Design and strength analysis of C-hook for load using the finite element method

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Abstract. The special type of C-hook is investigated in this paper. The C-hook is designed to carry a special load, where is not possible to use classical hooks or chain slings. The designed hook is consisted of two arms that ensure the stability of the load being carried. The finite element analysis is performed for the control of the stress and deformation state in the whole hook. The fatigue analysis is performed for the check of a lifetime of C-hook.

1 Introduction

In nowadays, the hooks are normalized standard machine components of cranes [1, 2]. The hooks are made from steel with high strength but sometimes the other materials are used. The lifting hooks can be classified into the single hook, C type hook, and double hook, etc. However, in special cases, the classic hooks cannot be used. For this reason, some engineers design and investigate the special types of hooks [3-7].

In this paper, a special design of the C-hook for the industry is investigated. The new type of C-hook is designed and used to bearing a lifting load because the normalized standard hooks and chain slings cannot be used. The stress analysis of the C-hook is performed using a finite element method.

2 Design of C-hook

The C-hook is designed and dimensioned for lifting and transporting the cut rings with the maximum weight of 6.500 kg (Fig. 1). The ring has the shape of a cut circle and a shape complex beam is located inside. The ring is located above the ground and is cut off from the device so the standard possibilities cannot be used. For this reason, the special shape of the C-hook is created. The designed hook (Fig. 2) is made from steel and is consisted of more parts e.g. arms, stiffeners, and pin. The arms with stiffeners are welded together and are made from steel 1.0570. Only the pin is the mobile part and is made from the material

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1.7131. The pin is fixed by a washer and a nut. The basic dimensions of the C-hook are height 1775 mm, width 410 mm and the minimum length of the ring can be 900 mm.

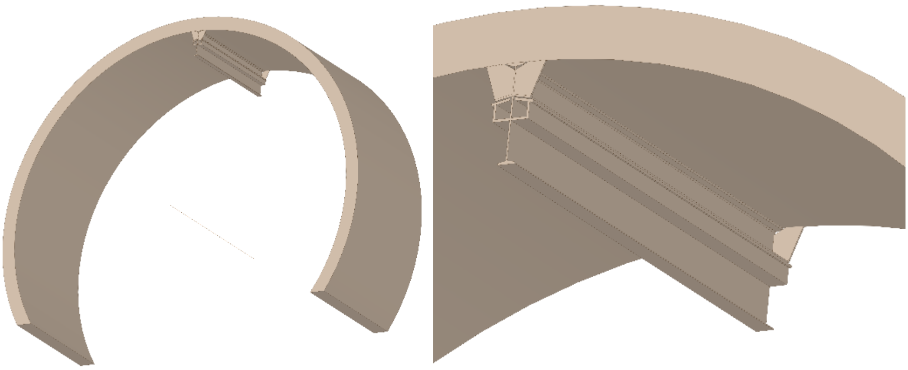

Fig. 1. The transported ring.

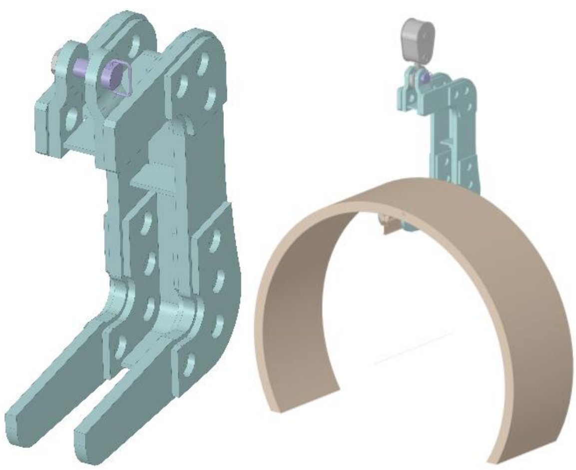

Fig. 2. Model of designed C-hook and the whole assembly with the transported ring.

The mechanical properties of the used materials are given in Table 1. The pin is the most stressed part so it is made from steel with higher yield stress.

Table 1. Basic mechanical properties of used materials.

W.Nr.	ISO	Yield stress (MPa)	Tensile stress (MPa)	Elastic modulus (MPa)
1.0570	Fe510	345	510-630	200 000
1.7131	16MnCr5	588	Max. 637	190 000

3 Finite element analysis

The stress-strain analysis of the C-hook is performed by the FEM. This method divides structure to the finite elements that are connected by nodes. The set of the simultaneous algebraic equations is used for the computations of these elements

$$\mathbf{Kx}=\mathbf{F} \tag{1}$$

where **K** is the stiffness matrix, **x** is the displacement vector and **F** is the load vector.

