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METHODOLOGY FOR CREATING A MOBILE CRUSHING PLANT TAKING INTO ACCOUNT THE STRESS-DEFORMED STATE OF ITS STRUCTURAL ELEMENTS

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Due to the growing requirements for the quality of building materials, as well as the expansion of the scope of their use, the task of reducing energy costs for the processes of manufacturing building materials arises. The main areas of reducing energy costs are optimization or improvement of the designs of individual machines included in technological lines, technological lines themselves, the processes of extracting materials for construction and their delivery to the consumer. On the other hand, Ukraine is experiencing a sharp increase in the volume of construction waste, which is associated with large-scale destruction of infrastructure and housing stock, reconstruction and dismantling of dilapidated structures. Recycling construction waste allows you to reduce future construction costs and also solves environmental safety problems. A large number of current problems in the production and processing of building materials are solved by mobile crushing and sorting plants. Mobile crushing and sorting plants designed for crushing and separating rocks, construction waste or other bulk materials directly at the place of extraction or processing. Such complexes can function as independent units or as elements of entire plants, while ensuring flexible adaptation to production conditions. Mobile crushing plants combine high productivity, autonomy, mobility and economic feasibility, ensuring minimal loss of time and fuel while maintaining the quality of crushing and sorting. One of the most important advantages of mobile crushing plants compared to stationary machine designs is a significant reduction in logistics costs associated with transporting raw materials to the crushing site. In addition to direct savings in fuel and transport resources, reducing logistics provides a number of indirect benefits. First of all, the technological cycle time is reduced. This, in turn, increases the company's cash flow and reduces the need for intermediate warehouses. An important advantage is the reduction in infrastructure construction and maintenance costs. For stationary crushers, it is necessary to build concrete foundations, access roads, overpasses, loading hoppers, and also provide for the supply of communications. Another aspect that has a financial impact is the reduction of downtime related to weather conditions and road conditions.

The paper performs a criterion-based assessment of mobile crushing and screening plants, builds models of technological schemes for single-stage crushing and two-stage crushing, which include the designed mobile crushing plant, and provides calculations of the parameters of the mechanical mode of the jaw crusher, the running gear, and the hydraulic system. Based on the load scheme of the structural elements of the jaw crusher, the stress-strain state of the eccentric shaft and the spacer plate was determined using the finite element method.

Keywords: mobile crusher, jaw crusher, criterial evaluation, technological scheme, mechanical mode parameters, hydraulic scheme, crushing force, stresses, deformations, parameterization.

Introduction. Mobile crushing and sorting plants designed for crushing and separating rocks, construction waste or other loose materials directly at the place of extraction or processing. Such complexes can function both as independent units and as elements of entire plants, while ensuring flexible adaptation to production conditions.In modern conditions, when increasing efficiency and reducing costs are the key tasks of the construction industry, the transportation stage is considered as one of the main areas of optimization. Mobile crushing complexes combine high productivity, autonomy, mobility and economic expediency, ensuring minimal loss of time and fuel while maintaining the quality of crushing and sorting. One of the most important advantages of mobile crushing complexes compared to stationary ones is a significant reduction in logistics costs associated with the transportation of raw materials to the crushing site.In addition to the direct saving of fuel and transport resources, the reduction of logistics provides a number of indirect benefits. First of all, the time of the technological cycle is shortened: the material is crushed immediately after mining, which speeds up further sorting and shipment of finished products. This, in turn, increases the turnover of the company's working capital and reduces the need for intermediate warehouses. An important advantage is the reduction of infrastructure construction and maintenance costs. For stationary crushers, it is necessary to build concrete foundations, driveways, overpasses, loading hoppers, as well as to ensure the introduction of communications. Another aspect that has a financial impact is the reduction of downtime related to weather conditions and road conditions. In quarries with clay soils, after rains or during frosts, rock transport by road often becomes impossible or economically unprofitable due to slippage and increased fuel consumption. An equally important advantage of mobile complexes is the possibility of reducing the number of material overloads. In stationary schemes, the mass needs to be loaded and unloaded several times, which is accompanied by losses, dusting and wear and tear of equipment. Mobile crushing reduces the number of such operations, improving the environmental performance of the enterprise - dust emissions, noise and fuel consumption are reduced.

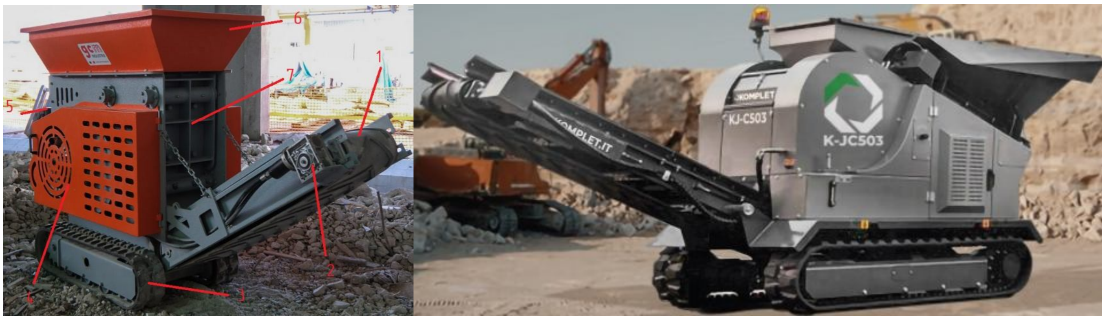
In connection with the need to process construction materials in compressed conditions, as well as a significant number of locations with existing construction waste and taking into account the considerable cost of modern crushing complexes, there is a need to create compact mobile crushing plants.

