The difference consists in the fact that in the method that we are proposing, a portion of the enveloping slip line located in the supporting layer is not varied, but is found in constructing the limiting stressed zone. Since the effect of the load due to the foundation vanishes rapidly with depth, the method described is valid for embankments whose height exceeds the width of the foundation by not more than 2-2.5 times.

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DETERMINING THE VIBRATION AMPLITUDE OF FOUNDATIONS SUPPORTING CRANKSHAFT PRESSES

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Significant dynamic loads, which reduce in a number of cases to loss of stability of crankshaft presses, arise in performing separating operations of the blanking-punching type, the cutting of sheet and structural metal, the cold fracturing of structural metal, etc. [1].

Experimental data cited in studies devoted to investigation of the dynamics of crankshaft presses [1-4] make it possible to evaluate the character and magnitude of the dynamic loads transmitted onto the foundations of these presses during separation operations. Vibrographs of forces in the frame, which were obtained during cutting on different presses, have an identical character and differ only in the magnitude and duration of the effective forces, as well as in the frequency of their variation.

It is apparent from Fig. 1 that the force in the frame increases rapidly to the maximum value $P_t$, and the unloading phase then sets in. It is obvious that the force in the frame of the press, which arises during blanking, is a load on the foundation supporting the press. A crankshaft press and its foundation experience greatest dynamic effects during blanking with a die having straight cutting edges. In this case, after attainment of the maximum occurs almost instantaneously $(4-8 \cdot 10^{-4}$ sec) [1]. On the basis of experimental data, we can assume that a vertical-force pulse that varies as a triangle with time is transmitted onto the foundation of the press.

The foundation under a crankshaft press can be treated as a system with one degree of freedom during separation operations [5].

The general expression for displacements of the system under consideration with time takes the form [6]:

$$u_x(t) = \frac{1}{\lambda_2} \int_{0}^{t} \int_{0}^{t} \sin \lambda_2 (t-\tau) d\tau.$$

(1)

Fig. 1. Force in frame of 3SK 32323 press during blanking (after Katkov et al. [2]).
Fig. 2. Dynamic coefficient $\mu (\nu)$.

where $m$ is the mass of the foundation and press; $\lambda_z$, frequency of the natural vertical vibrations of the system; and $f(\tau)$, force acting on the foundation, tons. In applying to the foundation a force that varies in accordance with the law $f(\tau) = \beta \tau$ and that remains on the foundation for an indefinite length of time, we have the following expression

$$u_s (t) = \frac{\beta t}{K_x} - \frac{\beta}{\lambda_z K_x} \sin \lambda_z t,$$

(2)

where $K_x$ is the stiffness coefficient for natural foundation beds under uniform elastic compression. Setting

$$\frac{\beta t}{K_x} = \frac{P_1}{K_x} = A_\infty \text{ and } \lambda_z = \frac{2\pi}{T},$$

(12a)

we obtain

$$u_s (t) = A_\infty \left(1 - \frac{1}{2\pi} \cdot \frac{T}{t} \sin \lambda_z t\right).$$

(3)

Equation (3) is the equation of harmonic vibrations with a frequency $\lambda_z$. When the force remains on the foundation for an indefinite time, the system experiences the greatest displacements when $t = 0.75T$.

Let us examine the case when a force varying in accordance with the law $f(\tau) = \beta t_1$ acts on the foundation for a certain time $t_1$, and then vanishes suddenly. Under the action of a vertical-force pulse that varies with time according to this law, we have

$$u_s (t) = \frac{\beta t}{K_x} - \frac{\beta}{\lambda_z K_x} \sin \lambda_z t - \frac{\beta t_1}{K_x} \left[1 - \cos (t - t_1)\right] - \frac{\beta (t - t_1)}{K_x} + \frac{\beta}{\lambda_z K_x} \sin (t - t_1),$$

(4)

for the system under consideration. After transformation, we obtain the equation

$$u_s (t) = A_\infty \left[\frac{1}{2\pi} \cdot \frac{T}{t_1} \sin \lambda_z (t - t_1) - \frac{1}{2\pi} \cdot \frac{T}{t_1} \sin \lambda_z t + \cos \lambda_z (t - t_1)\right]$$

(5a)

for determination of foundation displacements, or in another form

$$u_s (t) = A_\infty \left[\left(\frac{1}{2\pi} \cdot \frac{1}{a} \cos 2\pi a - \frac{1}{2\pi} \cdot \frac{1}{a} + \sin 2\pi a\right) \sin \lambda_z t - \left(\frac{1}{2\pi} \cdot \frac{1}{a} \sin 2\pi a - \cos 2\pi a\right) \cos \lambda_z t\right].$$

(5)

where $a = t_1/T$.

Equation (5) is the sum of harmonic vibrations with a frequency $\lambda_z$.

The vibration amplitude of the press foundation can be determined from the expression

$$A_x = A_\infty \sqrt{\left(\frac{1}{2\pi} \cdot \frac{1}{a} \cos 2\pi a - \frac{1}{2\pi} \cdot \frac{1}{a} + \sin 2\pi a\right)^2 + \left(\frac{1}{2\pi} \cdot \frac{1}{a} \sin 2\pi a - \cos 2\pi a\right)^2}.$$

(6)

Values of $P_1$ and $t_1$ are given by the technologies or are found experimentally, while $\lambda_z$ or $T$ is determined in conformity with requirements set forth in the chapter of SNiP II-19-79.

According to Zhivov [1], for example, the maximum blanking force $P_1$ should not exceed $0.4P_n$ (where $P_n$ is the nominal force of the press) for heavy-duty ($P_n > 400$ tons), $0.5P_n$ for medium ($200$ tons $< P_n < 400$ tons), and $0.7P_n$ for small ($P_n < 200$ tons) presses. Computation of the vibration amplitude of the press foun-