Application of Fem Method for Modeling and Strength Analysis of Feed Elements of Vibroscreen

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Abstract. The article presents a three-dimensional solid-state computational model of vibroscreen feed elements, as well as the analysis results of the stress-strain rods state. An algorithm for solving the problem numerically using the finite element method is proposed. The obtained results were used at the stage of feed elements designing for an industrial vibroscreen.

Keywords: Vibroscreen · Feed elements · Strength analysis

1 Introduction

Important groups among construction machines are vibroscreens used for segregation of bulk materials [1, 2]. In the scientific and technical literature, the results of theoretical and experimental research on these machines are presented [3–5]. Paper [6] presents a new vibroscreen construction solution, i.e. vibroscreen with additional feed elements. The schematic structure of the machine is shown in Fig. 1. Sieve (1) is mounted in the box (2) and on elastic supports (3). Sieve (1) is set in a vibrating motion using the vibration engine (4). Above sieve, feed elements (5) are placed, which are mounted in platform (6). Bulk material (7) flowing down the sieve is simultaneously vibrated by the vibration engine and crushed and shredded by feed elements. These simultaneous effects increase efficiency and shorten the sieving process time.

Feed elements play a very important role in this process. Their effectiveness depends on the efficiency and reliability of the sieving process. Therefore, the aim of the work was to carry out modeling and strength analysis of feed elements. This process was carried out using the FEM method, which as shown, among others, in [7–9] is commonly used in the construction of machines and it will be useful for feed elements research.

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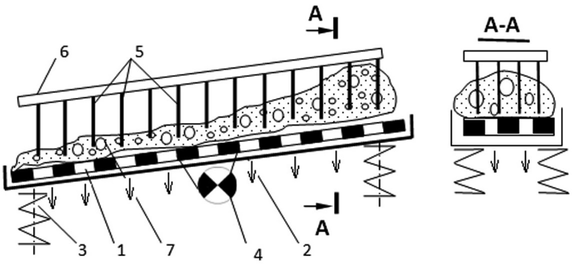

Fig. 1. Scheme of vibroscreen with additional feed elements: 1 - sieve, 2 – box, 3 - elastic supports, 4 – vibration engine, 5 - feed elements, 6 - platform, 7 – bulk material.

2 Modeling of Vibroscreen with Feed Elements

The solid-state 3D model of the whole vibroscreen with a special area of feed elements (Fig. 2) and separate calculation models (Figs. 4, 5, 6 and 7) of the feed elements part were developed and executed in the system of parametric solid-state modeling KOMPAS-3DV17.1. Calculations were made in the APM FEM system, which is an integrated tool in KOMPAS-3DV17.1 for the preparation and subsequent finite element analysis of a three-dimensional solid model (Attestation Certificate No. 330 dated April 18, 2013).

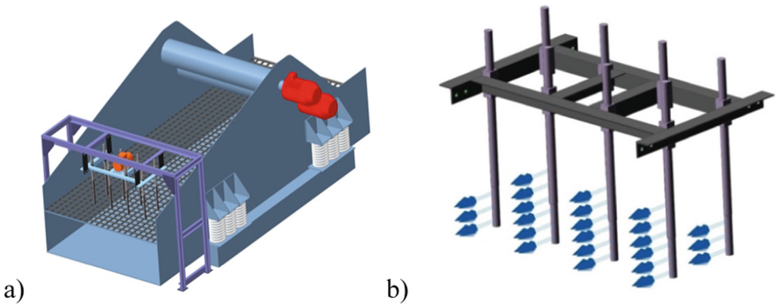

Fig. 2. Geometric 3D model of the vibroscreen and platform with feed elements: a - vibroscreen; b - platform with feed elements

The investigated object is feed elements platform of 8 vertical rods, by 4 in two rows and at a certain distance from each other. The installation of feed elements on the vibroscreen is shown in Fig. 2a. The calculated finite-element grid of the platform with feed elements is shown in Fig. 3. Conditional groups, sorted material with a shadow trace from the movement is shown schematically between the feed elements. Conditionally, it is assumed that in the middle of the screen the flow of bulk material flowing around the feed elements rods is higher, and to the edges it flows smoothly below, which is shown in Figs. 4, 5, 6 and 7.

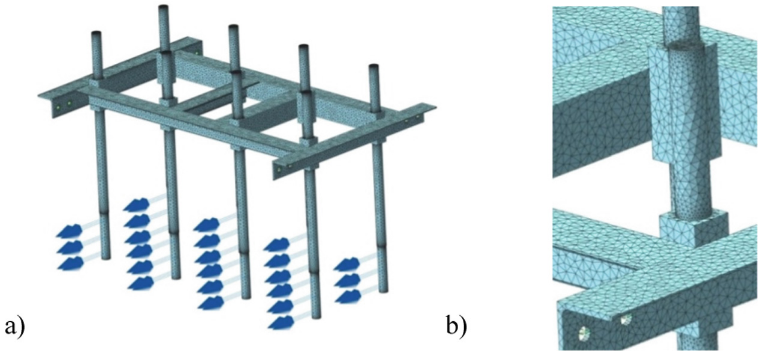

Fig. 3. Mesh of the platform with feed elements: a - the platform with feed elements and streams of bulk material (arrows), b - fixing of feed elements

The feed elements platform can be conditionally divided into two groups of homogeneous elements - a metal corner (Steel 20, according to interstate standard GOST 1050-2013), from which the platform is made, it serves as a base for fastening the rods; and rods (Steel 45, GOST 1050-2013) mounted on this platform.