Analysis of publications. The work [1] presents the results of the study of the effectiveness of the use of crushing and sorting complexes in granite quarries. The authors note that at a pit depth of up to 150 m, the cost of manufacturing crushed stone products decreases by 1.71 times. However, there are no data on the use of crushing complexes in the processing of construction materials in compressed conditions. Another interesting study of crushing and sorting complexes is given in the source [2]. A complex mathematical model for optimizing the production schedule and location of semi-mobile crushing and sorting plants in the quarry is considered. An important emphasis in the work is the analysis of operating costs incurred for the transport of the rock. In the source [3], the developed reliability assessment system for preventive maintenance planning of the Metso Lokotrack LT1213S mobile crushing plant is considered. In the analysis, the reliability characteristics of critical components were determined quantitatively. It should be noted here that the research covered only a full-scale crushing and sorting complex. In sources [4] and [5] calculations were made on the strength of the crushing jaw of the PC5282 jaw crusher and the frame part by the finite element method. On the basis of calculations, local zones of stress concentration and optimization of structural elements are determined. The disadvantages include incomplete calculation of the entire structure of the crusher and the use of the cosmos works software product, which, compared to specialized cae systems, is less accurate and does not have sufficient flexibility at the stages of model preparation and obtaining calculation results. In the source [6], optimization of the shape of the profiles of the grooves of the teeth of the crushing plates of the jaw crusher was performed using the finite element method. In contrast to the previously considered sources, studies using the cae method were performed in Ansys, but without experimental confirmation. The source [7] gives the results of research into the design of the mobile jaw of a jaw crusher using the finite element method. A feature of this study is the use of the Design of Experiments method to determine the optimal parameters of the cheek. The authors prove the fact that the geometry of the cheek plate significantly affects the distribution of stresses and strains during the crushing process. The shortcomings include the fact that the model or dimensions of the jaw crusher are not specified in the work, as well as the lack of calculations of other design elements of the jaw crusher. In the source [12], an analysis of vibration machines for the production of building materials is performed and corresponding technological schemes are given. A key role in the technological scheme is played by a vibrating jaw crusher with an inclined crushing chamber, the degree of crushing of which can reach 100 units. Based on the analysis of mobile crushing complexes, it is promising to study the possibility of placing a vibrating jaw crusher on a mobile chassis, which will increase the scope of application of such machines.

Purpose of the paper. Develop the design of a mobile crushing plant and analyze its parameters.

Research results. At the first stage of development, research was conducted among similar solutions of foreign manufacturers. Figure 1 shows the mobile crushing plant of the Italian company GCM Industrie GCM-FMM/4025. It is designed for the production of building materials and can work in hard-to-reach places. The main crushing machine is a jaw crusher 7 with a size of 400x250 and a capacity of up to 8 t/h. Material is loaded into the crushing chamber through hopper 6 with a volume of

0.5 m3. The crushing product is unloaded by conveyor 1, which is driven by hydraulic motor 2. The speed of material movement on the conveyor is 0.5 m/s. The maximum slope of the surface on which the complex can work is 10%. The installation is equipped with a series 11 diesel engine KW-Monocilindro. The total weight of the complex is 1300 kg. Dimensions: width 800 mm, height - 1600 mm, length 2700 mm. The size of the crushing product is 10-50 mm.

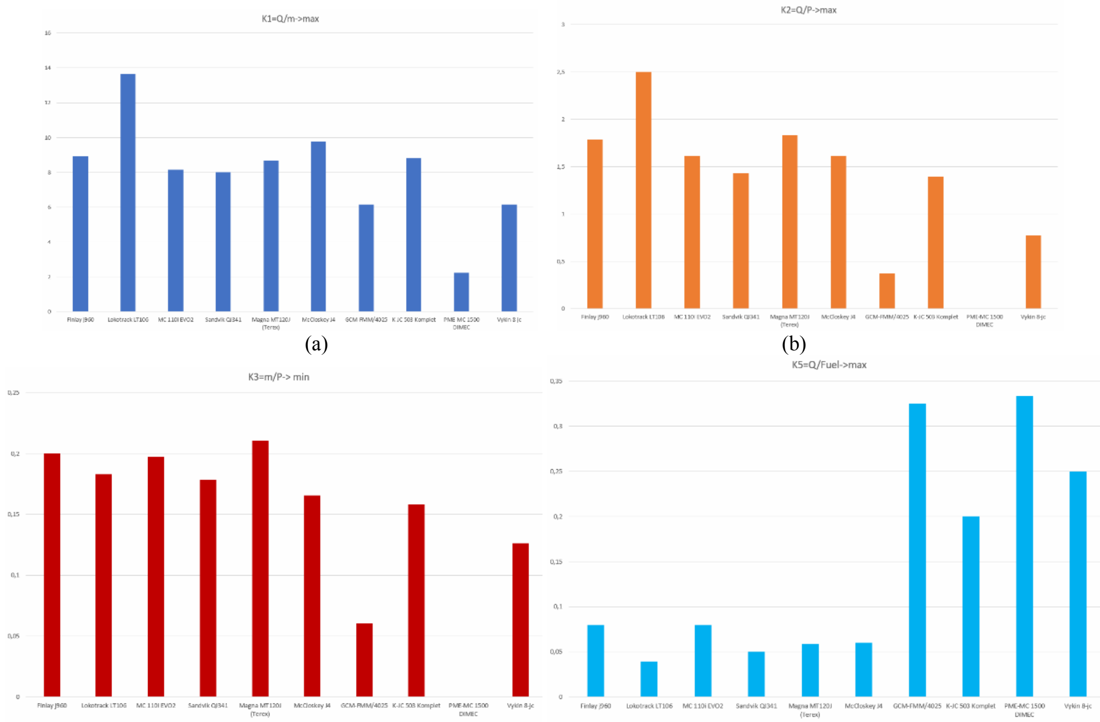


(a) (b)

