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M. SC. ANNA ULATOWSKA
Politechnika Krakowska

SHAPE OPTIMIZATION OF THE CONNECTING ROD

Ця стаття описує використання методу CAO (автоматизована оптимізація) для оптимізації шатуна для двигуна внутрішнього згорання. Це була виконувана оптимізація форми, бо сталь викувала шатун. Мета була скороченням великого тиску влучні.

У Першій моделі перед оптимізацією тиску менш ніж 100 Мра і більш ніж 320 Мра, протягом процедури оптимізації була проведена спроба утримувати Min і Макс Von Misess навантаження між 270 - 300тра.

Коли є тиск менш ніж 270 Мра, CAO видаляє матеріал для того, щоб збільшити тиск в цьому пункті. Коли є більше тиску, чим 300 Мра, CAO добавлет матеріал для того, щоб зменшити тиск в цьому пункті.

У завершенні, один новий проект для шатуна на думку результат оптимізації форми виконується. Істотне скорочення великого тиску мітки було досягнуте.

This paper is concerned to use CAO (computer-aided optimization) method for the optimization of the connecting rod for combustion engine. It was performed shape optimization for a steel forged connecting rod. The task purpose was reduction of large notch stresses.

In First model before optimisation there are stresses less than 100 MPa and more than 320 MPa, in during the optimisation procedure has been try to keep Min and Max Von Misess stress between 270 – 300MPa.

When there is stress less than 270 MPa, CAO Program remove material in order to increase the stress in this point. When there is more stress than 300 MPa, CAO add material in order to decrease the stress in this point.

In finally, one new design for connecting rod according to result of shape optimization is performed. A significant reduction of large notch stresses was achieved.

1 Introduction

In this project Shape optimisation for one connecting rod was performed.

In [2] was performed shape optimization of an engine connecting rod using variational equations of elasticity, material derivative idea of continuum mechanics, and an adjoint variable technique to calculate shape design sensitivities for stress. The results were then used in an iterative optimization algorithm of numerical solution for an optimal design.

In [3] was developed approximate mathematical formulae to define connecting rod weight and cost as objective functions as well as constraints. The optimization was achieved using a geometric programming technique.

In [4] was optimized the wrist pin end of an engine connecting rod with an interference fit. They generated an approximate design surface and performed optimization of this design surface. The objective and constraint functions were updated in an iterative process until convergence was achieved. The load cycle that was used consisted of compressive gas load corresponding to a maximum torque and a tensile load corresponding to maximum inertia load. The modified Goodman equation with alternating and mean octahedral shear stress was used for fatigue analysis.

[5] presented an approach of optimization of connecting rod's shape subjected to a load cycle which consisted of the inertia load deducted from gas load as one extreme and peak inertia load exerted by the piston assembly mass as the other extreme. A finite element routine was first used to calculate the displacements and stresses in the rod, which were then used in another routine to calculate the total life. Fatigue life was defined as the sum of crack initiation and crack growth lives, with crack growth life obtained using fracture mechanics.

In [6] an optimization study was performed on a steel forged connecting rod with a consideration for improvement in weight and production cost. Weight reduction was achieved by using an iterative procedure. In this study weight optimization is performed under a cyclic load comprising dynamic tensile load and static compressive load as the two extreme loads. Constraints of fatigue strength, static strength, buckling resistance and manufacturability were also imposed. An estimate of the cost savings is also made.

2 Problem statement

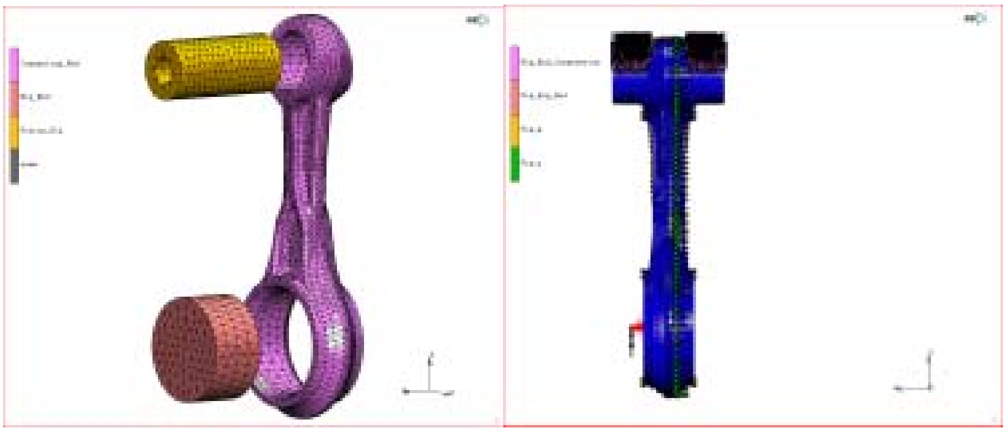
Connecting rod is one of the dynamic parts in combustion engines. Mass of this part can be so important for performance of motor. Therefore, optimization and reduction of mass in this part is meaningful.

In considered problem it was made shape optimization for model which was made according to topology optimization. Result after optimization was used to make new design for this connecting rod.

3 Boundary conditions

Literature survey suggests that cyclic loads comprised of static tensile and compressive loads were often used for design and optimization of connecting rods.

