car suspension system

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1. Introduction

A car suspension system consists of abundant units and details. They include elastic elements, vibration dampers & rods and arms. The principal task of a car suspension system is withstanding strong shocks of the road and their transformation into inconsiderable vibrations of the car body.

In cars, suspensions of „McPherson“ type are usually used. The structure of them is simple and they have good kinematic properties; they excellently withstand both horizontal and vertical loads. In a suspension of this type, ones of the key details are transverse arms that are usually produced of steel; however, striving to reduce the total weight of the car as well as to improve its controllability and stability on a road, the manufacturers more and more often use alloys of light metals – usually aluminium. So, the object of this investigation includes assessment and comparison of the stresses that affect steel and aluminium alloy arms, to detect dangerous points of the equipment and to offer optimum models of arms. Pursuing the said object, scientific papers where these problems are discussed upon shall be examined first of all.

In car manufacturing, multi-link suspensions are used as well; however, adjusting and designing of such suspensions is much more complicated because of their intricate spatial configuration in the structure of a car [1].

On designing elements of the suspension system of a car, using of lightweight and firm materials for their production is of the key importance. In such a way, it is strived to reduce the total weight of the car without losing a reliability of its details.

Striving to define the limits of durability of car suspension details, their real operational conditions are assessed in experiments on a road prior to mass production. However, such testing of the detail upon assessing the environment where the detail will be used by a client requires increasing financial input, so tests and experiments are carried out at laboratories upon using special stands that simulate cyclic loads of the details similar to those upon the real conditions [2].

Currently, the motor industry often applies also various computer-aided simulation techniques that enable to analyze and assess the structure of the suspension system of a car and the behavior of the latter on a road. Such programmable tools enable saving time to be spent for designing and improving new suspensions. For ensuring correct results of an analysis, a computer model should be adjusted to the operational condition of a real car suspension to the maximum possible extent. Nevertheless, an accurate simulation is a complicated task, because some factors that express themselves upon the real conditions, such as vibrations of a car, are not easily accessible [3]. However, computer-aided simulation techniques and the finite elements method (FEM) enable both saving the costs of the tests and the duration of analysis on developing or improving elements of a car suspension [4], [5].

The chosen direction of optimization is of a great importance for the durability and the weight of a detail. On simulation, it is also important to take into account the minimum weight of the detail; however, the detail should not lose its maximum strength properties when stresses appear [6]. According to the conclusions of the authors, an aluminium alloy arm optimized in correct way for several times distinguishes itself for a more even distribution of stresses and a better structural durability, as compared to the original steel detail, upon an impact of external forces on driving the car in different modes (Table 1).

Table 1

A comparison of maximum stresses (MPa) in the original steel arm and the optimized aluminium alloy arm [6]

	Braking	Driving on a turn	Acceleration	Driving across a pothole	Driving along a pothole
Steel arm	745	640	103	336	476
Aluminium alloy arm 1	246	135	85	204	282
Aluminium alloy arm 2	182	104	68.5	185	260

An arm usually consists of several parts: a cast form, pressed-in rubber-metal bushings, pressed-in or screwed-in ball joints mounted on the body or a wheel of the car. The rubber-metal bushings facilitate an acceptance of external forces and soften their transfer to the body of the car; however, any pressed-in detail causes considerable stresses in the arm itself. In addition, friction between two details causes an appearance of vibrations that, in their turn, may result considerable damages of the arm. Even the minimum motion that expresses itself by 1-100 μm oscilation between the contacting surfaces may cause a huge damage to the detail that will result shortening of its service time [7].

The external forces considerably impact the arm's resistance on acceleration of the car, it's braking or driving on a turn, so in course of designing, it should be taken into account that the suspension arm should withstand multiple cyclic loads on the road. Upon complicated operational conditions, abundant micro- and macro-stresses may appear in elements of the suspension system [8].

Particularly high loads and vibrations affect elements of the suspension system on emergency braking of the car [9, 10]. The whole suspension system should be reliable to withstand the often vibrations of the body caused by variable deceleration of the car's acceleration [11, 12].

Durability and reliability of elements of the suspension system highly depend on the values of the dynamic loads and the number of the above-mentioned cyclic loads [13]. Because of this, assessment of cyclic loads turns into one of the key factors in analysis and improvement of elements of the suspension system. However, because of different mechanical properties of the materials and varying operational conditions, an accurate assessment of the service time of the details is a hard task [2].

Striving for a light weight and the maximum possible reliability of elements of the suspension system, aluminium alloys 4032-T6 or 6082-T6 (of the class 4-6) with the limit strength of 300-400 MPa are usually used in production of arms for suspension systems of cars. The said alloys satisfy a majority of requirements set by manufacturers of vehicles, such as a light weight, a sufficient strength and environmental friendliness on processing [7, 8, 14]. In course of designing, it should be also taken into account that choosing an aluminium alloy of a higher strength causes increased costs, so an optimum version of the alloy should be chosen.