Fig. 1. Mobile jaw crusher: (a) - GCM-FMM/4025; (b) - K-JC 503

Another manufacturer of such equipment is the Italian company Komplet, which presents the K-JC 503 model, fig. 2. The mobile crusher is designed for construction waste processing. Equipped with a tracked running device, there is the possibility of remote control, which simplifies the process of performing many works. In general, the structure is similar to the rice crusher. 1. The difference lies in the installed equipment. The complex is equipped with a 500x300 jaw crusher with a capacity of 30 tons per hour. The range of adjustment of the outlet opening of the crusher is within 20-80 mm. Engine power is 18.5/21.5 kW. The weight of the installation is 3400 kg. Remote control is also available. Overall dimensions: width 1.3 m, height 2 m, length 4.6 m.

Based on the consideration of the designs of mobile crushing machines, their criterion evaluation was performed. In fig. 2 presents the histograms of the evaluation of crushing plants according to the criteria of influence of mass on productivity, power on productivity and power on mass.



(a) (b) (c) (d)

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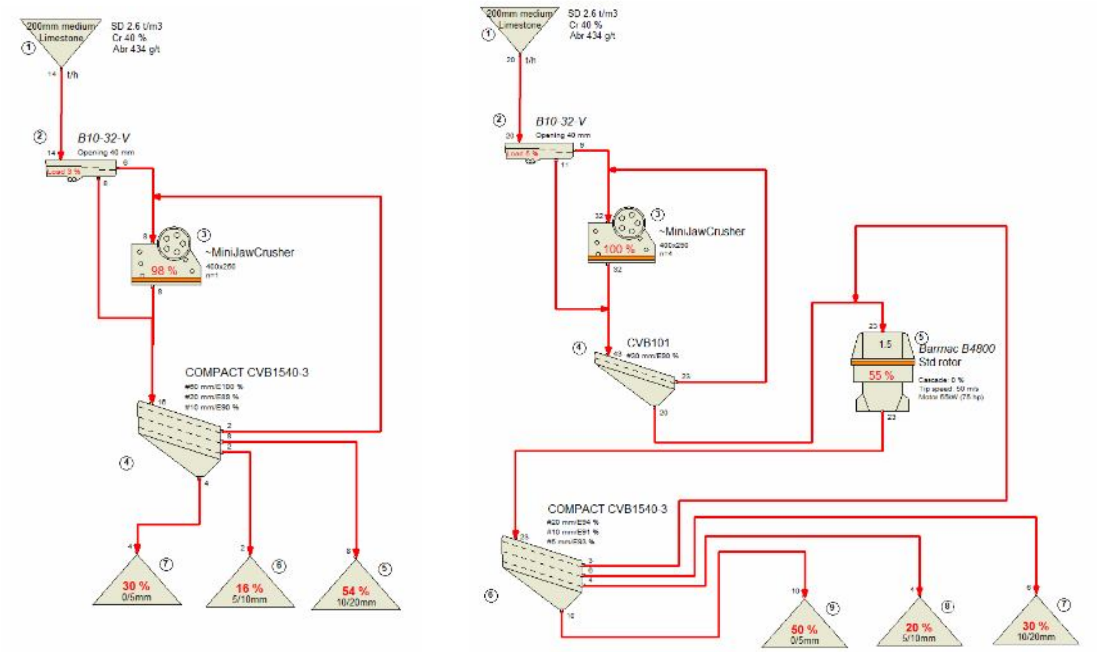
Fig. 2 – Criterion assessment of mobile crushing complexes:
(a) – productivity-mass; (b) – productivity-power; (c) – mass-power; d – fuel consumption-productivity

In parallel with compact mobile installations, full-size crushing complexes were considered. Particular attention should be paid to the criterion of fuel efficiency per unit of production, fig. 2, d. From the analysis of histograms, it is possible to conclude about the prospects of using mobile crushing plants in the compressed conditions of the city with small volumes of crushing work.

At the next stage, technological lines for the production of building materials were modeled, which include a pre-calculated jaw crusher for a mobile crushing complex, fig. 3.



(a) (b)

Fig. 3. Crushing and sorting lines for the production of building materials:
(a) – one-stage scheme; (b) - two-stage scheme

The productivity of a one-stage sandstone processing scheme is 14 tons per hour, fig. 3, and while the two-stage scheme has a productivity of 20 tons per hour, Fig. 3, b. It should be noted here that the diagram, fig. 3, and is designed for use in conditions where relatively low operating and energy costs are required with low product quality, in contrast to the scheme, fig. 3, b.

The main parameters of the mechanical mode of most construction machines are the required performance and power, on the basis of which all other parameters are determined. Since the main machine of a compact mobile crusher is a jaw crusher, we accept the values of these parameters relative to the main machine.

In this way, we determine productivity based on the dependence [8]:

$$Q=\frac{1800\cdot C\cdot S_{av}\cdot L\cdot b\cdot n\cdot\left(B+b\right)}{D_{av}\cdot \mathrm{tg}\alpha}, \qquad (1)$$

where C – kinematics coefficient; S_{av} - the average value of the cheek stroke, m; L – length of loading hole, m; b – width of the unloading hole, m; n – eccentric shaft rotation frequency, rpm; B – width of loading hole, m; D_{av} –average size of material particles, m; b - capture angle, degrees.

