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THE DESIGN-THECHNOLOGICAL METHODS TO GUARANTEE THE RELIABILITY FOR THE ROLLING STOCK OF THE RAILWAY

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Summary. The design-technological methods of increase of reliability of railroad underframe frictional dampers have been given. Technological ways of increase of strength and wear resistance were developed that allowed quantitatively to estimate a reserve of increase of strength and thermal wear resistance by methods of plastic deformation.

Key words: reliability, friction damper, rolling stock, railway.

INTRODUCTION

Increase of profitableness and competitiveness of railway transportation in many respects depends on an opportunity of its adaptation to a modern tendency of development of global transport system as a whole, which is characterized by raising average and maximal speeds of movement of vehicles.

Alongside with advantages of internal-economical character, the decision of this problem will allow to improve the investment attractiveness of Ukraine, as the states capable to provide an effective railway communication between the European Union and the countries of Transcaucasia, Central Asia and the Far East by means of transit transport corridors.

Achievement of the set object assumes radical qualitative transformation of a railway transformation of Ukraine, including, first of all, track and locomotive facilities, and carload park also.

The prime and urgent tasks are modernization of outdated rolling stock of railways and creation of the new rolling stock, satisfying the modern requirements on parameters of operational properties and reliability.

Operating experience of railway transportation has shown that mobile mating units are the least reliable elements of rolling stock underframe part. The reason of it are complex conditions of their operation characterized by a high level of working temperature, frequency of interaction and the stressed state of contact area of working elements, and influence of climatic factors also. The consequence of it is deterioration of stability of operational characteristics both mobile mating units and a rolling stock as a whole. First of all, it concerns to frictional dampers, responsible for leveling of high-frequency oscillations of spring superstructure, with are displayed which rise of movement speed of rolling stock.

THE ANALYSIS OF CONDITIONS OF OPERATION OF PASSENGER CAR UNDERFRAME AND THE CAUSES OF REDACTION IN STABILITY OF WORK

Increase of traffic safety is the main task at designing and operation of rolling stock which is used in extremely complex and severe conditions. The large distances, high daily average runs a wide range of change of climatic conditions and other features of their work of rolling stock demand creation of highly reliable constructions with the big safety margins of such important units, as oscillation dampers. The investigations, which have been carried out by many authors [Chelnokov I.I., 1963], have shown that the heightened wear of parts, impacts in work, possible seizures and significant instability of friction coefficient are usually characteristic for the frictional dampers and these factors are principal causes of reduction of the general operation reliability. Main factors of instability are violation of manufacturing techniques of frictional elements, deviations of the sizes of separate details and imperfection of a structural design with the big sensitivity to change of friction coefficient.

In the article the problem of increase of operational reliability of the main friction pair frictional damper of oscillations of the passenger carriages, which are used in heavy conditions of operation is accomplished due to constructive change of geometry of the main friction pair and technology of its manufacturing.

Basic elements of the frictional oscillation damper are the shpinton sleeve 1, which together with six frictional slide blocks 2 forms the main friction pair (fig. 1). Moving in the process of oscillations of the running part of the carriage, the frictional blocks 2 are retained against the shpinton sleeve 1 by special conical rings 3, 4, lower of which through the rubber shock-absorber acts on a wing of an axle box, and inner spring acts on the upper ring.

The conditions of operation of friction pair are following:

- pressure of friction surfaces – no more than 2 MPa;
- speed of relative sliding of pairs – 0,1-0,2 m/s,
- duration of one cycle of loading– 0,2-0,4 s,
- hourly average number of loading - 200-1500 cycles.

