CALCULATIONS AND VERIFICATIONS OF SHREDDING CHAMBER OF TWO-SHAFT SHREDDER FOR CRUSHING OF CONCRETE, RUBBER, PLASTIC AND WOOD

ИЗЧИСЛЕНИЯ И ПРОВЕРКИ НА РАЗДРОБЯВАЩА КАМЕРА НА ДВУВАЛОВ ШРЕДЕР ЗА РАЗДРОБЯВАНЕ НА БЕТОН, ГУМА, ПЛАСТМАСА И ДЪРВО

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ABSTRACT. The article is devoted to the calculation and verification of the shredding chamber of a two-shaft shredder for crushing of concrete, rubber, plastic and wood. In this work a model study of the shredding chamber of such type of shredder has been done. The studies of the mechanical load and behavior of the shredding chamber have been conducted through solving the equations describing the mechanical processes under operating conditions by the finite element method. For this purpose, a three-dimensional geometric model of the bottom of the chamber has been generated, which is discretized to a planned network of finite elements in the programming environment of ANSYS MECHANICAL APDL.

Keywords: STRESSES, DEFORMATIONS, TWO-SHAFT SHREDDER.

1. Introduction

Shredders are machines, shredding the secondary and waste materials. This is a group of relatively new machines, which are classified mainly according to the number of working shafts (Abadzhiev, Tonkov, 2007) to: single-shaft, two-shaft and four-shaft .

Shredders are configured according to each unique application of theirs, with selection of different thicknesses and number of cutting teeth, shaft diameter, thickness of spacing collars, power of drive, productivity (Vatzkitcheva, Grigorova, 2015) .

According to the technology of shredding, there is a choice between single-shaft, two-shaft, three-shaft, four-shaft, five-shaft shredders, with varying degree of automation and control of the key parameters, different level of noise, different speed of rotation, supply, degree of pressurization, etc. (Borshtёv, 2004).

The advantage of the two-shaft shredders is their high productivity. The disadvantages are related to the high price and the high cost of maintenance of the machines.

The hydraulic two-shaft shredder consists of feeder-conveyor, (receiving) hopper, shredding chamber, output belt (strip), discharging belt, and belt for separation of metal particles (Vatzkitcheva, Valkov, 2013).

In the present work a model study of the shredding chamber of such type of shredder has been done.

2. Object of Study

The shredding chamber consists of a receiving hopper and crushing shafts.

The receiving hopper is constructed of hot-rolled sheet steel with extra ribbing. The depth of the hopper is 1000 mm, and the width at the top - 2400 mm. The volume of the bunker is 3.0 m³. These dimensions are consistent with the sizes of recycled wastes and the possibility of their wedging (seizure) when placing in the hopper.

The crushing shafts are parallel, with length 900 mm, wheel-base 350 mm, and hexagonal cross-section. On the shafts there are mounted the crushing discs. Between the discs, to the chamber body, there are mounted counter-knives for cleaning the space between the separate discs.

The construction of the chamber is verified for general strength, by applying the loads from the weight of the shafts, the chamber elements, the input hopper, as well as the support reactions at the bearings of the shafts (Tavakoli, Mohtasebi and Jafari, 2008). The studies have been conducted through the mathematical models and numerical procedures described below.

3. Concept for model study.

The studies of the mechanical load and the behavior of the shredding chamber have been conducted through solving the equations describing the mechanical processes under operating conditions by the finite elements method. For this purpose, a three-dimensional geometric model of the bottom of the chamber has been generated, which is discretized to a planned network of finite elements in the programming environment of ANSYS MECHANICAL APDL (Braess, 2007).

The boundary conditions, reflecting the mechanical load during operation of the steel structure, include the following parameters:

-input power: P_{vh} = 90 kW ;

- revolutions of the working shaft: $n_v = 25$ min^{-1};

- frequency of rotation of the working shaft: $\omega_V = (\pi.n_v) / 30 = 2,62$ rad / s;

- torque of the working shaft: $M_v = Pvh / (\omega_v.\eta) = 35$ kN.m, where $\eta = 0,98$ is efficiency factor of the transmission ;

-failure stress of concrete: $\tau_s = 60$ MPa;

-shear force by one knife: $F_s = M_v / (3.0,175) = 66,7$ kN;

-resisting moment of shredding by 1 knife: $M_{S1} = F_s . l_s = 11,67$ kN.m.

The mechanical load during operation of the structure is presented in Figure 1 (FAG Spherical roller bearings E1, 2011) .

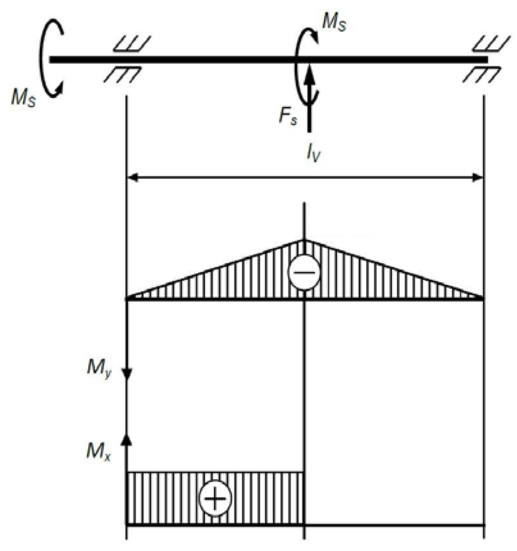

Fig.1. *load*

The system of equations is solved with parameters of the steel presented in Table 1.