In turn, there will be power [9]:

$$N=\frac{k_{pr}\sigma^2{}_{st}\pi k_p Ln}{12E\eta_d}\left(D_{av}^2-d_{av}^2\right), \qquad (2)$$

where k_{pr}– proportionality factor; k_p– correction factor; E – modulus of elasticity of the material; D_{av} – average particle size of the material; d_{av} – the average size of the crushing product; η_d – drive efficiency.

The next step is to determine the energy transfer method. A mobile crushing complex should at least include a jaw crusher, a conveyor and a moving chassis. One of the best options for the drive will be the installation of a hydraulic system that combines compactness, flexibility and sufficient power. The hydraulic diagram of the drive is presented in fig. 4.

Based on the required power of the drive and the working pressure of the hydraulic system, we calculate the pump supply [10]:

$$Q = 61.2 \times \frac{N_d}{P_n}, \tag{3}$$

Where P_n – nominal working pressure of the hydraulic system; N_d – required power, kWt.

Next, we calculate the working volume of hydraulic motors, cm^3/rev:

$$q_\partial = \frac{1000 \times Q \times \eta_{rev}}{z \times n}, \tag{4}$$

where Q – pump supply, η_{rev} – volumetric efficiency; n – frequency of revolutions of the pump shaft, rev/min.

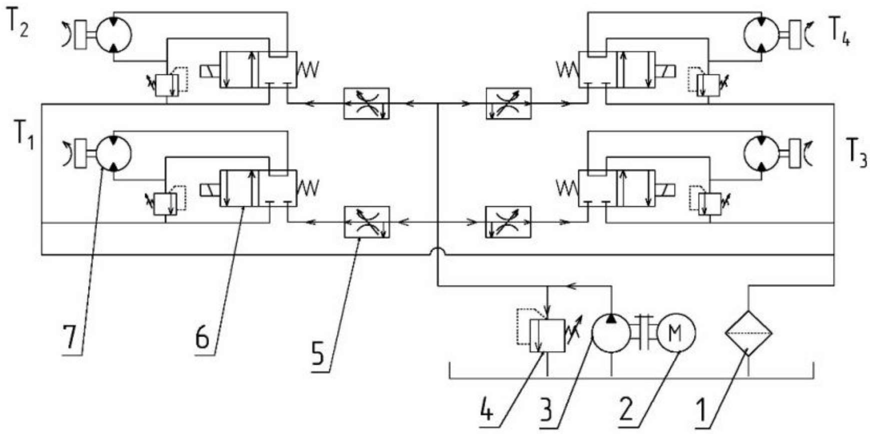


Fig. 4. Hydraulic diagram of the drive of the mobile crusher: 1 - filter; 2 –motor; 3 –pump; 4 – safety valve; 5 – adjustable throttle; 6 – two-position four-channel spool; 7 – hydraulic motor

Self-propelled modules are subject to the following requirements: 1) increased load capacity; 2) rational dimensions and weight; 3) maneuverability; 4) permeability.

In our project, we are creating a mobile jaw crusher of small dimensions. In the conditions of movement on the construction site, we do not need significant movement speeds, but the stability of work in conditions of uneven surfaces, soft soil, snow, sand is important, as well as high passability, minimization of specific pressure on the soil, work with loads and high traction are important. In this case, a crawler is best suited.

For this purpose, we determine the specific pressure on the soil, kPa:

$$p = G/(2BL), \tag{5}$$

where G – weight of the car, N; B – track width, m; L – contact length, m.

Typical allowable specific pressure values: Hard soil: ≤ 60–80 kPa, Normal soil: 30–45 kPa. Provided that the weight of the machine does not exceed 2000 kg, the width of the track can be accepted within the limits 250 mm.

The load on one support roller is determined by the formula:

$$F_k = G/2n_k, \tag{6}$$

where n_k – total number of support rollers, G – weight of the car, N.

Next, we determine the diameter of the drive sprocket:

$$D = (pz)/\pi,, \quad (7)$$

where p – step between teeth, z – the number of teeth.

The required thrust is determined based on the dependency:

$$F_g = F_{rr} + F_{lr} + F_a, \quad (8)$$

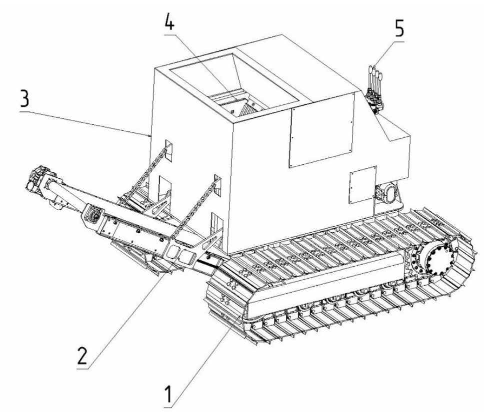
where F_{rr} – rolling resistance force, F_{lr} – lift resistance force, F_a – additional resistance forces (turning resistance and internal losses).

Knowing the total required traction (8), we determine the power of the drive:

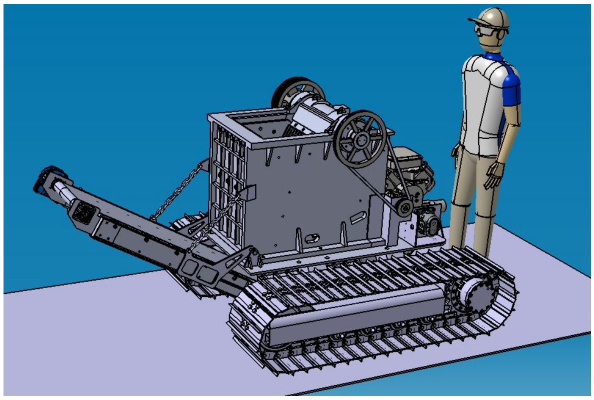
$$N = \frac{F_g \times v}{\eta}, \quad (9)$$

where v – speed of movement, m/s; η – drive efficiency.

