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OVERVIEW OF MATERIALS USED IN THE CONSTRUCTION OF SHAFTS AND AXLES

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Abstract
The axle is a part designed only to support the rotating parts, and does not directly participate in the transmission of energy. Shafts are designed to support the rotating parts of the machine and to transmit torque from one rotating part of the machine to another. The choice of material is determined by the design of the shaft, the requirements for it, the operating conditions, and the necessary period of guarantee of trouble-free operation. This article analyzes the materials used in the manufacture of shafts and axles.

Keywords: Shaft, axle, steel, alloy steel, chromium-plated steel, cast iron, strength, rigidity, heat treatment.

Introduction

In modern machines, the rotational movement of parts is most widely used. Translational motion and its combination with rotational (screw motion) are less common. The movement of progressively moving parts of machines is provided by special devices called guides. To carry out rotational movement, special parts are used - shafts and axles, which, with their specially adapted sections - trunnions (spikes) or heels - rely on support devices called bearings or thrust bearings.

A shaft is a part (usually of a smooth or stepped cylindrical shape) designed to support pulleys, gears, sprockets, rollers, etc. installed on it, and to transmit torque.

During operation, the shaft experiences bending and torsion, and in some cases, in addition to bending and torsion, the shafts may experience tensile (compressive) deformation.

Some shafts do not support rotating parts and work only in torsion (cardan shafts of cars, rolls of rolling machines, etc.).

The shaft (Fig. 1) has supports 2, called shaft supports. The part of the shaft covered by the support is called the trunnion. The end pins are called spikes 3, and the intermediate pins are called necks 4.

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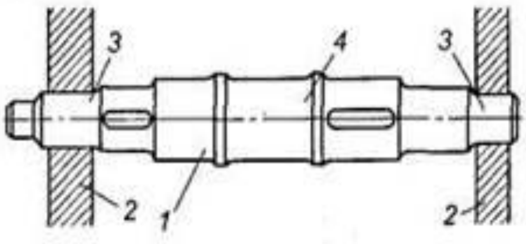

Fig.1. Straight shaft: 1 - shaft; 2 - shaft supports; 3 - spikes; 4 – neck

An axis is a part designed only to support the parts installed on it. Unlike the shaft, the axis does not transmit torque and only works in bending. In machines, the axles can be stationary or they can rotate with the parts sitting on them (moving axles). The concepts of "wheel axis" should not be confused, this is a detail and "axis of rotation", this is a geometric line of centers of rotation. An example of a rotating axle is the axles of a railway rolling stock, an example of a non-rotating axle is the axles of the front axles of a car.

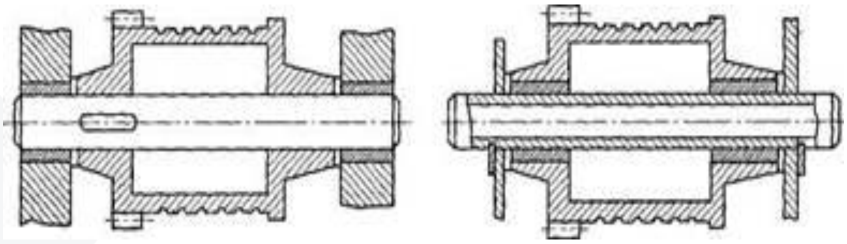

Fig.2. Axle designs: a - rotating axis; b - fixed axle

The shapes of shafts and axles are very diverse, from the simplest cylinders to complex cranked structures. Known for the design of flexible shafts, which were proposed by the Swedish engineer Carl de Laval back in 1889. The shape of a shaft is determined by the distribution of bending and torque along its length. A properly designed shaft is a beam with equal resistance. Shafts and axles rotate, which means they experience alternating loads, stresses and deformations. Therefore, failures of shafts and axles are of a fatigue nature.

The choice of material and heat treatment of the shafts is determined by the criteria for their performance (stiffness, bulk strength and wear resistance with relative microdisplacements that cause corrosion), including the performance criteria for pins with supports or splined sections with hubs of the parts placed on them. The significance of the latter criteria in the case of sliding bearings or movable spline (key) connections can even be decisive. The main material for the shafts are carbon and alloy steels (rolled products, forgings, steel castings), as they have high strength, the ability to surface and volume hardening, cylindrical billets are easily obtained by rolling and are well machined, as well as high-strength modified cast iron and alloys. non-ferrous metals (in instrumentation).

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For shafts and axles subject to the criterion of rigidity and not subjected to heat treatment, steels are used: Steel 5; Steel 6. For most shafts, heat-treated steels 45, 40X are used. High-speed shafts rotating in plain bearings require very high trunnion hardness. They are made from hardened steels.

Only for the manufacture of heavy crankshafts, shafts with large flanges and longitudinal holes, high-strength (with nodular graphite) and modified cast irons are used. In the automotive and tractor industries, engine crankshafts are made of malleable or ductile iron.

Since the main criterion for the performance of shafts is their fatigue strength (endurance), for the manufacture of most shafts, thermally improved medium carbon steels 40 are used; 45; 50. They are used for the manufacture of shafts of stationary machines and mechanisms. The billet of such steels before machining is subjected to improving heat treatment (HRCe≤36). The shafts are machined on a lathe, followed by grinding the seats and trunnions on a grinding machine.

Responsible heavily loaded shafts are made of alloy steel. Shafts for critical gears of mobile machines are made from these steels (shafts of gearboxes of tracked vehicles). Improving heat treatment ($HRC_e \leq 45$) is most often subjected to a part after preliminary turning. Finally, the seating surfaces and pins are ground on grinding machines, and in repair production, sometimes on a lathe using a special grinding head. Only for high-stress shafts of critical machines, expensive alloyed hardened steels are used.

High-speed shafts rotating in sliding bearings require very high hardness of the surfaces of their trunnions. In this regard, such shafts are made of carburized steels or nitrided steels. The shaft, made with a minimum allowance for final processing, is subjected to surface chemical-thermal treatment (carburizing, nitriding, etc.), and hardened to high surface hardness (HRC_e 55...65). The working surfaces of the splines, seating surfaces and surfaces of the trunnions are ground after heat treatment in order to obtain the required accuracy. Chrome-plated pins have high wear resistance. For example, from the experience of the automotive industry, it is known that chromium plating of the crankshaft journals increases their resource by 3...5 times. Shafts operating in an aggressive environment are made of high-alloy stainless steels, and when using ordinary steels, they are insulated with bronze or polymer jackets, rubberized or enameled. For shafts whose dimensions are determined not by strength, but by rigidity, carbon structural steels 20 are used; 35 etc. without heat treatment. In this case, it is advisable to use heat-treated steels only when this is determined by the requirements for the durability of pins, splines, and other wear surfaces of the shafts.

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Conclusion

The materials of shafts and axles must be strong, well machined and have a high modulus of elasticity. Straight shafts and axles are made mainly from carbon and alloy steels. Crankshafts, due to their complex shape and the action of significant dynamic loads on them during operation, are often made by casting from cast iron, tk. cast iron is lighter and cheaper than steel, has good casting properties and high damping capacity.

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