2. Chemical analysis of the metals of suspension arms and tests of hardness of metals

In the research work described herein, first of all, chemical analysis of metals of the chosen prototypical arms was carried out. The chosen *L*-shaped prototypical arms included: a steel arm of an orbicular profile for PEUGEOT 406 arm (Fig. 1, a), a steel arm of T-profile for BMW 3 (Fig. 1, b) and an aluminium alloy arm of T-profile for BMW 3 (Fig. 2).

a b

Fig. 1 The arms of the suspension systems of cars under research: a) Transverse steel arm of PEUGEOT 406 front wheel independent suspension "McPherson"; b) Transverse steel arm of BMW 3 front wheel independent suspension "McPherson"

Such arms usually are used in suspensions of "McPherson" type because they are of a simple shape and withstand transverse forces well; in addition, they are easily produced and arranged in the structure of the car [15].

In addition, a triangular aluminium alloy arm of VOLVO S60 was chosen in order to make elements analysis of suspension arm material, as the shape and construction of BMW 3 alliuminium suspension arm was not suitable for mentioned analysis. Cars PEUGEOT 406, BMW 3 and VOLVO S60 were chosen because they belong to the same market classification sector (middle-size sedans). The weights, clearance and wheel base of the said cars are very much alike, so it was accepted (upon a certain reservation) that the forces acting in their suspension systems are similar (see the Chapter 3) and their values may be used for simulation of stresses in the arms.

In order to approximate the conditions of simulation by "Solid Works Simulation" package to the reality to the maximum possible extent, when the limits of resistance are preset, it is very important to choose the material in the simulation program that precisely coincides with the material of the real arm.

Table 2

The results of analysis of elementary composition of the metals of suspension arms

Description of a detail	The content of elements in metal alloys of the arms, %											Hardness according to Brinell scale (HB)
	C	Si	Mn	Cr	Ni	Mo	Ti	Al	Cu	S	P	
Steel arm of PEUGE-OT 406	0.29	0.63	1.62	0.17	0.06	0.05	0.03	0.02	0.11	0.024	0.018	249
Steel arm of BMW 3	0.29	0.62	1.65	0.18	0.05	0.05	0.03	0.02	0.10	0.022	0.020	200
Aluminium alloy arm of VOLVO S60	Al	Si	Mg	Cu	Mn	Zn	Fe	Pb	Ti	Sn	V	180
	94.35	4.85	0.00	0.01	0.00	0.18	0.35	0.11	0.14	0.01	0.02	

Fig. 2 Transverse aluminium alloy arm of BMW 3 front wheel independent suspension „McPherson“

Mechanical properties of metals directly depend on chemical elements of the alloy, so striving to get to know the real marks of the alloys, chemical composition of the alloys was analyzed. The analysis of elements of metals was carried out upon applying the optical emission method in accordance with the standard LST CR 10320:2006 [16]. For the analysis, the optical emission analyzer ARC-MET8000 was used. The results obtained by the optical emission analyzer are provided in the Table 2.

On the base of the results of the chemical analysis, 3 steel and 3 aluminium alloys were chosen; however, striving for approximating the simulation to the real conditions and choosing one type of steel arm and one aluminium alloy with their typical mechanical properties, supplemental tests on hardness of metals were carried out in order to narrow down the search as well. The tests on hardness were carried out by Shore method (HSD) in Brinell scale (HB) (Table 2).

According to the obtained results of the tests on hardness of metals and the results of chemical analysis (Table 2), it is believable that 2 steel arms for PEUGEOT 406 and BMW were made of DIN 1.1170 28Mn6 improved quality steel with middle carbon content [17], and the arm of the suspension system of VOLVO S60 is made of ISO 4032-T6 aluminium alloy.

3. Assessment of external forces that affect elements of suspension

After clearing up the metallographic composition of suspension arms, it should be purposeful to establish the forces expectably acting upon the real traffic conditions. As it is known, the biggest longitudinal forces usually appear on sudden braking of a car and biggest lateral forces acts when the car is being turned sharply. Either forces act the suspension when the car is suddenly accelerated. In the mode of acceleration, braking or turning the appeared longitudinal and lateral forces are transferred via the wheels to the suspension and the body of the car.

On car braking, the body of the car is affected by the braking force. The centre of gravity C_m shifts forward, so a part of the vertical force affecting the rear wheel $\Delta F_{Z,C_m}$ transfers to the front axle and contributes to the acting braking force $F_{X_{fr\,brake}}$ (Fig. 3).

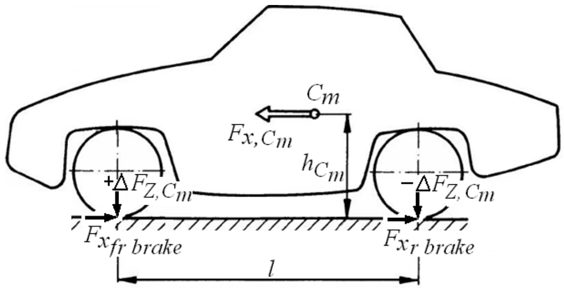

Fig. 3 The support reactions affecting the suspension on braking [15]

The value of the force $\Delta F_{Z,C_m}$ that shifts from the rear axle to the front one is calculated as follows [15]:

$$\Delta F_{Z,C_m} = \varphi_X \times m \times g \times \chi \,, \tag{1}$$

where: φ_X is the coefficient of cohesion of the wheels with the pavement in the longitudinal direction; χ is the ratio between the car's height of the centre of gravity and the wheel base, $\chi = \frac{h_{Cm}}{l}$.