Based on the performed calculations, the design of a compact mobile crushing plant was developed, which is presented in fig. 5.



(a)



(b)

Fig. 5. Model of a compact mobile crushing plant: a – scheme: 1 – running device; 2 – conveyor; 3 – body; 4 – jaw crusher; 5 – hydraulic distributor. b – solid model

The main crushing unit of the complex is a jaw crusher. In order to optimize the design of the jaw crusher, the corresponding calculations of its design elements were performed. The force analysis of the operation of the jaw crusher consists in establishing all external loads acting on its individual elements, as well as in determining the internal force interactions between these links during the operation of the mechanism.

Crushing force is determined by the formula [11]:

$$F_{mcr} = k_z qHL,, \quad (10)$$

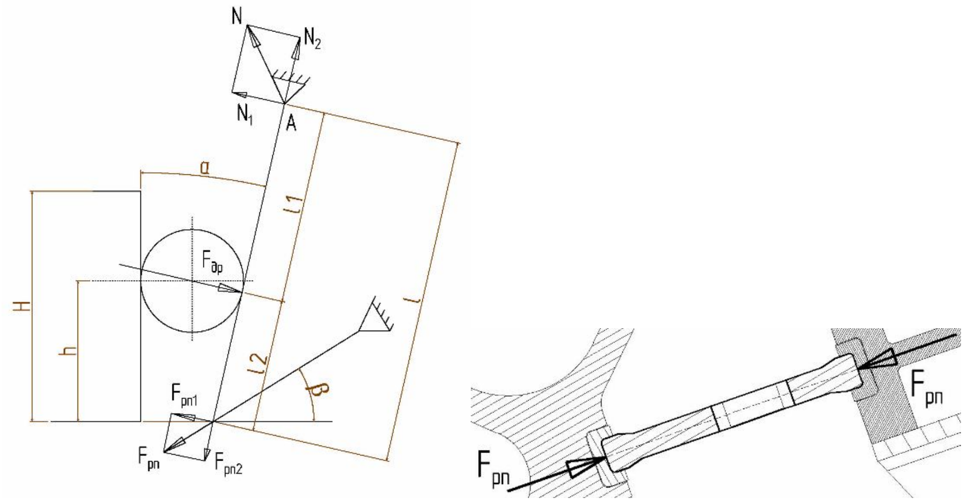
where k_z – stock factor; H – width of the crushing cheek; L – length of the crushing plate; q – specific crushing force (in separate sources it is given as q=2.7x10^6 MPa, when crushing granite with a strength of 300 MPa). In dependence (10), the specific crushing force parameter introduces some difficulties, since the given value is conditionally the maximum possible when crushing very strong materials. In turn, the compact mobile complex is not designed for crushing high-strength materials. In addition, the geometry of the design of such a complex is different from the designs of full-size jaw crushers.

In this work, we will calculate the spacer plate and eccentric shaft. The calculation scheme of the jaw crusher is presented in Fig. 6, and from which it can be seen that a force acts on the spacer plate F_{pn}. The spacer plate of jaw crushers operates under the conditions of a pulsating load cycle, and is also subject to sharp jumps in forces when non-crushing inclusions enter the crushing chamber.In general, it undergoes off-center compression, since its geometric axis does not coincide with the line of application of the load. This is caused by a change in the position of the support surfaces of the crackers when adjusting the width of the unloading gap, as well as the gradual wear of the surfaces of the plates and crackers. It should be noted that the spacer plate of the jaw crusher often has a special geometry curved in thickness, which provides the function of a safety element. This form allows for purposeful formation of a bending moment in the critical section, which artificially reduces the load-bearing capacity of the slab during overloading and thereby ensures its destruction under the given conditions, preventing more serious damage to the crusher.

For estimated calculations, the stress in the spacer plate can be determined based on the following relationship:

$$\sigma = \frac{F_{sp}}{S} \pm \frac{M_u}{W}, \quad (11)$$

where F_{sp} – force compressing the plate; S – calculated cross-sectional area of the plate; W – moment of section resistance; M_u – slab bending moment.



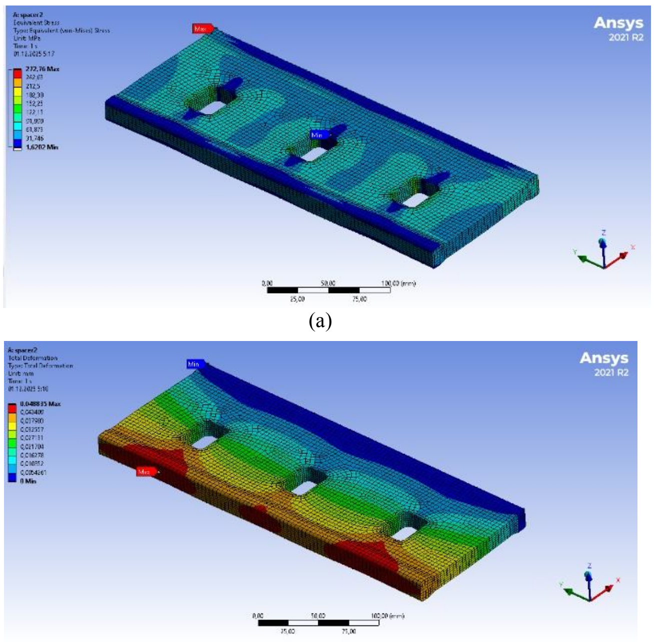
(a) (b)