The load cycle is consist of axial and tangential forces. Tangential forces are small in comparison to axial forces. Therefore tangential forces were negligible in calculations. In place where optimization was realized compressive load have influence. The tensile load is small in comparison to compressive load and it was not use for analysis. The applied load distributions were based on research of [1]. Compressive load was applied over 180° of piston pin surface with sinus distribution.



a) b)

Fig. 1. Boundary conditions. Contact bodies (a), Load and constrains (b)

4 Optimization procedure

Shape optimization of the connecting rod was concerned for the zone between crack end and pin end. Optimization consisted in decrease stress in places of the model where stress was the highest and increase stress in places where stresses was not so high. The purpose of this studies was to obtain the smaller difference between maximal and minimal values of stress. It was performed by adding and removing elements from meshed model.

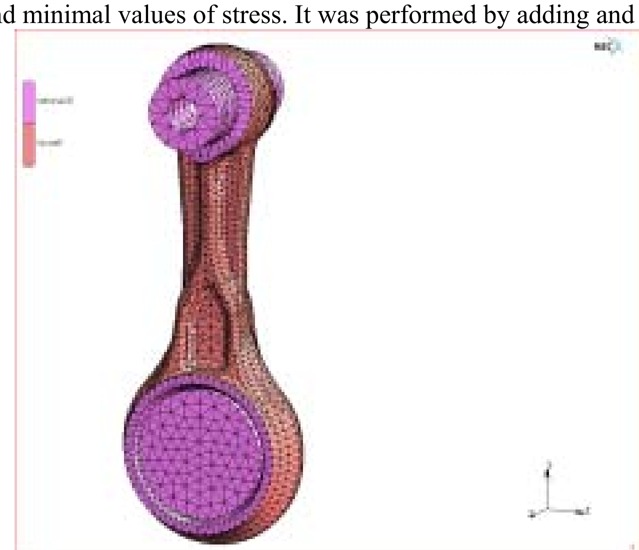


Fig. 2. FEM model

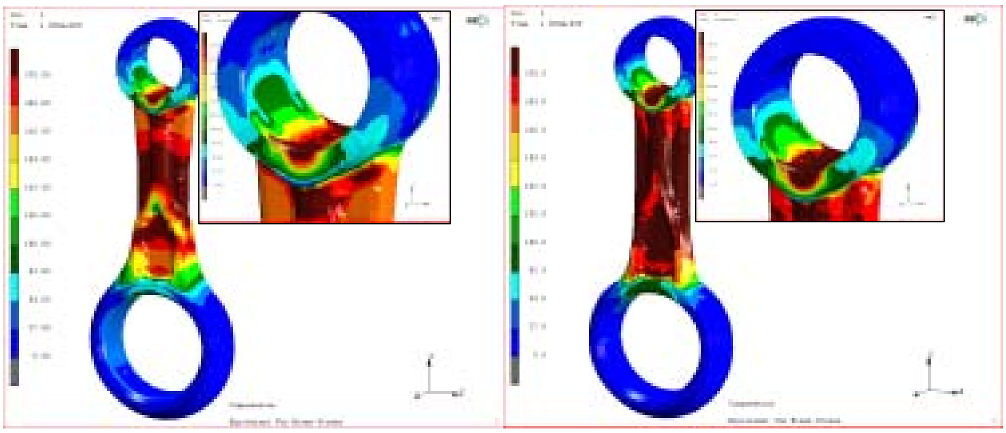
Fig. 3. New model of connecting rod after optimization

With this method it is possible to find stresses on the forging surfaces. In Fig 4-5 have been showed these stress distributions. For all Analysis has been showed stress distribution in two scaled 270 MPa and 300 Mpa.

5 Results. Conclusion

Finally a new model of connecting rod according to the results of SKO optimization without manufacturing restriction was performed. In fig. 3 new model of connecting rod is shown.

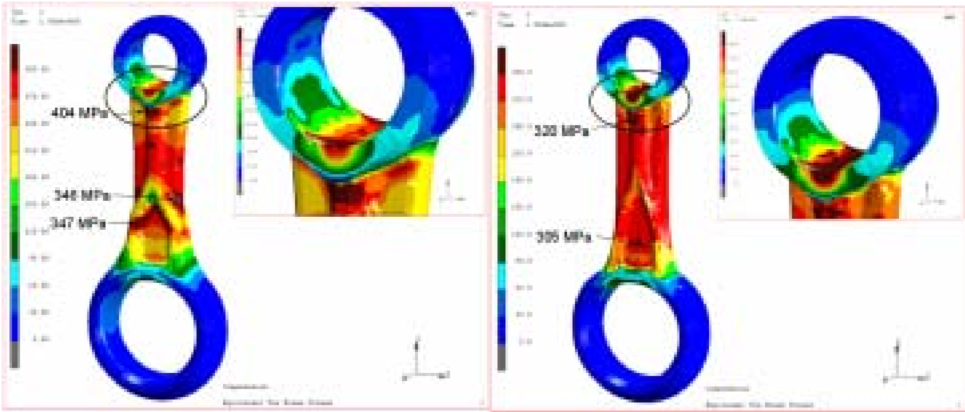
Fig. 4 shows comparison of stress distribution in connecting rod before and after optimization. Results are scaled to 270 MPa in order to show how stresses are compensated after optimization.



a) b)

Fig. 4. Von Mises Stress Distribution befor optimization (a), after optimization (b) [N/mm2].

Fig. 5 shows comparison of stress distribution in connecting rod before and after optimization. Results are scaled to 300 MPa in order to show how maximum stresses are decreased after optimization.



a) b)

Fig. 5. Von Mises Stress Distribution befor optimization (a), after optimization (b) [N/mm2].

It is shown that before optimisation it is a few place with stress concentration, but all model has moderate stress. After optimisation it is clear (especially it is evident in Fig. 5) that stress is more uniform, which was the object of this studies.

Literatura

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