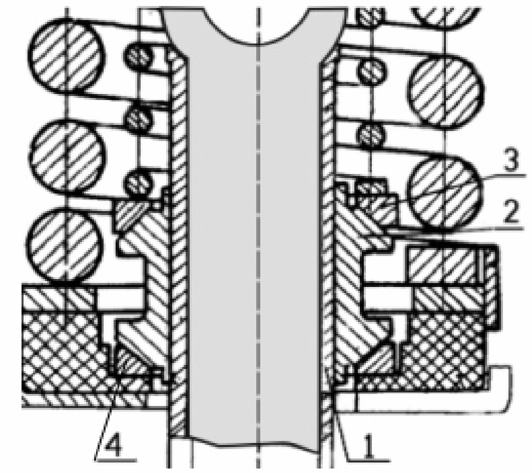

Fig.1. The components of friction damper
1 – shpinton sleeve; 2 – frictional slide block; 3 – conical rings; 4 - shpinton

The analysis of operational conditions of underframe of the passenger car has shown that the principal cause of deterioration of operational parameters of a train is wear of the mobile mating units connected with a change of geometry of mating surfaces. It is established, that change of geometry of mating units lead to a change of force characteristics of damping devices, to increase of displacements and acceleration of car body, to the raised wear of running parts and autocoupling devices, and also to the increase of stressed state in a frame of the carriage.

The investigation of the reasons of wear of mobile mating is made by the example of passenger car frictional damper. The investigation of units (528 units), taking place in operation, with the use metallographic methods have allowed to establish the reasons of catastrophic wear. The principal cause of intensive wear and violation of stability of damper characteristics consists in local overheat of separate sites of the middle link (the shpinton sleeve), resulting in dripping and tearing out of the metal. It lead to the change of structure of the metal with formation of ferrite network on borders of grains, to decrease in wear resistance and formation of wear out on a working surface [Gubacheva L.A., 2005; Gubacheva L.A., Naish N.M. 2005].

The basic parameter of reliability such as probability of non-failure operation was used for comparative estimation of the variants of constructions. This parameters was determined on the results of train tests with use of a special method of statistical processing [Gubacheva L.A. 2006], at which the normal law of distribution was determined by two two-parametrical functions of distribution of random variable – by density of distribution and function of distribution. The function of distribution determines the probability of non-failure operation P(t).

It is established, that the most worn elements of the frictional damper at run of the car, for example, 0f order of 400 thousand in km were the shpinton sleeve (P (t) =0,805) because of the wear and frictional blocks (P (t) =0,965) because of having broken away edges. New constructive decisions of the main friction pair friction and the technology manufacturing of its elements are necessary for increase of wear resistance of these links.

Besides the analysis of operation has shown, that serviceability of dampers depends not only on speed of wear of main friction pair, but also its geometry. The most vulnerable part is the shplinton sleeve. The special profiling and increase of strength and wear resistance of a working surface of friction allows to .raise durability of this part. Thus, for increase of the durability of the shplinton sleeve it is proposed two ways: constructional and technological.

NEW GEOMETRY OF THE MAIN FRICTION PAIR

The geometrical modelling was used to determine of geometry of a surface of the main friction pair. Necessity of change of the geometry of the main friction pair is established. As a result, replacement of a cylindrical surface of friction of the shplinton sleeve on pyramidal, for example, with 6 faces and cylindrical surface of slide blocks on flat surface of rectangular form have been offered [Evstratov V.A. and other 2005].

The design decisions on the organization of ways of dissipative energy and heat exchange withdrawal in an environment will provide a constancy of a contact surface area of the friction pair "frictional slide block- shplinton sleeve" as well as a constancy of friction coefficient and stable work.

The whole complex of mathematical models is necessary for the connected supervision over all determining factors of work of the mating. Efforts and movements transfer from one part to another is made by pressure in the contact field. Determination of these pressures has essential value for calculation of stresses, wear resistance, a temperature mode, displacements and other factors of contact strength and rigidity.

Mathematical simulation of contact interaction of elements of mobile mating parts is mainly made by a method of final elements with the purpose of determination of contact and thermal stresses, distribution of thermal streams on the surfaces of mating elements, the knowledge of which will allow to create highly reliable of rail underframes.

The method of final elements is one of the most effective methods of the solution of problems of the mechanics of deformable rigid body, including contact tasks. Therefore, the solution of the set connected task, representing the whole complex of tasks which should be solved simultaneously, has been carried out with use of a package of applied programs MSC.MARC and MSC.NASTRAN, thus preparation of the model has been carried out in NASTRAN with subsequent its export in MSC.MARC 2003. Using the specified advantages of these two packages, the three-dimensional contact task of the frictional interaction of elements of mobile matings of rail underframe in thermal-elastoplastic presentation has been solved.