Fig. 6. Scheme for determining the forces acting on the design elements of the jaw crusher: (a) – general scheme of forces; (b) - diagram of forces acting on the spacer plate

Based on the scheme of fig. 6, and determine the force acting on the spacer plate:

$$F_{sp} = F_{cr} \times \cos\left(\alpha - \frac{\beta}{2}\right) = \frac{2\pi\sigma_s^2(D^2 -}{12E \times} \quad (12)$$

where y_s – compressive strength limit; E – modulus of elasticity; S_d – movement of the movable cheek; L – length of the grinding chamber; D – average diameter of loading material; d – the size of the unloading material; F_{cr} – crushing force. In fig. 6, b shows a spacer plate with an axis located normal to the support surfaces. In this case, the slab is subject only to compressive stresses. However, as it was mentioned above, during the operation of the crusher, the line of action of the compressive load may not coincide with the axis of the plate, which causes eccentric compression and bending moment.



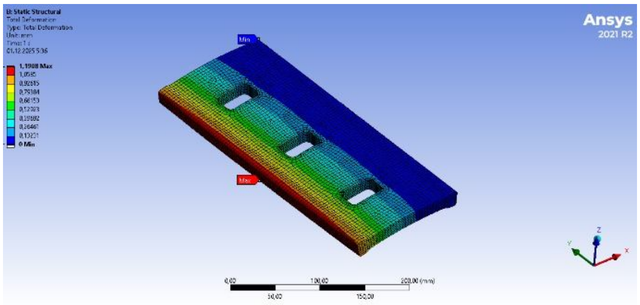
(a)

(b)

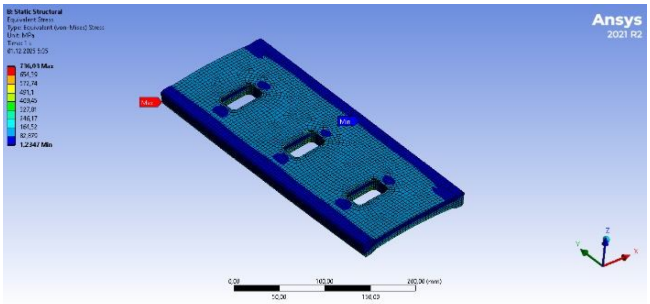
Fig. 7. Calculation results under axial load: (a) – stress pattern; (b) – pattern of deformations

Based on the determined load, we will perform a detailed calculation of the spacer plate in the Ansys software complex. The strength of the grinding material is assumed to be 80 MPa. For the conditions of axial application of forces, the pattern of stresses and deformations is presented in fig. 7.

Based on the results of the calculation, it was established that under the conditions of choice for this plate, the material in the form of steel 20 and its corresponding dimensions does not provide sufficient strength. This is also not indicated by the software-calculated safety factor, which was 0.9. Next, the case of off-axis force application was considered. The pattern of stresses and deformations is presented in fig. 8.



(a)

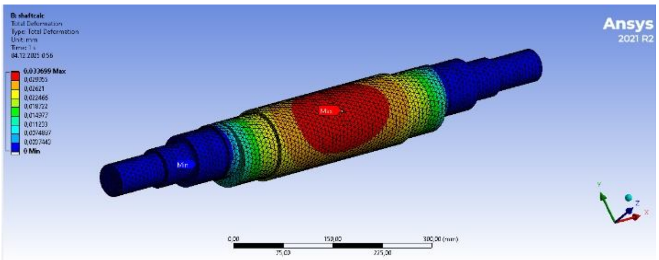


(b)

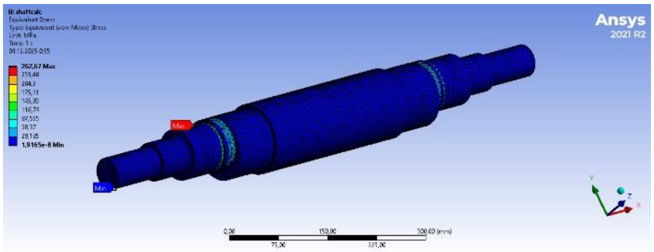
Fig. 8. Calculation results for off-axis loading:
(a) – stress pattern; (b) – pattern of deformations

The safety factor for the case of an off-center load was 0.3. Based on the obtained calculations, we conclude that it is necessary to change the plate material to steel 65G. Another solution to the problem of insufficient strength is to change the geometry of the plate. When using 65G steel, the safety factor for axial load increases to 3.6 and for off-axis load to 1.3.

The eccentric shaft of the jaw crusher operates under combined load conditions, simultaneously accepting bending and torsional stresses. The occurrence of bending forces is caused by the action of the reaction force N_2, which is transmitted to the shaft through the bearing supports of the connecting rod assembly. It is through these bearings that the movable cheek is hinged connected to the eccentric neck of the shaft, creating a variable force effect and determining the periodic nature of the load.



(a)



(b)

Fig. 9. Results of eccentric shaft calculation: (a) – pattern of deformations; (b) - pattern of stresses

Bending stresses in the dangerous section of the shaft are defined as:

$$\sigma_b = \frac{M_b}{0.1d^3} = \frac{R_A l_n}{0.1d^3}, \qquad (13)$$

where l_n – distance between bearing supports, m; R_A – reaction in bearing resistance, N; d – diameter of the shaft in the dangerous section, m; M_b – bending moment, Nm.

Torsional stress:

$$\tau_{tor} = \frac{M_{tor}}{0.2d^3} = \frac{F \times e}{0.2d^3}, \qquad (14)$$

where e – eccentricity of the shaft, m; M_{tor} – torque, Nm.

