STRUCTURAL OPTIMIZATION OF HELICOPTER AIR-LANDING ROPE CONSOLE WITH MULTIPLE LOADING CONDITIONS

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1. Introduction

The air-landing troops rope console was designed in frame of modernization of the helicopter Mi-17, executed by WZL-1 Łódź, in order of Land Force Command of the Polish Army. It permits full equipped soldiers to fast air-landing directly from the helicopter. Total loading mass is 600 kg. Hitherto existing device could be used to 300 kg only. Project, calculations and investigations of the console were executed in the Institute of Aviation in Warsaw.

2. Description of the air-landing troops rope console prototype

The console structure is made of steel tubes Φ25x3,5 mm. The main elements were depicted on Fig. 1.

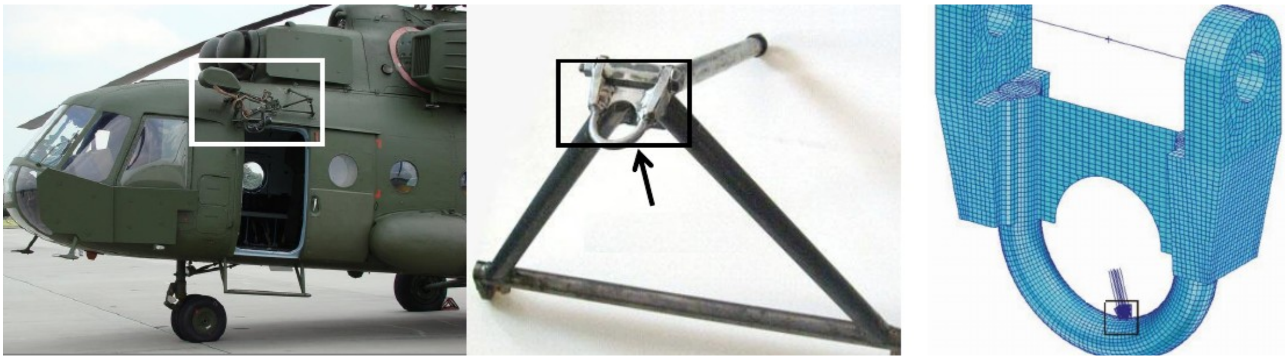

Figure 1. The main elements of the air-landing troops rope console prototype - from the left to the right: the console position on the helicopter roof, the basic console structure, the detailed model of the shackle.

The applied load was based on the assumed landing mass with the basic safety factor, according to regulations [1], p. 29.303, set to n = 1,5. The material assumed for the manufacturing was 30HGSA steel with the allowed Huber-Mises stress of 781 Mpa. The list of analyzed load cases for the static analysis was as follows: case 1 – 9000N (vertical load, horizontal position of the helicopter), case 2 – 9000N (pitch +15°), case 3 – (case1+case2). The Finite Element tests showed, that the highest Huber-Mises stress occur in the structure of the shackle.

3. The biomimetic optimization procedure

The shackle, as an overloaded element of the console with exceeded allowed stresses had to be subjected to the structural optimization. It was decided to use the biomimetic method [2, 3] of structural optimization to solve the problem for different load cases. The method-specific features (such as domain independence, functional configurations during the process of optimization, and multiple load case solution implemented in the optimization scenario) enable to find the optimal structural form. This approach allows simultaneous structural size, shape, and topology optimization.

4. Results

On Fig. 2. the results achieved during the shackle optimization are depicted. The initial configuration (left) was the prototype. The Finite Element analysis showed, that for all load cases the maximum allowed stresses were exceeded.

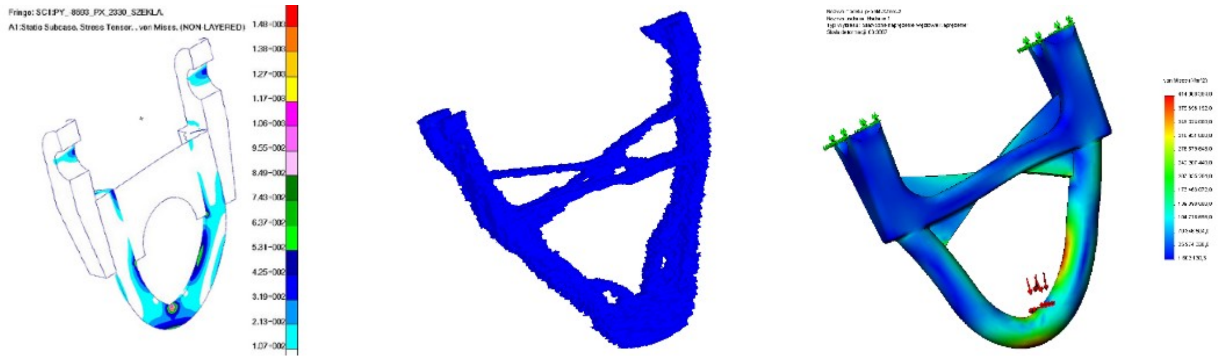

Figure 2. The biomimetic optimization of the shackle - from the left to the right: the initial configuration exceeded allowed stresses– the prototype , the optimization result, the final structural form of the shackle, after taking into account manufacturing constraints. Note, that the stresses are reduced below the assumed level.

This configuration was used as a basis for biomimetic optimization. The used optimization method allows the direct search for a solution for all load cases. The method allows efficient performance of the optimization process for several cases of loading, when homogenization of SED on the surface of the structure guarantees the optimality of the solution. The optimization result is depicted in the central position on Fig.2. The last step in the shackle optimization was the interpretation of the results. Taking into account manufacturing constraints the final structural form of the shackle was proposed and tested with Finite Element analysis. The final structural form was depicted also on Fig.2. (right).

5. Conclusions

In the paper the structural optimization with the goal of reducing stresses was presented. Multiple load cases were considered resulting from real helicopter operations. Results of Finite Element analysis indicate that the optimization goal was achieved. The final solution satisfies stress limits. With use of the biomimetic optimization method proposed the substantial reduction of stresses was obtained with minor changes in the original configuration.

6. Acknowledgments

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7. References

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