ve 100°C). Rubber-metal elements are, as a rule, used in elastic connecting rods.

*Conveyer Calculation*

The theory and calculation of a shaking conveyer involves three interrelated problems: (1) calculation of the oscillating system of a conveyer; (2) determination of the cross-sectional dimensions of the load-carrying element on the basis of the calculated average speed of the load and conveyer throughput capacity; and (3) determination of the power of the drive to overcome the inertia forces, resistances to load motion and losses in the elastic elements of the oscillating system.

Solution of the first problem gives the amplitude and frequency of vibrations, the forces in the drive and elastic ties, and their adjustment. The calculation is carried out along the principles of the theory of mechanical vibrations and the dynamics of oscillating systems with linear and non-linear ties, by compiling and solving the differential equations of motion of the system. The simplest equations of systems and their solutions have been given in descriptions of particular types of conveyers.

The frequency and amplitude of vibrations of a conveyer are determined by the recommended coefficient of operating mode (see Table 13.1) and can be taken from Table 13.4, depending on the type of drive and the characteristics of transported load. The values of frequency and amplitude thus found are substituted into the differential equation of motion of the system to determine the characteristics of the elastic ties of the conveyer and the parameters of the drive and the forces acting on it.

The kind of adjustment of elastic ties of the system (resonant or super-resonant) is determined by the conveyer type as has been given earlier.

The direction angle of oscillations,

**Table 13.4. Recommended Amplitudes $a$ and Frequencies $\omega$ of Vibrations of Shaking Conveyers**

| Type of drive | $\omega$, 1/min | $a$, mm, for loads | |
|---|---|---|---|
| | | dusty and pulverized | lumpy |
| Electromagnetic | 3000 | 1.2-2 | 0.75-1 |
| Centrifugal single | 2800-1500 | 1.2-3 | 0.8-2.5 |
| Centrifugal double | 1500-1000 | 2-4 | 2-3 |
| Eccentric | 800-450 | 5-15 | 4-8 |

$\beta$, is taken depending on the oscillation frequency $\omega$: with $\omega \geqslant 1000$ min$^{-1}$, $\beta = 20\text{-}25°$; with $\omega < 1000$ min$^{-1}$, $\beta = 30\text{-}35°$; on the average, $\beta = 30°$.

The speed of load $v$ (m/s) depends on the properties of the material and the angle of incline of the conveyer

$$v \approx (K_1 \mp K_2 \sin\alpha)\, a\omega \cos\beta \sqrt{1 - 1/C^2} \tag{13.16}$$

where $K_1$ and $K_2$ are empirical coefficients depending on the physico-mechanical properties of the transported load (see Table 13.5); $\alpha$ is the angle of conveyer incline; $a$ is the amplitude of oscillations; and $C$ is the coefficient of operating mode of the conveyer (see Table 13.1).

In formula (13.16), the 'minus' sign in the brackets is taken for inclined

**Table 13.5. Average Generalized Experimental Coefficients $K_1$ and $K_2$ according to V. K. Dyachkov)**

| Kind of load | Typical particle size, mm | Moisture content, % | $K_1$ | $K_2$ |
|---|---|---|---|---|
| Lumpy | 5-200 | — | 0.9-1.1 | 15-2 |
| Granular | 0.5-5 | 0.5-10 | 0.8-1.0 | 1.6-2.5 |
| Pulverized | 0.1-0.5 | 0.5-5 | 0.4-0.5 | 1.8-3 |
| Dusty | up to 0.1 | 0.5-5 | 0.2-0.5 | 2-5 |

conveyers (with the load moving up the slope) and the 'plus' sign, for descending conveyers (where the load moves down the slope).

For horizontal conveyers $K_2 \sin \alpha = 0$ and the speed

$$v = K_1 a\omega \cos\beta \sqrt{1 - 1/C^2} \quad (13.16')$$

Lower values of the coefficient $K_1$ and higher values of $K_2$ relate to loads with smaller particle size (finer particles can be conveyed at a lower speed, see Table 13.5).

The throughput capacity of a shaking conveyer is found by formula (2.8), with the coefficient of filling taken within the following limits: $\psi = 0.6$-$0.9$ for open troughs, $\psi = 0.6$-$0.8$ for rectangular pipes, and $\psi = 0.5$-$0.6$ for circular pipes; lower values relate to finer materials.

The width of a trough or diameter of a pipe should be checked for the largest size of lumps of the material. The largest lumps of ungraded loads should measure not more than 1/4 and those of graded loads, not more than 1/3 of the pipe diameter or trough width.

The power $N$ (kW) of a drive motor with an elevated starting torque is determined by the empirical formulae proposed by V. K. Dyachkov:

for short conveyers (of a length up to 10 m)

$$N \approx \frac{C_t Q}{10^3 \eta}\left(K_3 L + \frac{H}{0.36}\right) \quad (13.17)$$

for conveyers of a length $L > 10$ m

$$N \approx \frac{C_t Q}{10^3 \eta}\left[10K_3 + (L - 10) K_4 + \frac{H}{0.36}\right] \quad (13.18)$$

where $C_t$ is the coefficient of transportability of the load; for granular and lumpy loads (sand, coal, slag, grain) which possess a high transportability, $C_t = 1$; for pulverized and dusty loads of a reduced transportability (cement, cinder, apatites), $C_t = 1.5$-$2$; $Q$ is the rated throughput capacity of conveyer, t/h; $K_3$ and $K_4$ are the coefficients of unit power consumption (Table 13.6); $L$ is the horizontal projection of the length of load transportation, m; $H$ is the lifting height (in inclined and declined conveyers), m; and $\eta = 0.95$-$0.97$ is the efficiency of the drive mechanisms.

### 13.4.4. Vertical Shaking Conveyers

A vertical shaking conveyer-elevator (Fig. 13.19*a*) has a rigid cylindrical casing (pipe) *1*; a helical open trough (or closed pipe) is attached at the out-

**Table 13.6. Average Values of Coefficients $K_3$ and $K_4$**

| Conveyer type | Rated throughput capacity, t/h | $K_3$ | $K_4$ |
|---|---|---|---|
| Single-mass suspended with centrifugal drive | 5-50<br>above 50 | 6-7<br>5-5.5 | —<br>— |
| Single-mass supported with inclined guide springs and centrifugal drive | 5-50<br>above 50 | 7-10<br>5-6 | 5-6<br>3.5-4 |
| Single-and double-pipe double-mass balanced, with eccentric drive | 5-50 | with rigid connecting rods<br>10-12 | <br>8-10 |
| | 5-50<br>above 50 | with elastic connecting rods<br>4.5-5<br>4-5 | <br>3.5-4<br>3-3.5 |