The vertical force acting in the front axle and the rear axle on braking is calculated as follows:

The longitudinal braking force for the front and the rear wheel is calculated as follows (the coefficient of cohesion of a wheel with the pavement in the longitudinal direction φ_X = 0.9):

$$\begin{cases} F_{X_{fr}brake} = \dfrac{\varphi_X \left(R_{Z,C_m,fr} + \Delta F_{Z,C_m} \right)}{2}; \\ F_{X_r brake} = \dfrac{\varphi_X \left(R_{Z,C_m,r} - \Delta F_{Z,C_m} \right)}{2}, \end{cases} \tag{2}$$

where $R_{Z,C_m,fr}$ is the vertical support reaction in the front axle when the car is standing, N; $R_{Z,C_m,r}$ is the vertical support reaction in the rear axle when the car is standing, N.

It was accepted that on turning the car, the coefficient of cohesion of the wheels with the pavement φ_y = 1.0 [15]. The horizontal lateral reactions (Fig. 4) affecting the wheels of the front suspension in the point of contact with a solid surface are calculated as follows:

$$\begin{cases} R_{y\,l} = \varphi'\left((m_g g / 2)(1+\varphi' 2 h_{Cm} / B)\right); \\ R_{y\,r} = \varphi'\left((m_g g / 2)(1-\varphi' 2 h_{Cm} / B)\right), \end{cases} \tag{3}$$

where m_g is the share of the mass of the car corresponding to the front suspension, kg; h_{Cm} is the height of the centre of gravity, B is car wheel track, m.

The maximum possible traction force $P_{accel.}$ affecting the relevant axle shall be calculated according to the known methodology [15]. In BMW 3, the acceleration forces were not assessed because the car is driven by the rear wheels, so the front suspension is not affected by the longitudinal acceleration force.

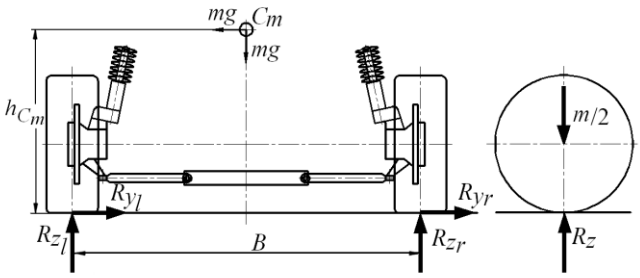

Fig. 4 Forces affecting the wheels of the car on turning

Table 3
The longitudinal and transverse forces affecting the front suspension of cars PEUGEOT 406 and BMW 3 (according to the calculation)

A car	Tractive force on a wheel, N	Braking force on a wheel, N	Transverse force on a wheel, N
PEUGEOT 406	2851	4450	6337
BMW 3	—	4310	6144

After completion of calculations for the above-mentioned cars, it was found that the average longitudinal force of about 4.4 kN appears on braking and the transverse force of about 6.2 kN appears on turning a car.

4. Distribution of stresses in the front suspension steel arms of various profiles

After metallographic tests of suspension arms and assessment of the forces affecting elements of car suspension system on its movement, it becomes possible to develop models of optimization of suspension arms with a sufficient accuracy. For the said purpose, the program package “Solid Works 2009” was used in the research work under discussion. Upon applying the package, the computer models of arms of the chosen prototypical cars (scale 1:1) were developed (Figs. 5 and 6).

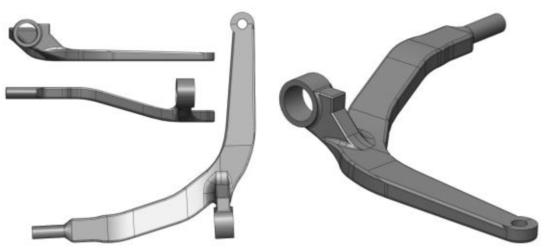

Fig. 5 The model of the front arm of PEUGEOT 406 in the environment of the program package “SolidWorks 2009”

Fig. 6 The model of the front arm of BMW 3 in the environment of the program package “SolidWorks 2009”

Distribution of stresses in steel suspension arms was explored by “SolidWorks Simulation”, the detail strength simulation supplement to the program package “SolidWorks 2009”. For PEUGEOT 406 and BMW 3 arms, metal alloy 1.1170 28Mn6 with the yield point equal to 460 MPa was chosen. In all simulation cases of suspension arms, rubber-metal bushings and ball joints were not involved into research. Simulation of loads of the suspension arms was carried out upon using the finite elements method (FEM), when the arms are individually loaded by the maximum longitudinal braking forces and transverse forces as well as simultaneously by longitudinal braking forces and transverse forces. During all simulation cases external loads were enclosed on suspension arms in place where the wheel hub is being attached to it. Vertical forces and forces which appear from stabilizer bar or steering mechanism were not assessed in mentioned simulation.

