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Theoretical Basis of Chain Transmission Parameters

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Abstract:

This article provides information on the types of chain transmissions, advantages, disadvantages, areas of use, and theoretical calculation of chain transmission parameters.

Keywords: mechanical, transmission, geometric, kinematic, parameter, chain, force, length, diameter.

Introduction. The reason for the fact that the active working bodies produced in the agricultural sector do not work at the required level, fail before the deadline, do not transmit enough power during operation, that is, the transmission quality is low (it is not properly fixed, not stretched, the material for the transmission is incorrectly selected, etc.) will be [1].

Chain transmissions are mainly used in active working bodies in the agricultural sector. Different types of chain transmissions are used in active working bodies, depending on the working conditions and the work they perform. This, in turn, prevents various defects or inconveniences. In order not to cause many inconveniences, it is necessary to correctly choose the type of chain transmission and theoretically justify its parameters [2, 3].

Research method. The mechanism consisting of the leading and driven stars and a chain worn on them is called a chain transmission (Fig. 1) [4].

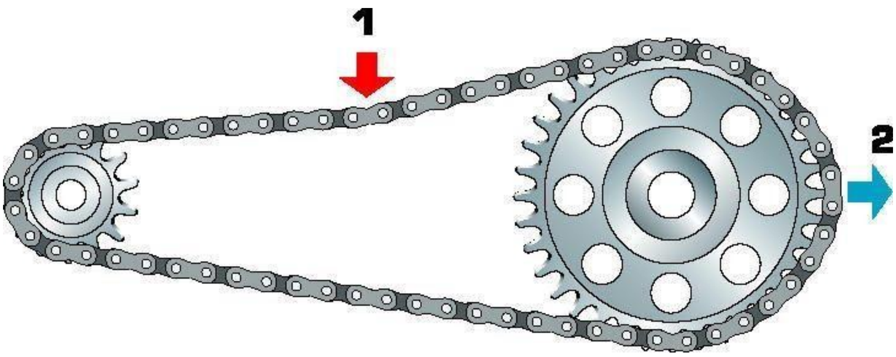

Figure 1. Chain drive.

In addition, the transmission includes shafts, bearings, tensioning devices, lubrication devices and protective barriers.

It is possible to use several rolling stars at the same time.

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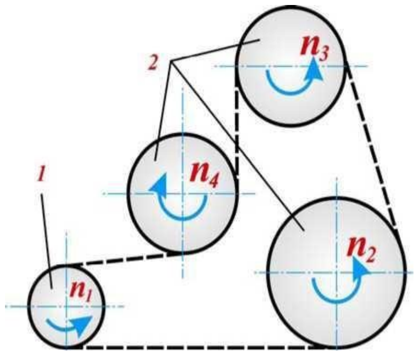

Figure 2. Distribution of the movement to several drive shafts through a chain drive.

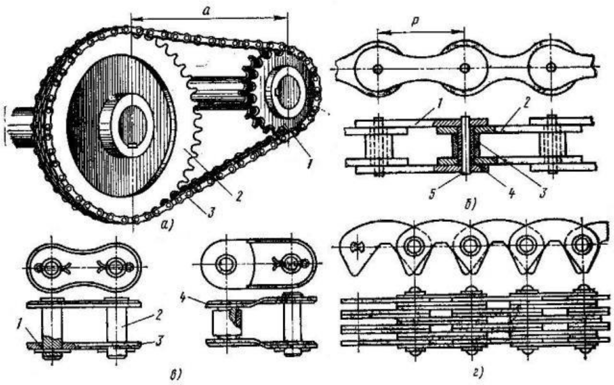

Figure 3. Types of chains.

In mechanical engineering, the driving mechanism of chain transmissions is used - types intended for driving, cargo transportation and traction. Chains used for cargo transportation are used for hanging and lifting cargo on low-speed lifting mechanisms. Chains used for traction are used in mechanisms such as elevators, conveyors and escalators. Such transmissions, depending on the type of chain: bushing, bushing-roller (Fig. 3 and 4), gear (Fig. 3 and 5); depending on the number of chains, they are divided into single-row and multi-row varieties. In addition, these transmissions can be open or closed (included in a special shell).

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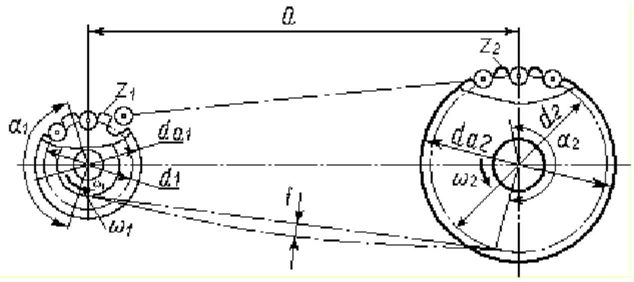


Figure 4. Chain drive.