The initial data for solving the problem are summarized in separate tables (Tables 1, 2 and 3).

For each distributed force, acting on the feed elements, the corresponding objects are selected and the following load parameters are applied: Force vector: X = 400; Y = 0; z = 0. Force value 400 N, which is measured in experimental studies, depending of bulk material flow.

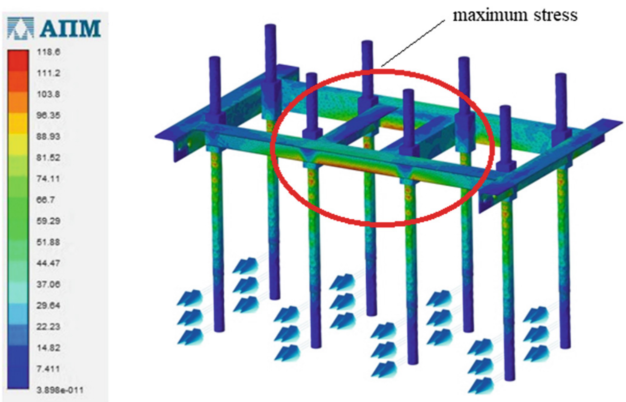

Fig. 4. Equivalent stresses of the feed elements platform on Mises

Accordingly, information on fixations and coinciding surfaces is included in the program, and the finite element mesh is selected, consisting of 10 nodal tetrahedrons. Tetrahedrons are the only elements that can be used to thicken the adaptive grid.

When the density of the grid is increased, the solution becomes more precise. So it is unerringly assumed a relatively slow change in the stresses in these areas.

The loadings of the model are determined in Table 4.

Table 1. Data of platform material (Steel 20, GOST 1050-2013)

1	Yield stress (MPa)	235
2	The modulus of normal elasticity (MPa)	200 000
3	Poisson's ratio	0,3
4	Density (kg/m^3)	7 800
5	The temperature coefficient of linear expansion (1/C)	0,000012
6	Thermal conductivity (W/m • C)	55
7	Compressive strength (MPa)	410
8	Tensile strength (MPa)	157
9	Torsional fatigue strength (MPa)	139

Table 2. Data of feed elements material (Steel 45, GOST 1050-2013)

1	Yield stress (MPa)	560
2	The modulus of normal elasticity (MPa)	210 000
3	Poisson'sratio	0,3
4	Density (kg/m3)	7810
5	The temperature coefficient of linear expansion (1/C)	0,000013
6	Thermal conductivity (W/m • C)	47
7	Compressive strength (MPa)	600
8	Tensile strength (MPa)	294
9	Torsional fatigue strength (MPa)	150

Table 3. Parameters and results of feed element location

	Description	Value
1	Element type	10-nodal tetrahedrons
2	Maximum length of the element side (mm)	10
3	The maximum coefficient of condensation on the surface	5
4	The coefficient of vacuum in the volume	3,5
5	Number of finite elements	114953

Table 4. The inertial characteristics of the model

	Name	Value
1	Weight of the model (kg)	55,810975
2	Center of the model gravity (m)	(0,000011; −0,117649; −0,000087)
3	The inertia moment of the model relative to the mass center (kg • m^2)	(8,229942; 7,831576; 3,248618)
4	The reactive moment with respect to the mass center (N • m)	(0,656308; −47,820212; −1151,888135)
5	The total reaction of supports (N)	(−3057,227214; 0,157531; −1,370206)
6	The absolute value of the reaction (N)	3057,227525
7	The absolute value of the moment (N • m)	1152,880514

3 Results of FEM Analysis

Static calculations were performed for all accepted parameters; the results are presented in Figs. 4, 5, 6 and 7.

According to the calculation results, large deformations or stresses exceeding the yield strength of the material are not found in the design, so it is no need to solve the problem with new data. The finite element method gave an approximate solution for the physical and geometrical linear feed elements rods of the screen, greatly simplifying the resulting system of equations.

The equivalent stresses for Mises - SVM (support vector machine, MPa) (Fig. 4), ranged from the minimum value (0) to the maximum (118.57). Accordingly, the total linear displacement, USUM (mm), also varied from the minimum value (0) to the maximum of 3.90 (Fig. 7).