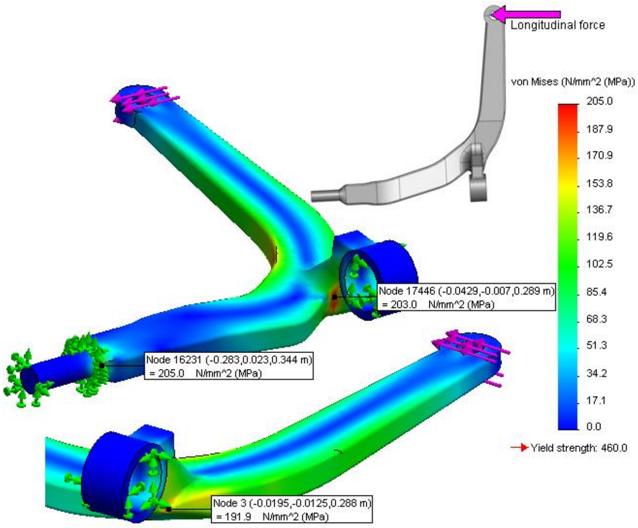

Fig. 7 Distribution of stresses in the model of steel arm of PEUGEOT 406 upon action of the longitudinal force of 4450 N

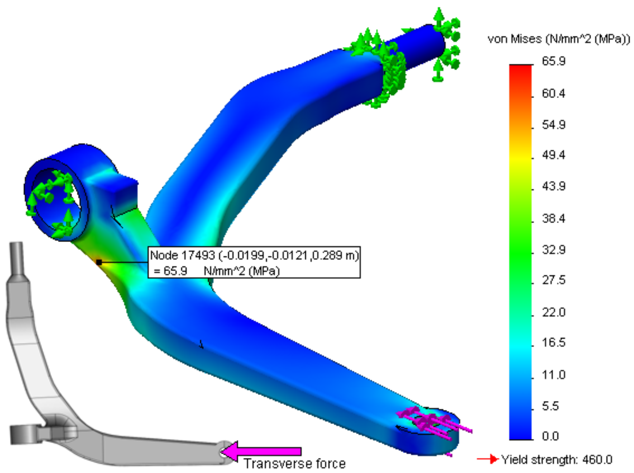

Fig. 8 Distribution of stresses in the model of steel arm of PEUGEOT 406 upon action of the transverse force of 6337 N

After formation of the model of stresses in the arm of PEUGEOT 406 front suspension, it may be seen that upon action of the longitudinal braking force of 4450 N, the maximum stresses, equal to 192-205 MPa appear at the points where rubber-metal bushings are fixed to the body (Fig. 7). The obtained results of assessing the stresses do not exceed the permissible limit of 460 MPa set for a steel detail. However, on simulation of loads of the steel arm of the same car upon the maximum transverse force (6337 N), quite even distribution of stresses is found in the detail. The formed stresses appear to be small (65.9 MPa), as compared to the permissible yield point (Fig. 8).

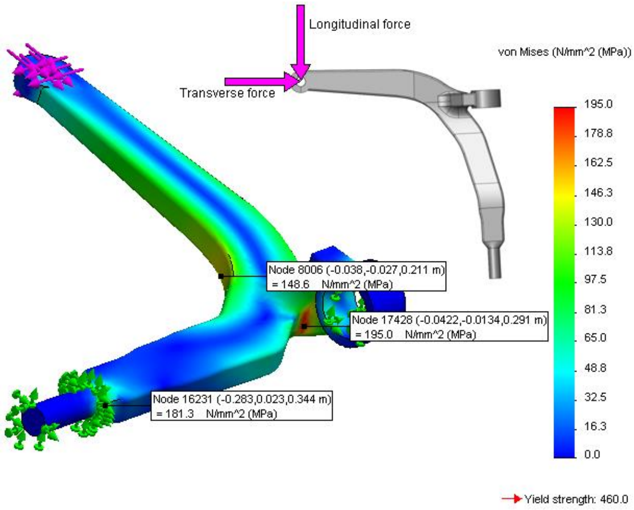

Fig. 9 Distribution of stresses in the model of steel arm of PEUGEOT 406 upon a simultaneous action of the longitudinal force of 4450 N and the transverse force of 6337 N

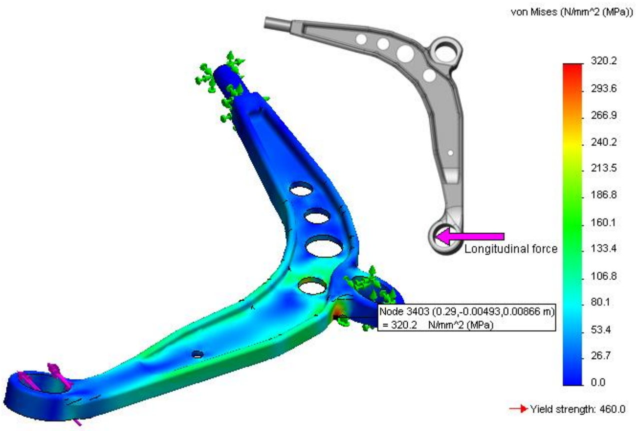

Fig. 10 Distribution of stresses in the model of steel arm of BMW 3 upon action of the longitudinal force of 4310 N