Total tension:

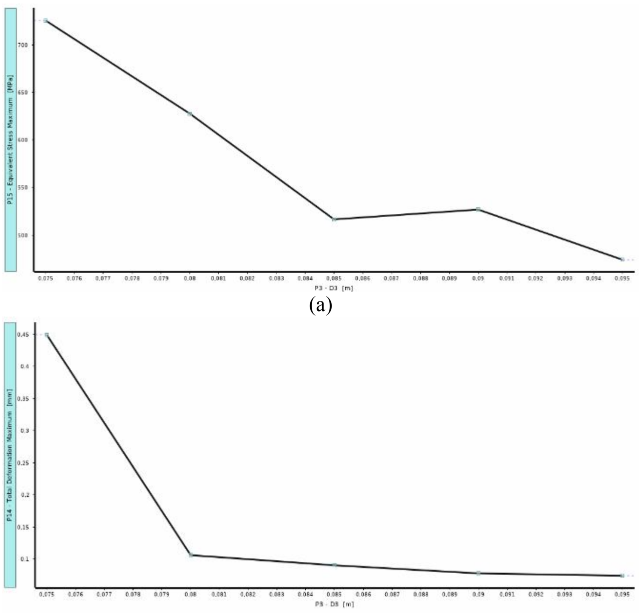
$$\sigma_{\max} = \frac{\sigma_b}{2} + \frac{1}{2}\sqrt{\sigma_b{}^2 + 4\tau_{tor}^2}. \qquad (15)$$

The pattern of stresses and

deformations of the eccentric shaft due to bending and torsional stresses is presented in fig. 9.

As we can see from fig. 9, the maximum stresses are high, which is explained by the presence of stress concentrators between the stages of the shaft. In general, the general pattern of stresses corresponds to those calculated according to general formulas. The safety factor is 3.8. 38HN steel can be used as a material.

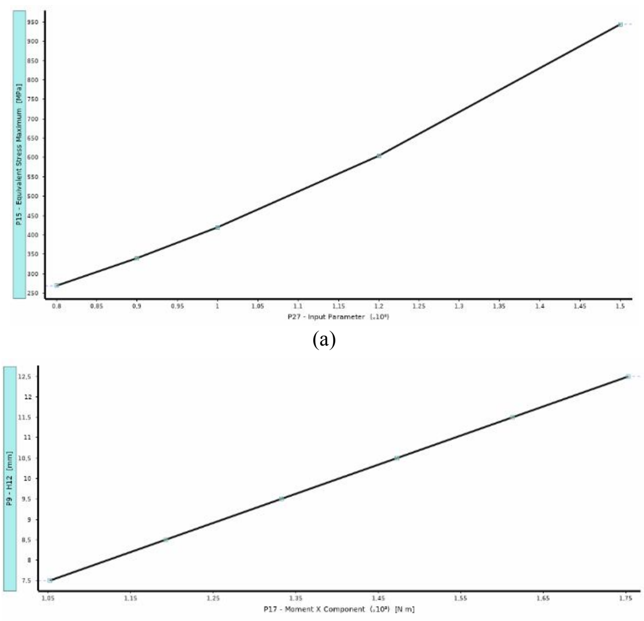
Graphs of the influence of the shaft diameter in the dangerous cross-section on the maximum stresses and deformations under the condition of crushing the material with a strength of 80 MPa are presented in fig. 10.



(a) (b)

Fig. 10. Graphs of the influence of the diameter of the eccentric shaft in the dangerous section on: (a) – tension; (b) – deformation

An important parameter of the eccentric shaft of the crusher is the value of its eccentricity, which affects the value of the torque, fig. 11, b. As we can see, the change in eccentricity directly affects the change in torque. In order to optimally assess the capabilities of the crusher for crushing material, a corresponding graph was constructed, fig. 11, a. The horizontal axis on the graph of fig. 11, a is determined by the input parameter, which is essentially the value of the required crushing force.



(a) (b)

Fig. 11. Graphs: (a) – the effect of the strength of the crushed material on the amount of stress in the eccentric shaft; (b) - the influence of the eccentric value on the change in torque

Conclusions. In the work, a criterion evaluation of crushing and crushing-sorting complexes of various manufacturers was performed, which indicates the prospects of using compact mobile crushing plants for processing building materials in the compressed conditions of urban development. The advantages of compact mobile crushing plants include significant savings on transport logistics, simplicity of design, energy efficiency and low cost compared to full-sized crushing complexes. Modeling of technological lines using compact mobile crushers reflects their sufficient efficiency under conditions of small volumes of processing or production of building materials. The parameters of the chassis, drive, hydraulic system and crushing forces were calculated. On the basis of which, a model of a compact mobile crushing plant with a capacity of up to 8 t/h and a power of up to 14 kW was designed.

Based on the scheme of load transfer between the structural elements of the crusher, the loads transmitted to the eccentric shaft of the crusher and its spacer plate were determined. In order to optimize the design, a parameterized calculation model of the eccentric shaft and spacer plate was created, and on the basis of graphic constructions, the optimal values of the corresponding parameters were determined depending on the conditions of the work process.

