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T. F. Arkhipova

MOTOR VEHICLE DEFORMATION ENERGY UNDER CONDITIONS OF TRAFFIC ACCIDENTS

Vinnytsia National Technical University, Vinnytsia

Анотація: *На прикладі експертизи дорожньо-транспортної пригоди отримано вихідні дані для визначення величин швидкостей автомобілів, а також їх енергії деформації, яка була накопичена при зіткненні двох автомобілів. Застосування цього методу в даній роботі дозволило розв'язати задачу оцінки енергії перед зіткнення на основі натурних випробувань. Розроблений метод еквівалентної оцінки енергії деформації транспортних засобів дозволяє незалежно від метода твердості оцінити швидкість транспортних засобів.*

Ключові слова: енергія деформації, автотранспортні засоби, дорожньо-транспортна пригода, метод твердості, метод енергетичного еквіваленту

Abstract: *On the example of technical expertise, initial data were obtained for determining the values of vehicle speeds, as well as their strain energy absorbed upon impact. Developing these approaches, in this paper we solve the problem of estimating the pre-impact energy based on full-scale tests. A method for estimating the energy of deformations of vehicles under conditions of traffic accidents has been developed.*

Key Words: strain energy, vehicles, traffic accidents, technological legacy, hardness method, energy equivalent method.

In order to assess the deformation energy of cars 1 and 2, which received deformations as a result of traffic accidents (TAs), the volumes of damage to car structural elements were studied. These elements were photographed, and the hardness at the nodes of a pre-applied dividing grid with a base of 50 mm was measured using a portable hardness tester «Темп-3».

Following the works [1-3], the costs of plastic deformation and destruction of vehicle structural elements were determined by the formula:

$$W_{cap} = W_0 exp\frac{lnk_H/D}{C}, \tag{1}$$

where W_{cap} – specific potential energy, J/cm^3,

$k_H = \frac{(H_T)_i}{(H_T)_0}$, $W_0 = \frac{\sigma_{0.2}^2}{2E}$ – elastic specific potential energy, J/cm^3,

$\sigma_{0,2}$ – material yield strength, *MPa*,

E – modulus of elasticity of the 1st kind (Young's modulus), *MPa*.

D and C – curve fitting coefficients $k_{HT} = f(k_W)$.

The value of W_{cap} was also calculated using the formula:

$$W_{cap} = \int_0^e \sigma_u \, d\varepsilon_u, \tag{2}$$

where σ_u – stress intensity, *MPa*, ε_u – strain intensity (dimensionless value).

The curve $\sigma_u = f(\varepsilon_u)$ in the theory of plasticity is called a single flow curve [4-6], which does not depend on the type of stress state. It was approximated by the equation:

$$\sigma_u = A\varepsilon_u^n, \tag{3}$$

After substituting (3) into (2), we obtain:

$$W_{cap} = A\int_0^e \varepsilon_u^n \, d\varepsilon_u = A\frac{\varepsilon_u^{n+1}}{n+1}, \tag{4}$$

where A, n – flow curve approximation coefficients that have a physical meaning:

A – yield stress (in *MPa*) at strain intensity ε_u =1,

n – the degree of deformation corresponding to the maximum load on the conditional tension diagram.

The value ε_u in formula (4) was determined in each specific case either by hardness (by k_H) or by the diagram of plasticity or stability [7].

Material property data obtained by identifying material properties [7].

According to this work, the initial yield strength $\sigma_{0,2}$ (*MPa*) is brought into line with the initial hardness Hm_0, following the equation:

$$\sigma_{0,2} = B+0,33Hm_0\ , \tag{5}$$

where coefficient B when measuring hardness with a hardness tester "Темп-3" is equal B = 176. The initial yield strength $\sigma_{0,2}$ is put in accordance with the coefficient of approximation of the flow curve of materials, following the equation:

$$A = 1000\cdot exp(-0,0008\ \sigma_{0,2}), \tag{6}$$

where A – equation approximation factor (3).

Coefficient n in formula (3) for various materials used in the automotive industry, is within $0,35 \le n \le 0,1$. It can be found from the equation:

$$N = 0,35exp(-0,0008A), \tag{7}$$

The value of W_{cap} obtained by formulas (1) and (2) was multiplied by the volume of the deformed metal of the structural element, which made it possible to calculate the value of the total potential strain energy:

$$W_{def} = \Sigma(W_{уд})_i\cdot V_i\ . \tag{8}$$

As a result of summing up the energy costs for all the listed damaged structural elements of cars 1 and 2, the following values of the strain energy were obtained, respectively: W_{def1} = (35500..36000) J and W_{def2} = (23500..23950) J. The deformations of cars 1 and 2 are determined by the energy intensity constants in accordance with [2].

Conclusion

The method has been developed for estimating the energy of deformations of vehicles under the conditions of traffic accidents. On the basis of full-scale tests, the strain energy can be determined by the energy equivalent method and the hardness method. Satisfactory convergence of the results of calculating the strain energy by two methods is shown.

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Arkhipova Tetiana – Ph.D., Docent, Docent of the Department of Strength Materials and Applied Mechanics, Vinnytsia National Technical University, e-mail: tfarhipova@ gmail.com