After the simulation of stresses of the arm of PEUGEOT 406 front suspension, it may be seen that upon a simultaneous action of the longitudinal braking force (4450 N) and the transverse force (6337 N), the maximum stresses of 181.30–195 MPa appear in two zones (Table 4). Such stresses do not exceed the yield point, i.e. 460 MPa (Fig. 9). The dangerous zones are the zones of fixing the detail to the body where a rubber-metal bushing is mounted.

On simulation of the element of BMW 3 suspension upon action of the longitudinal braking force equal to 4310 N, it may be seen from the obtained distribution of stresses that such a force causes the maximum stresses of 320.20 MPa at the zones of fixing the ball joint (Fig. 10). The stresses do not exceed the permissible yield point. When the same steel detail of the suspension is impacted by the maximum transverse force (6144 N), it may be seen that the maximum stresses of 95.40–98.20 MPa appear in the zone of fixing the ball joint (Fig. 11).

After simulation of the situation where the steel arm of BMW is simultaneously affected by the longitudinal and transverse forces, the maximum stresses of 320.20 MPa were found in the zone of fixing the ball joint as well (Fig. 12).

In all cases of simulation of steel arms, the maximum concentration of stresses was found at zones of fixing the rubber-metal bushings and the points of fixing the ball joint in the suspension arm. They are caused by acute (sharp) angles in the mentioned points of the arms. In other points of the arms, distribution of stresses is even enough.

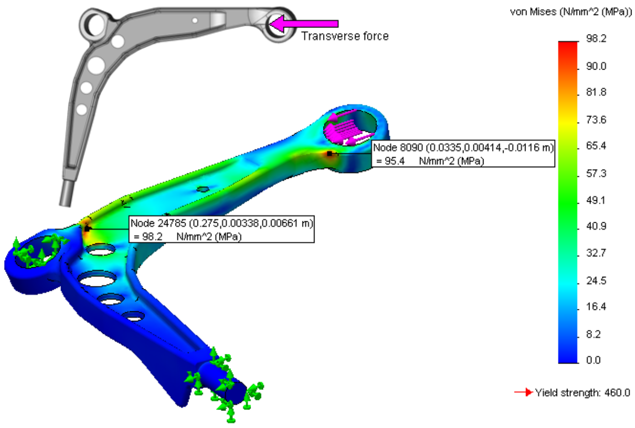

Fig. 11 Distribution of stresses in the model of steel arm of BMW 3 upon action of the transverse force of 6144 N

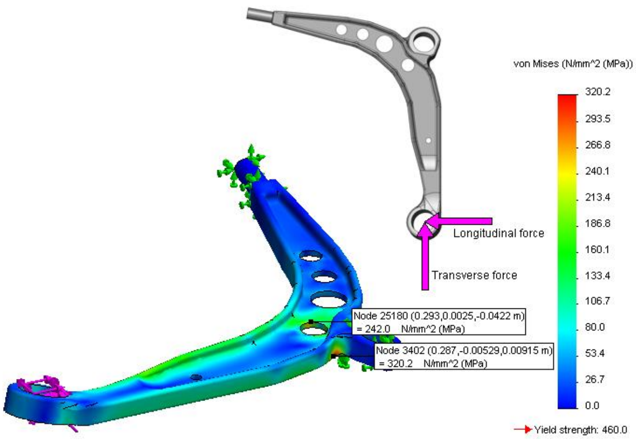

Fig. 12 Distribution of stresses in the model of steel arm of BMW 3 upon a simultaneous action of the longitudinal force of 4310 N and the transverse force of 6144 N

The obtained results of simulation of steel arms show that the stresses formed upon individual action of longitudinal and transverse forces and their simultaneous action differ inconsiderably. So, hereinafter, the arms simultaneously affected by the above-mentioned external forces will be simulated.

5. Distribution of stresses in aluminium alloy front suspension arms of various profiles

In the following phase of the research, the aluminium alloy arm-prototype of BMW 3 front suspension is simulated. Such arm under discussion may be of the same shape and profile, as a steel arm of BMW 3; however, it was found that in such a case, the value of the stresses that appear in the dangerous zones (at fixing of the bushings) equals to 321.30 MPa, i.e. it exceeds the yield point of aluminium alloy equal to 315 MPa (Fig. 13).

Because of this, as it was planned by the manufacturer, the zone of fixing includes structural changes, such as a larger arm, holes of another character and so on (Fig. 14).

Such results of simulation were obtained upon choosing the new arm made of aluminium alloy 4032-T6 with the yield point equal to 315 MPa. Upon a simultaneous action of the longitudinal braking force (4310 N) and the transverse force (6144 N), the small stresses (74.20 MPa) do not exceed the permissible yield point that equals to 315 MPa (Fig. 15).