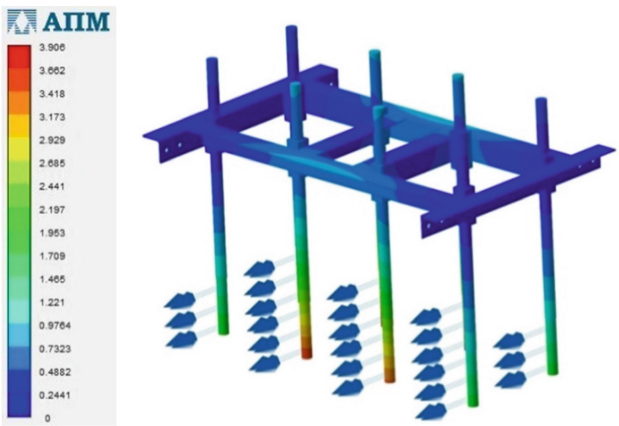

Fig. 5. Total linear displacement on the platform

The Fig. 4 shows the minimum and maximum (critical) stresses that arise in a given construction under loading, and also allows determining the numerical value of the stresses at any point.

The displacement map (Fig. 5) represents the minimum and maximum (critical) displacement (determination) occurring in a given structure under loading, and also allows the determination of the numerical value of the displacement (determination) at any point.

Yield coefficient is a strength characteristic of a stressed construction within the framework of the elasticity law (Hooke), within the limits of elastic vibrations. The Fig. 6 shows the minimum and maximum safety factor of the construction at the yield point, and also allows you to determine the numerical value of this coefficient at any point.

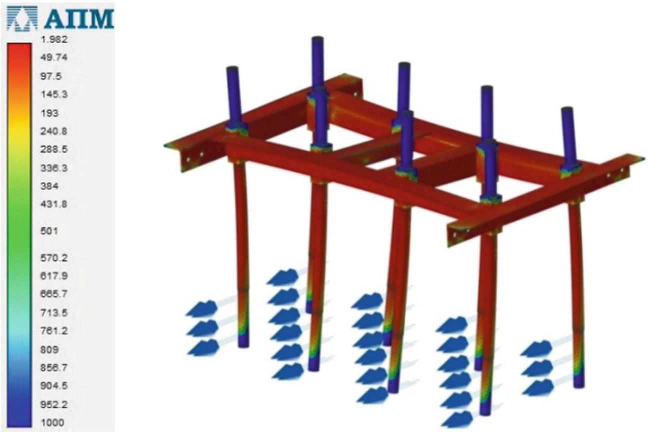

Fig. 6. Distribution of the yield coefficient on the platform

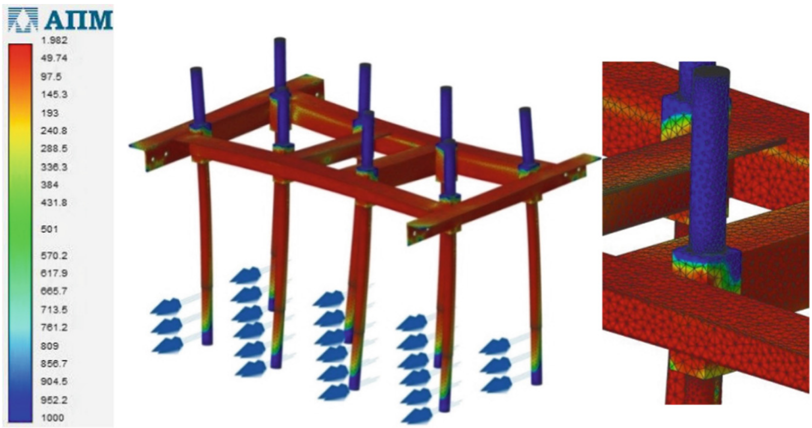

Fig. 7. Distribution of strength limit on the platform

The Fig. 7 shows the minimum and maximum safety factor of the structure by the tensile strength, and also allows determining the numerical value of this coefficient at any point.

The yield factor varied from the minimum value (1.98), to the maximum (1000) – Fig. 6. The safety factor for strength ranged from 3.45 to 1000 (Fig. 7).

Fig. 8. Industrial platform with feed elements is installed in the vibroscreen trough, built on the data basis of finite element modeling and analysis

The main check of any calculation results is a physical experiment. Considering that the above calculations represent only simulation of the real structure of the feed elements, and how accurate the model and mathematical apparatus implementing this model depend on the results of experimental verification. Therefore, according to the finite element analysis, a natural, industrially applicable platform with feed elements was assembled (Fig. 8), tested for strength and reliability in real production conditions.

4 Summary and Conclusions

1. The simulation model with the finite element method, in contrast to full-scale manufacturing, allows determining the « weak » places in the design at the design stage and approaching the task of optimal parameters selection. The finite element analysis of the feed elements platform is the best and accurate method of researching and predicting the operability of the structure under given operating conditions, allowing selecting the parameters of the future design reasonably prior to its industrial manufacture.
2. The application of the mathematical apparatus (FEM) simplifies the construction of an object model consisting of a finite elements set. FEM allows obtaining a solution in the form of stress and strain fields in practically any section of the element. These advantages of the method have not yet been used in the design of vibroscreen elements. Their implementation can reduce the metal equipment consumption, increase the reliability of its operation and reduce self-cost and, ultimately, improve the quality of the sorted material.

3. Computer simulation technology with the help of FEM allows reliable determination of the real operational characteristics of products, helps customers to ensure that their products comply with the necessary requirements and standards.

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