Advantages: it can transmit the movement over a long distance compared to gears (the distance between the shafts reaches up to 8 meters); the coefficient of useful work is sufficiently high (η = 0.96...0.98); the fact that the sliding event does not occur and therefore the number of transmissions does not change; that it is possible to transfer the movement to several leading stars; chain replacement is easy; relatively small forces falling on shafts and supports.

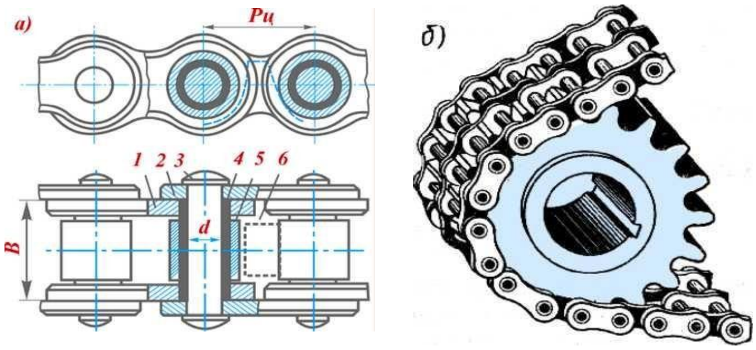
Disadvantages: the manufacture of chains and stars is complicated and expensive; control is required when working; require high accuracy in assembly; the wear of the chain elements causes an increase in the length of the links and the appearance of additional dynamic forces, which in turn leads to uneven operation of the transmission; noise output.

Types of extension. Currently, all sizes of chains used in machine and mechanism drives are standardized. Bushing-roller chain (Fig. 5) consists of a roller pressed into the outer link, a bushing pressed into the inner link, and a roller dressed to rotate freely around the bushing. The chain is attached to the star by means of rollers. The rolling of the roller when it hits the sprocket tooth turns sliding friction into rolling friction. This reduces tooth wear and improves gear performance. Multi-row chains are used in transmissions that operate at high speeds and loads.

Bushing chains differ from bushing-roller chains in that there is no roller worn on the bushing. As a result, the weight and cost of the chain is reduced. However, the teeth of the bushing chain and the stars that are in contact with it are eaten relatively quickly. Therefore, they are recommended for use in transmissions with low load and relatively low speed.

Figure 5. Bushing - roller chain.

Gear chains consist of a set of plates with teeth-like grooves on both ends, and star teeth are located



between these grooves to form a connection (Fig. 6).

These chains are relatively reliable and durable and are used in high speed and power transmissions.

Research results and discussions. But because of the relative weight of toothed chains and the difficulty of preparation, they are used less often.

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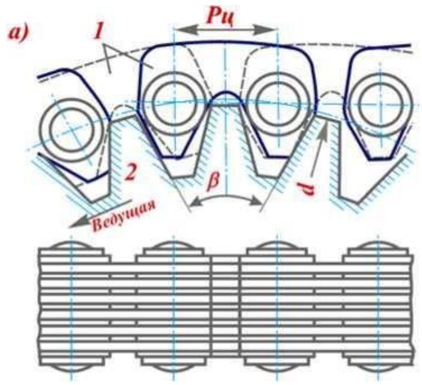

Figure 6. Toothed chain.

Transmission power:

$P = F_t \odot V / 1000$, kW.

Speed:

$V= z \odot t \odot n / 60 \odot 1000$ m/s.

where: z is the number of sprocket teeth; t - pitch of chains; n - the number of revolutions of the star, min^{-1}; F_t is rotational force, kN.

Transmission number of transmission:

$U = \omega_1 / \omega_2 = n_1 / n_2 = z_2 / z_1$.

In transmission, $P \leq 100$ kW, $V \leq 15$ m/s, $n \leq 500$ min^{-1}, $u \leq 7$ are recommended. For asterisks for medium-speed roller transmission - z_{1min}= 17...19; $z_{2\ max}$ =100...120 [5].

The structure of gears is similar in many ways to the structure of gears. Its pitch diameter passes through the center of the chain rollers in contact with it and is determined as follows [6]:

$d = t / sin\ (\pi /z\ )$.