Generation of finite element grids is executed by semi-automatic way. The design of the given friction unit is centrally symmetric. It allows to examine finite element model not for the whole unit, but only its sixth part.

The calculation of temperature and thermal-elastic stresses in a zone of contact of the mating elements was made in the connected presentation of the task, as the thermal stream arising owing to friction of working surfaces of the shplinton sleeve and frictional slide blocks was beforehand unknown in examined problem. So the solution of the connected tasks of thermal-elasto-plasticity has been carried out by means of package MSC.MARC 2003 in quasi-static formulation.

The determination of contact stresses in the main friction pair was carried out in local coordinates. Taking into account that the design of the given unit is centrally symmetric, therefore with the purpose of economy of time of the calculation only account 1/12 part of the shplinton sleeve was examined. Iterationally selecting the displacement of the upper conical surface of the frictional slide block so that the sum of projections of the contact forces which act in the units, contacting with the given surface, was equaled 600 N (the total force that corresponds to the general load of 7200 N), the contact stresses were calculated.

The fields of stresses in the beginning and at the end of a working stroke of the fictional damper were studied. Its distribution has allowed to estimate the local maximums accordingly equal 1,268 MPa and

2,584 MPa.

The field of normal contact stresses upon termination of a working stroke (0,195s), is presented on

fig. 2. The essential difference from similar distribution of contact stresses in static's is established not only by value of the maximal stresses (2,584 MPa), but also a gradient of change of a field of stresses.

It leads to a rise of contact nodular forces of friction, to increase of work of force of friction and a thermal flow. The analysis of growth of temperature in interacting bodies on each cycle of loading is conducted (fig. 3).

It is established, that the temperature grows gradually, on the average on 0,054°C during each cycle of loading. With the purpose of prevention of the gripping phenomenon on the working surfaces of the damper it is advisable to perform the surface of shplinton sleeve in the form of a step pyramid with surface hardness not less than 50 HRC and with degree of roughness of the surface not higher than 0,63 R*a*, and to execute the slide blocks with a flat surface of friction surface of the rectangular form.

Development of technological procedures of hardening is necessary for providing the required strength and thermal resistance of the working surfaces of damper. And so the technological methods of increase of strength and thermal wear resistance have been developed. These procedures allow quantitatively to estimate a reserve of increasing the strength and thermal wear resistance by methods plastic deformation. Besides the new way of manufacturing of the blank of the shplinton sleeve from a rectangular card is offered, by way of its bending, rolling up and applications of direct extrusion on pass (reduction per pass in a matrix) [Evstratov V.A. and other 2004]. Therefore, the new manufacturing technology of the shplinton sleeve is offered by a cold die forging method with the purpose of increase of wear resistance and resourcesaving.

Simulation of bending and rolling up processes is executed with the help of applied programs package MSC.MARC 2003, thus preparation of model is carried out in MSC.NASTRAN with subsequent export of it in MSC.MARC 2003 and preparation of additional modular programs.