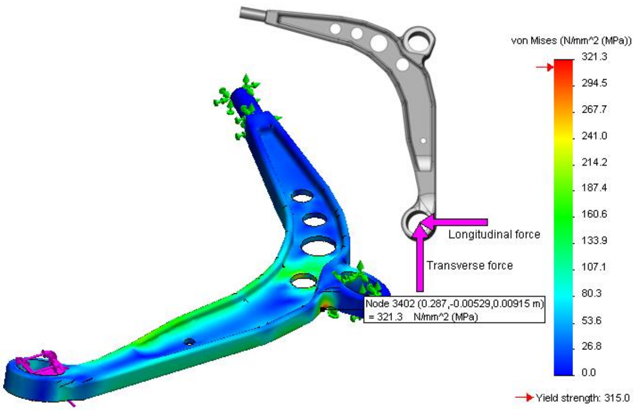

Fig. 13 Distribution of stresses in the model of aluminium alloy arm of BMW 3 upon a simultaneous action of the longitudinal force of 4310 N and the transverse force of 6144 N

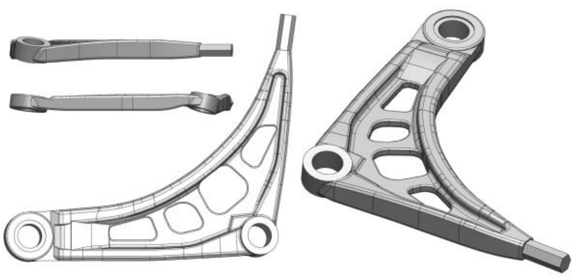

Fig. 14 The aluminium alloy arm of the independent suspension "McPherson" in BMW 3

The stresses appear at the zones of fixing the rubber-metal bushings and at structural holes inside the arm. However, all said stresses are very small, as compared to the permissible yield point. In course of simulation, it may be observed that the zone of fixing to the hub is considerably less loaded and the formed stresses are less, as compared to the analogue of a steel arm. The said effect is achieved by inconsiderable change of the shape of the arm. On designing the detail, right and acute angle and edge where concentration of large stresses may appear were avoided.

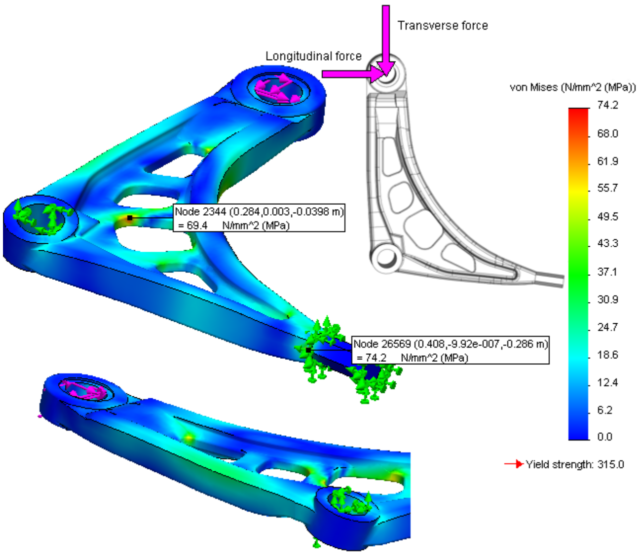

Fig. 15 Stresses in the aluminium alloy arm of BMW 3 upon a simultaneous action of the longitudinal force of 4310 N and the transverse force of 6144 N

On simulation of the distribution of stresses in aluminium alloy arm of PEUGEOT 406, it was found that, in contrast to the arm of BMW 3, the aluminium alloy arm of PEUGEOT 406 shows a sufficient strength in the dangerous zones upon no changes of its sizes or shape. It was found that if the arm of PEUGEOT 406 is made of aluminium alloy 4032-T6 and is simultaneously affected by the above-mentioned external longitudinal and transverse forces, stresses of 176.20–194.70 MPa appear in zone of fixing the rubber-metal bushing. The said stresses do not exceed the permissible yield point of the aluminium alloy that equals to 315 MPa (Fig. 16).

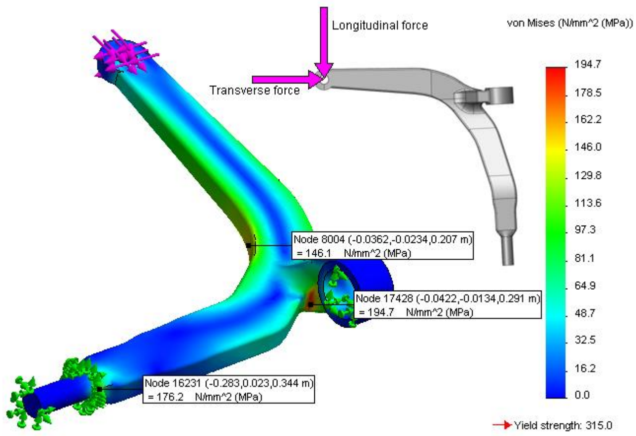

Fig. 16 Distribution of stresses in the aluminium alloy arm of PEUGEOT 406 upon a simultaneous action of the longitudinal force of 4450 N and the transverse force of 6337 N

