Optimisation of the composing part of hand brake mechanism

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Received 28.03.2007; published in revised form 01.09.2007

Analysis and modelling

ABSTRACT

Purpose: The purpose of work is to show an example of 3D modeling and optimization combined with the design and production of prototype and experimental testing of a very important composing part of the mechanism for compensating the aeration in automobile hand brake. The basic notions about purpose, function, buyer’s demands, specifics of the hand brake assembly construction are given. The proposal of concept for the development of the assembly, conceived by the buyer, is given as well.

Design/methodology/approach: Very important task of the mechanism for compensating the aeration in automobile hand brake is to assure its function safety and a permanent grip angle of the hand brake. A new construction is made, which will satisfy the above mentioned demands, then the 3D technique is used to choose an optimal model, and, based on it, prototypes were produced and experimentally tested in real conditions.

Findings: A new design of the elements of hand brake is developed.

Research limitations/implications: The proposed methodology is repeatable for other similar mechanisms.

Practical implications: Based on the research, new design of the mechanism of automobile hand brake is developed, by which the advancement of final product is enabled.

Originality/value: : The demands of construction and mechanism functional safety are entirely satisfied.

Keywords: Numerical techniques; 3D Modeling; Prototype testing

1. Introduction

Current concurrence, especially in the fields as it is the automobile industry, demands a permanent improvement of the construction and increasing the safety. Therefore, the automobile parts producers must permanently develop new solutions which will satisfy the above mentioned requirements. One of the examples of mechanisms which should be permanently improved is the mechanism for compensating the aeration in automobile hand brake. The primary function of a hand brake is to realize stopping the car in a parked position, then to serve as an auxiliary means in extraordinary situations, for example when down slope breaking is necessary. Its functionality must not be jeopardized during whole lifetime and brake-function and neither that of the automobile system as a whole. However, it is to be noted that a hand brake belongs to the group of safety elements, so, as such; it is subject of special standards in automobile industry. But, concerning modern trends, a great attention must be dedicated to the aesthetics, i.e. to the design and visual effects inside the automobile cabin.

Generally, it can be said about all hand brakes that they work on principal of pushing a handle through an appropriate mechanism (steel cord, lever etc.) to effectuate blocking the automobile wheels, until the handle is released. The average number of different hand brake mechanism parts is 10 to 15. Composing elements of a classic hand brake with separated detail of the aeration between steel cord ends and rocker arm are presented on the fig 1.
There are several methodologies both for the processes of the development of new products and the improvement of functionality, safety and other characteristics. Previously it was only the methodology of variant construction, statistical approach, and other [1-4, 7, 9]. However, with the development of information technologies and numerical methods, the process of product development has been facilitated in many aspects. Such examples are innumerable, i.e. [8, 10-13]. Especially efficient methodologies were these which combine 3D modeling, numerical calculations (the finite elements method, the finite volume method, the boundary elements method etc.) and experimental testing, for example [1-4, 5, 6, 13-17]. If an experiment is done according to the methodology based on mathematical theory of experimental design (regressive and dispersive analysis) or for instance according to Taguchi method, then the process of product development is reduced to shortest period possible, but, which is very important, the experimental testing of the prototypes is done by varying the influential factors. In that way the quality information have been obtained, related to stress – strain state, temperature characteristics, work safety, ergonomics etc.

One of frequent problems in functioning of a hand brake is appearance of aeration. That is a phenomenon when braking effect is achieved only after an increased angle of handle lifting, or not at all which is an extreme phase of hand brake failure. The problem of the aeration appearance can be of two origins: while mounting at the production line (so called primary or initial aeration) and during the exploitation (so called secondary aeration). The compensation of aeration effects is achieved mainly by tightening the steel cord with a nut on coil lever. However, there already exist successfully applied solutions of automobile mechanisms which do the compensation of aeration.

The demands posed to these mechanisms are following:

- Mechanism must enable a later change of the steel cords when necessary.

The procedure of construction of the automatic mechanism for compensating the aeration which satisfies mentioned demands is presented in this paper.

### 2. Proposal of the solution

By the analysis of possible solutions the conclusion is made that the key element of the mechanism is – the cover, fig. 2. In further proceeding the 3D modeling was performed of this element, part of the mechanism, fig. 3. Having in mind mentioned above, the start is done from two most important customer's requests:

- Keeping the mechanism in shut position (unknown is the reaction force due to coil force exerted over the safety pin)
- Cover rotation by executing the function of compensating the aeration (unknown is the force of cover opening/shutting)

The opening/shutting force is defined through corresponding limits from user's point of view. On the one hand, the force on hand brake lever use to be sufficiently low to permit handling, but sufficiently high too on the other, to assure a safe functioning of the mechanism.

![Fig. 1. Assemble parts of a classic hand brake](image1)

![Fig. 2. Brake shoes](image2)
In further procedure the numerical simulation and optimizing the cover are done (Figure 4). By using the corresponding software with the finite elements method, the stress – strain analysis was performed of the proposed variants of comparative solution.

By this example it was confirmed that in an early phase of designing the numerical methods can be efficiently applied. This is corroborated by numerous examples in the literature [3-5, 10, 11, 13].

![Fig. 3. Variants of mechanism solution](image)

**3. Experimental testing**

Based on the numerical analysis of variant solutions of the mechanism for compensating the aeration, it has been acceded to the construction of prototype which will be tested in real conditions. In that sense an adequate material of brake shoes was chosen (CK60 according EN10132) as well as the thickness of plate (1.5 mm) from which corresponding part was made. Four different measurements have been carried out. For the measurement was used the equipment consisting of a giver (measuring trail HBMS2/1000 N), a comparator and a computing software to process the data. Due to limited space here, the procedure and results of only one of four above mentioned measurements is presented. On the Figure 4 the model scheme of measuring is presented, where it is visible the impact of force F and measured deformation of upper brake shoes layer. The experimental installation is presented on Figure 5, and the measurement results are given in the Table 1.

![Fig. 4. Measuring scheme](image)

**Table 1. Experimental results**

<table>
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<tr>
<th>Load, N</th>
<th>100</th>
<th>200</th>
<th>300</th>
<th>400</th>
<th>500</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set up</td>
<td>No.1</td>
<td>No.2</td>
<td>No.3</td>
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<tr>
<td>Measurement No.</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
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</tr>
</tbody>
</table>

According to previous results of the numerical simulation, the obtained values of cover deformation $\Delta x$ are in the prescribed range (0.6 mm), which justifies the conclusion about a great accordance of numerical and experimental results. The proceedings of second, third and fourth measurement are identically described, with a difference that here the deformations were measured in other directions too, and with a change of the work position of static force F.
4. Conclusions

Based on performed researches in procedure the development of new product, namely that of the application of the automatic mechanism for compensating the aeration in automobile hand brake, it can be concluded as follows:

- A variant of construction solution can be obtained by previous making the 3D model, which is an optimal for both reasons - concerning the demands and the aspect of further testing procedure.
- The produced and experimentally tested prototypes are a basis for further development of the product, with really possible fulfilling the all projected demands.
- The methodology of development of the product, which consists of a combined use of numerical simulation and experimental testing, is reproducible for other similar products.

References