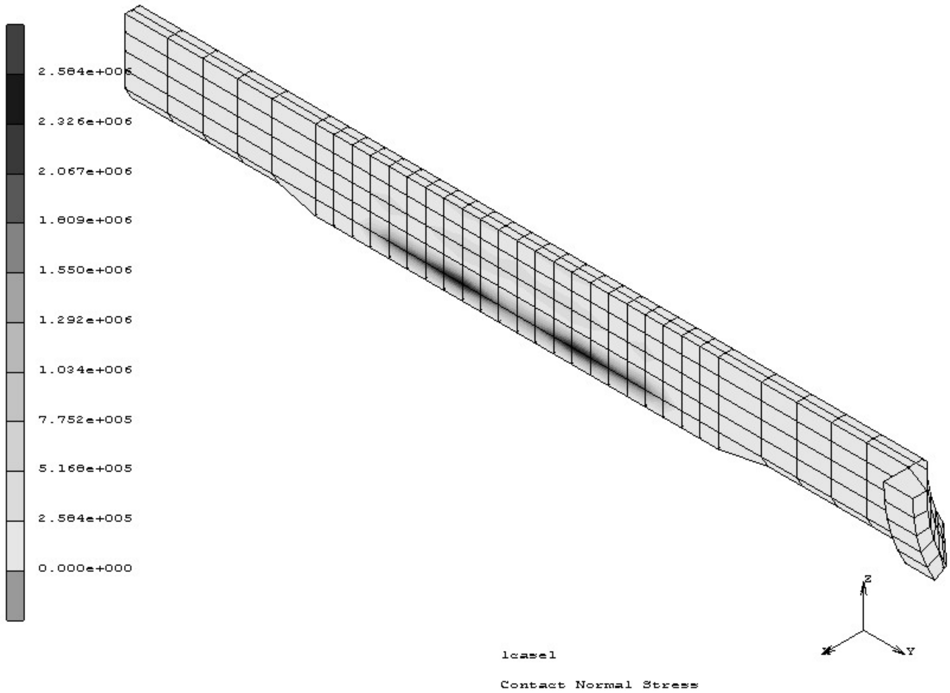

Fig. 2. Distribution of contact stresses on a surface of the shplinton sleev
e for a working stroke (time=0,195 s)

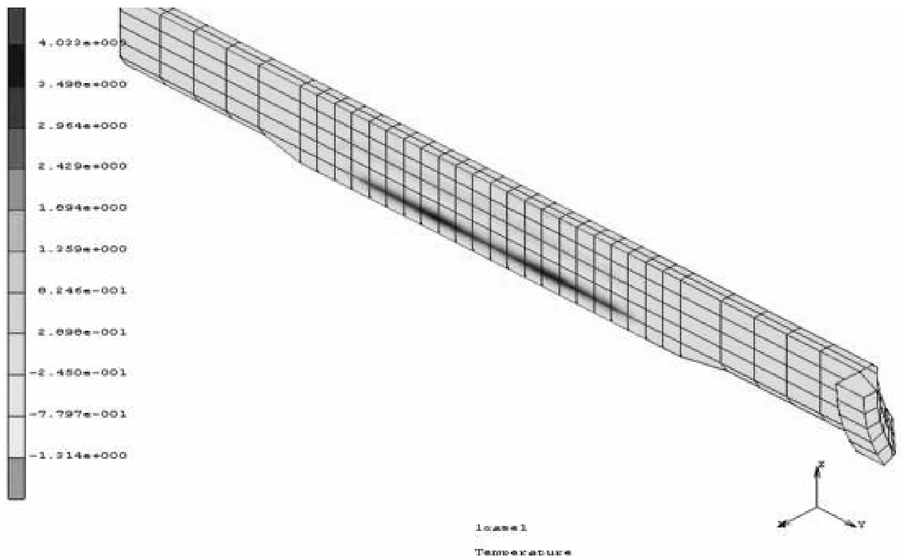

Fig. 3. Distribution of temperatures in the shplinton sleeve for a working stroke (time=0,195 c)

The special progressive die was developed for modelling of rolling up process of the sleeve blank. Two angular bending is examined on the first position, rolling up is carried out on the on the second position. The examined deformable object is divided on finite-elementary grid. The punch is set as a rigid body.

For bending the right and left parts of a matrix are set. To produce the required shape of the blank after deformation it is necessary to carry out two-angular bending in a die with a clamping of middle part of the blank. For rolling up the special die with two movable semi-matrixes and a mobile support are used for prevention of bulging of the blank on an initial stage of deforming. The rolling up process at work of three dies is shown on fig. 4.

The rolling up of the blank into the sleeve is process of elastic-plastic deformation. Therefore after end of rolling up process elastic deformation results to spring back. As a consequence there is a significant change of the dimensions of the sleeve in comparison with the sizes set by the tool. As a result of modelling of the process, the technological procedure was corrected, the transitions of forming were changed and the shape of the deforming tool was determined more exactly. It allowed to provide closing a joint (fig. 4).