However, it should be taken into account that driving a car across a pothole, larger forces may appear in the car suspension system (not assessed herein) and the lower yield point of aluminium alloy may appear to be too low, so the resulted value of the reserve coefficient for resistance to deformations may be too low. So, striving to explore whether a change of a dangerous part of the aluminium alloy arm really causes a more even distribution of stresses, a supplemental model of the arm of PEUGEOT 406 with a changed shape of the detail was developed (Fig. 17), where acute angles at the zone of fixing rubber-metal bushing were avoided. In this case, the chosen mark of aluminium alloy was 4032-T6 as well (the permissible yield limit 315 MPa).

The results show that upon a simultaneous action of the maximum external longitudinal and transverse forces, the stresses in the newly designed part at the zone of fixing rubber-metal bushing are small – 20-30 MPa (Fig. 18). The maximum stresses (136.50 MPa) appeared at the internal bending of the arm's shape; however, they did not exceed the permissible yield point (315 MPa).

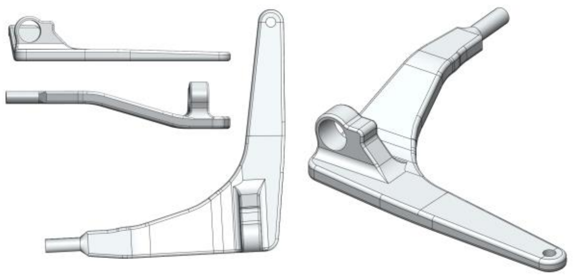

Fig. 17 The aluminium alloy arm of a changed shape in the front suspension of PEUGEOT 406

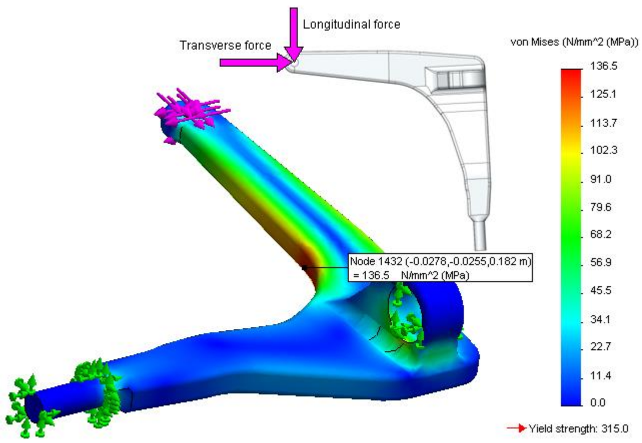

Fig. 18 Stresses in the improved part of the aluminium alloy arm of PEUGEOT upon a simultaneous action of the longitudinal force of 4450 N and the transverse force of 6337 N

On summarizing the results of simulation of stresses in aluminium alloy arms, it may be stated that the shape of arms usable in suspension systems of cars should be even, free of acute (sharp) angles and the casting should be precise to the maximum possible extent to avoid stress concentration. In addition, the obtained results show that in case of using aluminium alloys, the weights of the arms were reduced by about 30% – 50% (Table 4).

6. Conclusions

After a completion of the research on distribution of stresses in arms of car suspension systems, the following conclusions were formulated:

1. It was found that the lower arms of the front suspension of PEUGEOT 406 and BMW 3 are made of DIN 1.1170 28Mn6 steel with middle carbon content and the hardness of 249 Brinell scale (HB).

2. On simulation of the strength properties of steel arms of suspension systems in PEUGEOT 406 and BMW 3, it was found that on various combinations of loads (such as the longitudinal braking force, the transverse force, simultaneously acting maximum longitudinal and transverse forces), concentration of stresses at the dangerous structural zone (rubber-metal bushings and ball joints) does not exceed the permissible yield point of 460 MPa. The maximum obtained value of stresses (320.20 MPa) was obtained on a simultaneous affect of the maximum longitudinal and transverse forces upon the arm of BMW 3.

3. When the arm of aluminium alloy 4032-T6 of a shape identical to a steel arm was used in PEUGEOT 406 and the said detail was loaded simultaneously with the maximum longitudinal and transverse forces, the stresses of 194.70 MPa (i.e. not exceeding the permissible yield point of 315 MPa) appeared in the zone of fixing the rubber-metal bushing. However, in contrast to the case of simulation of the aluminium arm in case of PEUGEOT 406, in case of simulation of aluminium alloy arm of BMW 3 (the the shape and the sizes identical to the ones of a steel arm), the appeared stresses (321.30 MPa) exceeded the permissible yield point of aluminium alloy, so the arm will not withstand a simultaneous impact of longitudinal and transverse forces. When the retrofitted aluminium alloy arm of BMW 3 (with changed shape and sizes) is simultaneously loaded by the maximum longitudinal and transverse forces, the stresses of 74.20 MPa appeared at the zone of fixing the rubber-metal bushing are evenly distributed in the shape of the arm and do not exceed the permissible yield point of 315 MPa.