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МЕТОДИКА СТВОРЕННЯ МОБІЛЬНОЇ ДРОБИЛЬНОЇ УСТАНОВКИ З УРАХУВАННЯМ НАПРУЖЕНО-ДЕФОРМОВАНОГО СТАНУ ЇЇ КОНСТРУКЦІЙНИХ ЕЛЕМЕНТІВ

У зв'язку зі зростанням вимог до якості будівельних матеріалів, а також розширенням сфери їх використання постає завдання зниження енергетичних витрат на процеси виробництва будівельних матеріалів. Основними напрямками зниження енергетичних витрат є оптимізація або вдосконалення конструкцій окремих машин, що входять до технологічних ліній, самих технологічних ліній, процесів вилучення будівельних матеріалів і доставки їх до споживача. З іншого боку, в Україні спостерігається різке зростання обсягів будівельного сміття, що пов’язано з масштабним руйнуванням інфраструктури та житлового фонду, реконструкцією та демонтажем аварійних конструкцій. Переробка будівельного сміття дозволяє скоротити майбутні витрати на будівництво, а також вирішує проблеми екологічної безпеки. Велику кількість актуальних проблем у виробництві та переробці будівельних матеріалів вирішують мобільні дробильно-сортувальні установки. Пересувні дробильно-сортувальні установки, призначені для дроблення та сортування гірської породи, будівельного сміття та інших сипучих матеріалів безпосередньо на місці видобутку або переробки. Такі комплекси можуть функціонувати як самостійні одиниці або як елементи цілих заводів, забезпечуючи при цьому гнучку адаптацію до умов виробництва. Мобільні дробильні установки поєднують високу продуктивність, автономність, мобільність та економічну доцільність, забезпечуючи мінімальні втрати часу та палива при збереженні якості дроблення та сортування. Однією з найважливіших переваг мобільних дробильних установок у порівнянні зі стаціонарними конструкціями машин є значне зниження логістичних витрат, пов’язаних із транспортуванням сировини до місця дроблення. Крім прямої економії палива і транспортних ресурсів, скорочення матеріально-технічного забезпечення дає ряд непрямих переваг. Перш за все, скорочується час технологічного циклу. Це, у свою чергу, збільшує грошовий потік компанії та зменшує потребу в проміжних складах. Важливою перевагою є зниження витрат на будівництво та обслуговування інфраструктури. Для стаціонарних дробарок необхідно спорудити бетонні фундаменти, під'їзні шляхи, естакади, завантажувальні бункери, а також передбачити підведення комунікацій. Іншим аспектом, який має фінансовий вплив, є скорочення часу простою, пов'язаного з погодними умовами та дорожнім станом.

У роботі проведено критеріальну оцінку мобільних дробильно-сортувальних установок, побудовано моделі технологічних схем одноступінчатого дроблення та двоступінчатого дроблення, які включають проектовану мобільну дробильну установку, надано розрахунки параметрів механічного режиму щокової дробарки, ходової частини та гідросистеми. На основі схеми навантаження елементів конструкції щокової дробарки методом скінченних елементів визначено напружено-деформований стан ексцентрикового валу та розпірної плити.

Ключові слова: мобільна дробарка, щокова дробарка, критеріальна оцінка, технологічна схема, параметри механічного режиму, гідравлічна схема, сила дроблення, напруження, деформації, параметризація.

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METHODOLOGY FOR CREATING A MOBILE CRUSHING PLANT TAKING INTO ACCOUNT THE STRESS-DEFORMED STATE OF ITS STRUCTURAL ELEMENTS

Due to the growing requirements for the quality of building materials, as well as the expansion of the scope of their use, the task of reducing energy costs for the processes of manufacturing building materials arises. The main areas of reducing energy costs are optimization or improvement of the designs of individual machines included in technological lines, technological lines themselves, the processes of extracting materials for construction and their delivery to the consumer. On the other hand, Ukraine is experiencing a sharp increase in the volume of construction waste, which is associated with large-scale destruction of infrastructure and housing stock, reconstruction and dismantling of dilapidated structures. Recycling construction waste allows you to reduce future construction costs and also solves environmental safety problems. A large number of current problems in the production and processing of building materials are solved by mobile crushing and sorting plants. Mobile crushing and sorting plants designed for crushing and separating rocks, construction waste or other bulk materials directly at the place of extraction or processing. Such complexes can function as independent units or as elements of entire plants, while ensuring flexible adaptation to production conditions. Mobile crushing plants combine high productivity, autonomy, mobility and economic feasibility, ensuring minimal loss of time and fuel while maintaining the quality of crushing and sorting. One of the most important advantages of mobile crushing plants compared to stationary machine designs is a significant reduction in logistics costs associated with transporting raw materials to the crushing site. In addition to direct savings in fuel and transport resources, reducing logistics provides a number of indirect benefits. First of all, the technological cycle time is reduced. This, in turn, increases the company's cash flow and reduces the need for intermediate warehouses. An important advantage is the reduction in infrastructure construction and maintenance costs. For stationary crushers, it is necessary to build concrete foundations, access roads, overpasses, loading hoppers, and also provide for the supply of communications. Another aspect that has a financial impact is the reduction of downtime related to weather conditions and road conditions.

The paper performs a criterion-based assessment of mobile crushing and screening plants, builds models of technological schemes for single-stage crushing and two-stage crushing, which include the designed mobile crushing plant, and provides calculations of the parameters of the mechanical mode of the jaw crusher, the running gear, and the hydraulic system. Based on the load scheme of the structural elements of the jaw crusher, the stress-strain state of the eccentric shaft and the spacer plate was determined using the finite element method.

Keywords: mobile crusher, jaw crusher, criterial evaluation, technological scheme, mechanical mode parameters, hydraulic scheme, crushing force, stresses, deformations, parameterization.

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У роботі проведено критеріальну оцінку мобільних дробильно-сортувальних установок, побудовано моделі технологічних схем одноступінчатого дроблення та двоступінчатого дроблення, які включають проектовану мобільну дробильну установку, надано розрахунки параметрів механічного режиму щокової дробарки, ходової частини та гідросистеми. На основі схеми навантаження елементів конструкції щокової дробарки методом скінченних елементів визначено напружено-деформований стан ексцентрикового валу та розпірної плити.
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Fig. 11. Ref. 12

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