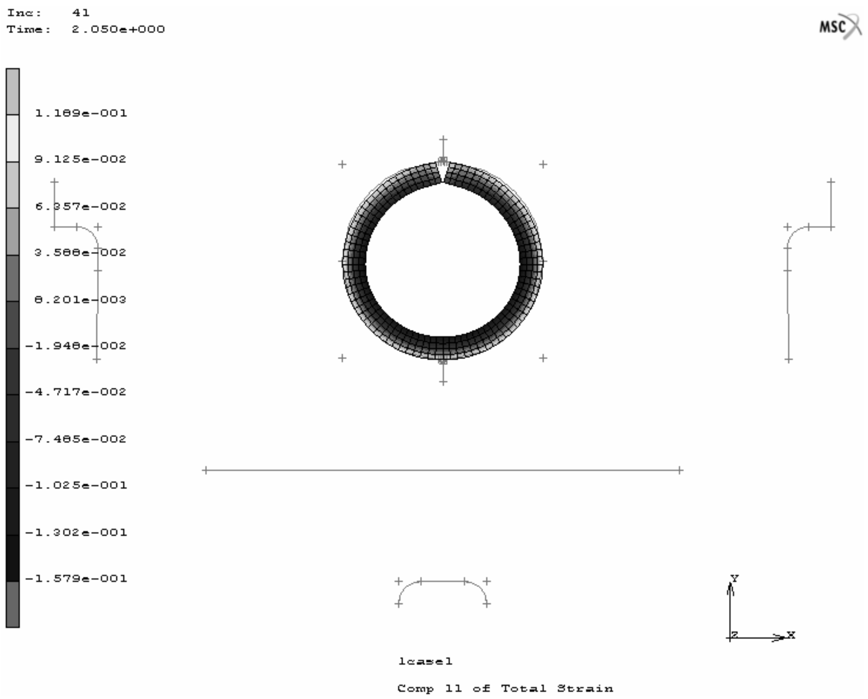

Fig. 4. Process of deformation of the blank at rolling up of the blank into sleeve

The theoretical analysis of forming of a cylindrical pipe from flat blank with the help of a method of finite element method has allowed to determine stresses and strains: current (at each stage of deforming) and residual stresses deforming forces and the sizes of the blank at springing back, that have allowed, in its turn, to provide preservation of a zero clearance in the joint.

The process of direct extrusion on pass (reduction per pass in the matrix) was executed in the matrix with an angle of an inclination of 12^0, with the purpose of closing a joint that has provided substantial increase of strength, hardness and wear resistance and creation of compressing stresses in the blank for producing higher hardness at the subsequent hardening process.

The carried out investigations have allowed to estimate quantitatively to estimate the reserve of hardness of the blank (150...200 MPa) due to change of metal structure and to increase of thermal stability of the working surfaces of mating parts on 6-8 HRC.

CONCLUSIONS

The new design of the frictional damper will allow:

1. To provide uniform wear of frictional surfaces.
2. To prevent of dripping and seizuring
3. To increase reliability and between-repairs run of the damper in 1,5 … 2 times.
4. The application of the new resource-saving technologies cold of die forging will allow to reduce waste products of expensive materials in 2,5 times.

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КОНСТРУКТОРСКО-ТЕХНОЛОГИЧЕСКИЕ МЕТОДЫ ОБЕСПЕЧЕНИЯ НАДЕЖНОСТИ ПОДВИЖНОГО СОСТАВА ЖЕЛЕЗНЫХ ДОРОГ

Лариса Губачева

Аннотация. Приведены конструкторско-технологические методы увеличения надежности фрикционных демпферов железнодорожного экипажа. Разработаны технологические пути увеличения прочности и износостойкости, что позволило количественно оценивать ресурс увеличения прочности и температурной износостойкости методами пластической деформации.

Ключевые слова: надежность, фрикционный демпфер, подвижной состав, железная дорога.