Table 4

The comparison of the results of simulation of steel and aluminium alloy arms of the front suspension of cars PEUGEOT 406 and BMW 3

Suspension arms	Formed maximum stresses, MPa	Yield point of the material, MPa	Density of the material, kg/m³	Weight of the detail, kg
L- shaped steel arm of PEUGEOT 406	205.00	460.00	7850	4.20
L- shaped aluminium alloy arm of PEUGEOT 406	194.70	315.00	2680	1.40
Aluminium alloy arm of of a changed shape of PEUGEOT 406	136.50	315.00	2680	1.90
L- shaped steel arm of BMW 3	320.20	460.00	7850	3.50
L- shaped aluminium alloy arm of BMW 3	74.20	315.00	2680	2.50

4. In order to reduce the value and concentration of stresses in the aluminium arm of PEUGEOT 406 in the zone of fixing the rubber-metal bushing, the structural shape of the detail was little changed and simulation of longitudinal and transverse forces was performed. The obtained stresses of 136.50 MPa do not exceed the permissible yield point of 315 MPa. Although arm with changed shape can be more optimized, primary results shows that striving for a reliability of elements of the car suspension system (satisfaction of the strength properties set for them), it should be purposeful to produce suspension arms (both of steel and aluminium alloy) with even surface, free of acute angles or sharp edged. In such cases, avoiding foci of stress concentration is expectable.

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ĮTEMPIŲ PASISKIRSTYMO LENGVOJO AUTOMOBILIO PAKABOS PLIENINĖSE IR ALIUMINIO LYDINIO SVIRTYSE TYRIMAS

R e z i u m ė

Lengvojo automobilio pakabos elementai vis dažniau gaminami iš lengvų, bet stiprių aliuminio lydinių. Lengvesnė pakaba leidžia sumažinti bendrą automobilio svorį, degalų sąnaudas ir pagerinti valdomumą ir stabilumą kelyje. Šiame straipsnyje išnagrinėti lengvųjų automobilių priekinių tiltų pagrindiniai „McPherson“ pakabos elementai – skersinės svirtys. Išanalizuotos išorinės jėgos, veikiančios pakabos svirtis automobiliui važiuojant skirtingais režimais. Nagrinėjant automobilių PEUGEOT 406 ir BMW 3 priekinės pakabos svirčių prototipus, atskleistos pavojingų įtempių tam tikruose svirties konstrukciniuose taškuose priežastys, pakabos svirčių optimizavimo galimybės,. Nustatytos išorinės jėgos, veikiančios automobilio pakabą apskritai, ir, naudojant kompiuterinio modeliavimo paketą „SolidWorks 2009“, minėtų automobilių pakabos kreipiamųjų elementų (svirčių) pagrindu sudaryti kompiuteriniai modeliai, Norint sužinoti tikrąsias lydinių markes bei priartinti modeliavimą prie realių sąlygų, atlikta metalų cheminė analizė ir metalų kietumo bandymai. Atliktas įvairių *L* formos profilių tiek plieninių, tiek aliuminio lydinio svirčių apkrovų modeliavimas.

Remiantis tyrimų rezultatais aptikti pavojingiausi svirčių konstrukcijos taškai. Pateikta rekomendacijų ir pasiūlymų, kaip tobulinti aliuminio lydinio svirčių konstrukcijas, kad atlaikytų dideles išorines jėgas.

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INVESTIGATION ON DISTRIBUTION OF STRESSES IN STEEL AND ALUMINIUM ALLOY ARMS OF A CAR SUSPENSION SYSTEM

S u m m a r y

Elements of a car suspension system more and more often are made of light and firm aluminium alloys. The lightweight suspension enables reducing the total weight of the car and the fuel consumption; in addition, it enables improving controllability and stability of the car on a road. In the Paper, transverse arms that are the principal elements of the front axle "McPherson" suspension system are discussed upon. The external forces that impact the suspension arms on driving a car upon different modes are analyzed. In course of analysis of prototypes of the front suspension arms in cars PEUGEOT 406 and BMW 3, the causes of dangerous stresses in certain points of the arm's structure and the opportunities of optimization of suspension arms were analyzed. The external forces that impact the car suspension were established; on the base of the above-mentioned guiding elements (arms) of a car suspension, computer models were developed upon applying the computer-aided simulation package "SolidWorks 2009". Striving to get to know the real marks of the alloys and to bring the simulation more in line with the real conditions, chemical analysis of metals and tests on metal hardness were carried out. Simulation of loads of L-shaped steel and aluminium alloy arms of various profiles was performed as well.

On the base of the results, the most dangerous points in arm structure were detected. The recommendations and proposals for improving the structure of aluminium alloy arms in order to make them able to withstand large external forces were provided.

Keywords: "McPherson" suspension, aluminium alloy and steel arms, knuckle, tansverse and longitudinal forces, chemical composition of metals, metal hardness, stresses, yield.

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