In most cases, the shape of the hooks is always complicated for the stress analysis is used in the finite element method (FEM). The FEM is the most widespread method for the stress-strain analysis of designed elements.

3.1 Finite element analysis of C-hook

The FEM analysis of the C-hook is performed. The computer model of the designed hook is divided into finite elements and the boundary conditions on the model are applied. The mesh consists of approximately 37 000 volume finite elements with quadratic approximation and approximately 183 000 nodes. The C-hook is loaded by ring weight and the C-hook is hanged on the standard hook. The welds are represented by contacts where the edges are connected to the face of individual parts. The computed displacement of the C-hook is shown in Fig. 3. The main deformation of the C-hook is in –X direction and can be stated, that the ring does not slide off from the C-hook.

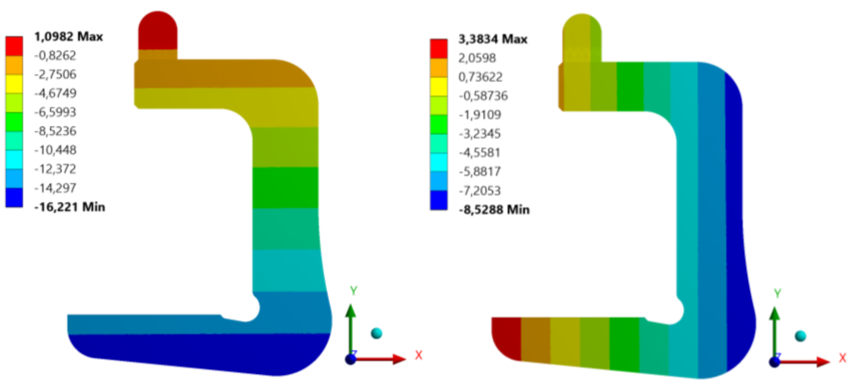

Fig. 3. Displacement field in X and Y direction (mm).

The maximal computed equivalent stress in the C-hook (Fig. 4) is equal to 72.311 MPa and is located on the pin. All computed values are smaller than the yield strength of the used materials (Table 1).

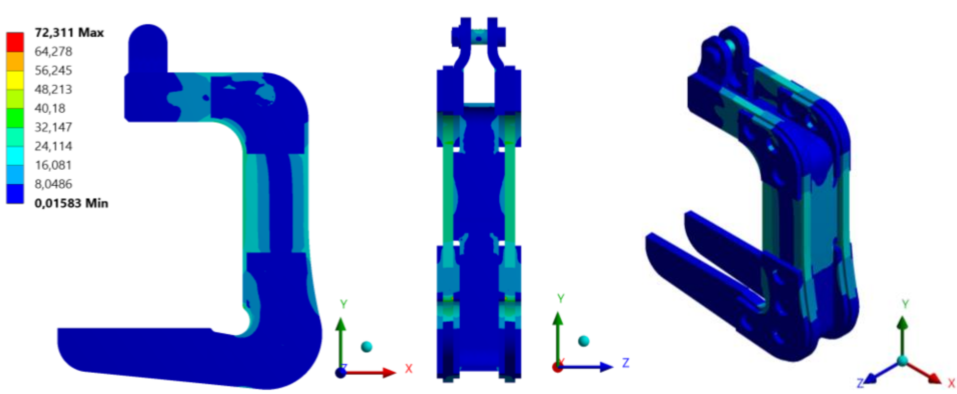

Fig. 4. Field of equivalent stress in the C-hook (MPa).

Because the C-hook is used repeatedly, the fatigue analysis after the static linear simulation is performed. The S-N curves for the materials are defined. From the results can be concluded that the life of the assembly is bigger than 1e6 cycles (Fig. 5).

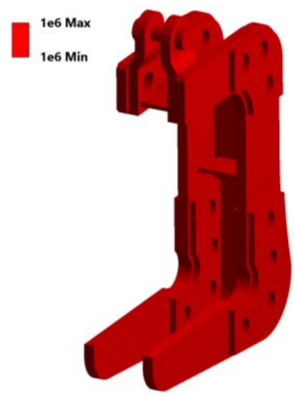

Fig. 5. Fatigue life of designed C-hook.

4 Conclusion

The stress analysis of the designed C-hook was investigated in this paper. The special type of C-hook was designed because classical hooks cannot be used. The parts of the C-hook were welded. Only the pin was the mobile part with a screw and ended by the nut. The analysis of the C-hook was performed using the finite element method. From the obtained results can be stated, that the computed stresses are smaller as the yield strength of used materials and the most stressed part of the C-hook is the pin. The safety factor is at least equal to 5. The fatigue life of the C-hook was investigated. As a result, the lifetime of the C-hook is maximum.

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