4. Numerical results

Table 1 summarizes the results of the verification of the strength of the chamber with the accepted mechanical properties of steel :

***Table 1**: Results of the verification*

Name	Steel	
General	Mass Density	7,85 g/cm^3
	Yield Strength	207 MPa
	Ultimate Tensile Strength	345 MPa
Stress	Young's Modulus	210 GPa
	Poisson's Ratio	0,3 ul
	Shear Modulus	80,7692 GPa
Stress Thermal	Expansion Coefficient	0,000012 ul/c
	Thermal Conductivity	56 W/(m K)
	Specific Heat	460 J/(kg c)

The figures below present a visualization of basic parameters characterizing the state of stress of the steel structure.

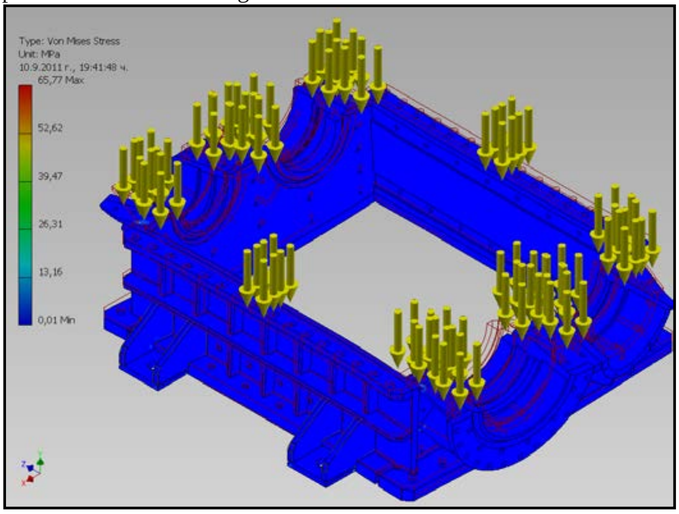

Fig.2 . Summarized stresses

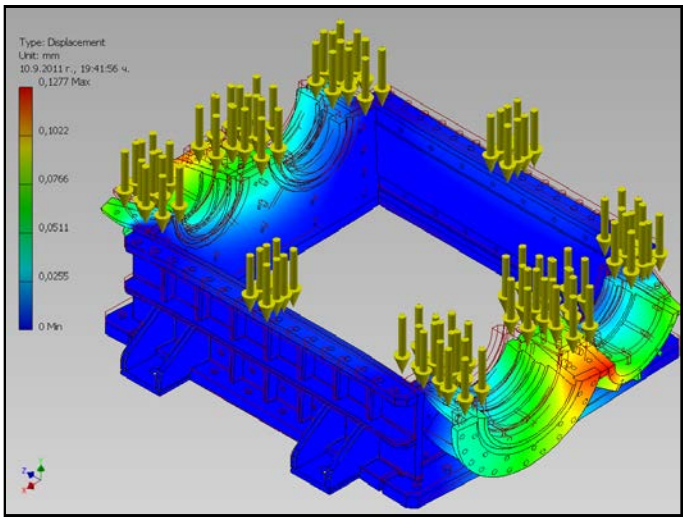

Fig.3 . Deformations

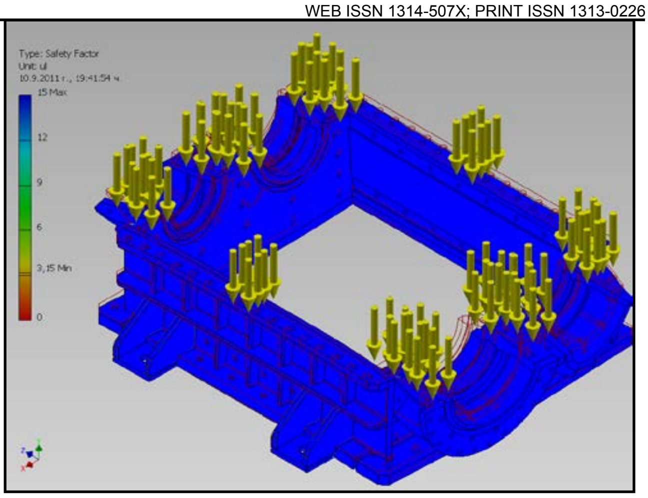

***Fig. 4** . Safety factor*

Table 2 summarizes the maximum and minimum stresses and deformations.

***Table 2:** Maximum and minimum stresses and deformations.*

Name	**Minimum**	**Maximum**
Volume	39292300 mm^3	
Mass	308,444 kg	
Von Mises Stress	0,00548071 MPa	65,7722 MPa
1st Principal Stress	-15,6595 MPa	28,8686 MPa
3rd Principal Stress	-83,2857 MPa	4,36874 MPa
Displacement	0 mm	0,127705 mm
Safety Factor	3,14722	15

The conducted study shows that the maximum stresses for the examined structure do not exceed the admissible values for the material of the chamber.

5. Conclusions

The conducted model studies show that the examined structure of the shredding chamber can be used for shredding machines of type shredders .

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