The distance between the centers of the stars is determined as follows:

$a_{min} = (d_{a1} + d_{a2}) / 2 + (30…50)$ mm,

where: d_{a1} and d_{a2} are surface diameters of stars.

It is recommended to make a = (30...50)t mm in order to ensure sufficient resistance of the chain.

Usually, the length of the chain is determined by the number of steps [7]:

$L_t \approx 2\ a / t + (\ z_1 + z_2) / 2 + ((z_2 – z_1) / 2\pi\ )^2\ (\ t /a)$.

Forces in extension. The following forces are generated in chain transmissions: F_1 and F_2 - forces in the leading and driven branches of the chain; F_t - rotational force; F_0 - initial tension force; F_v is the force produced by the centrifugal force.

The relationship between forces is as follows [8]:

$F_1 - F_2 = F_t$, $F_v = m \odot V^2$, $F_0 = K_f \odot a \odot m \odot g$

where a is the length of the part of the chain that creates coolness; m is the mass of one meter chain in kg/m; g - acceleration of gravity, m/sec^2; K_f is the coolness coefficient (depending on the location of the transmission relative to the horizontal plane and f is the coolness value of the chain). Usually, $f \approx$ (0.01…0.02)a is recommended.

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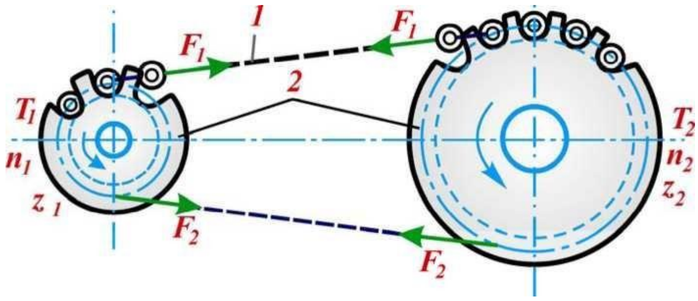

Figure 7. Forces acting on the chain drive.

Usually, for the transmission to work well, $F_2 = F_0 - F_v > 0$, i.e., the condition $F_0 > F_v$ must be met for the chain elements to be in the normal wear [9].

In practical calculations, $F_1 \approx F_t$, $F_2 \approx 0$ can be obtained for normal gears.

Voltages in the circuit. Mainly the following voltages are generated in chain elements (Fig. 8) [10]:

a) Tensile stress in the bushing part of the inner plates: $\sigma = F_t / 2(b-d_{bt})S \leq [\sigma]$

b) crushing stress in the part of the surface plates where the roller is installed: $\sigma = F_t / 2b_B S \leq [\sigma_{ez}]$

v) shear stress on rollers: $\tau = 2F_t / \pi d_B^2 \leq [\tau]$

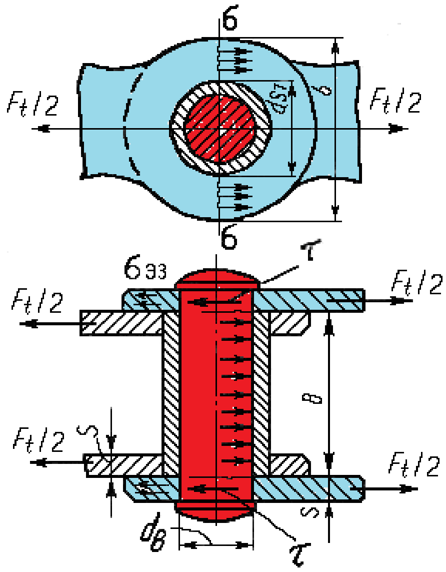

Figure 8. Voltages in the circuit.

These stresses are taken into account when determining the standard dimensions of the chain [11].

For bushing roller chains, which are widely used in mechanical engineering, the pressure generated in the hinge from the above-mentioned tension is the most important. Because the service life of the chain is determined by the service life of its hinges. Therefore, the corrosion resistance of chain hinges is determined, in which the following condition must be met [12]:

$q = F_t / (B \odot d_в) \leq [q]$,

where q is the pressure in the hinge (between the roller and the bushing); F_t - rotational force, N; d_v - the diameter of the shaft; V is the width of the chain; *[q]* is the permissible pressure, its value is given in the table according to the pitch of the chain and the number of revolutions of the leading sprocket.

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Conclusion. According to the given information, charging transmissions are designed for different voltages. So chain gears can be affected by different forces. When calculating chain transmissions under the influence of various forces, their main parameters are star diameters, distance between axles, and various forces generated in the chain. At the same time, the allowable stress of the metal is also one of the important factors in calculating the bending stress.

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