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Research Article

METHODS OF MANUFACTURING GEARS

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ABSTRACT

This article discusses the manufacture of gears with two methods (copy method and run-in method). The largest number of gear wheels are made of carbon and alloy steels, and less often of cast iron, bronze and plastic. In the manufacture of gears, two fundamentally different methods are used. copy method and run method. Gears, especially high-precision gears, must have dimensional stability, therefore, in their manufacture, high requirements are placed on material homogeneity and balance of internal stresses.

KEYWORDS

Gear manufacturing, high-precision, material homogeneity, copying method, running-in method, tooth profile, initial contour, gearing, involute curvature radius, tooth shape change.

INTRODUCTION

The largest number of gear wheels are made of carbon and alloy steels, and less often of cast iron, bronze and plastic.

Gears, especially high-precision ones, must have dimensional stability, therefore, in their manufacture, high requirements are placed on material homogeneity and balance of internal stresses [1,2,3,4]. It is most expedient to use in the manufacture of alloy steels, which warp less compared to carbon steels. For example, in the manufacture of wheels of the 5th ... 6th degree of accuracy, steels 20X, 12XNZA, 25XGT (heat treatment, nitrocarburizing), 18XGT (carburizing), 40X and 40XFA (hardening) are used. Carbon steels (steel 15, 20) are carburized, and steels 40, 45 are hardened [5,6,7,8,9].

The main part

In the manufacture of gears, two fundamentally different methods are used. Copy method and run method.

Copy Method

With this method, the profile of the tool (disk or finger cutter) follows the profile of the cavity of the cutter wheel.

As a method of cutting wheels, it has significant drawbacks - relatively low productivity and accuracy; the need to have a large number of tool sizes for cutting various wheels (the tool itself has a complex shape); the need to have an additional dividing device on the machine, and others. Therefore, this method is used very rarely when cutting gears (used mainly in repair production) [10,11,12].

Run-in method (envelope)

With this method, the tool is, as it were, involute gear, which has a cutting edge and is made of appropriate tool steel.

When cutting the wheel, in addition to the cutting motion, the tool and the workpiece are given a rolling motion, i.e. movement that simulates the operation of two gear wheels in engagement. In this case, the required number of teeth with an involute profile is automatically formed on the cutter wheel. In this case, the tooth profile is formed not as a copy of the tool profile, but as an envelope with too many positions. Significantly increased productivity (because the process is continuous) and accuracy (because there is no additional dividing device). The necessary nomenclature of the tool is sharply reduced, tk. one and the same tool can cut the wheel of this module with any number of teeth [13,14,15].

A toothed rack with a straight tooth profile is a special case of an involute wheel, therefore, with the rolling method, it is the most often rack type tool used(a tool that has the shape of a gear rack in an axial section). It can be a toothed comb or a worm cutter, which is used most often. This dramatically simplifies the shape of the tool and its manufacture. The standard gear rack underlying the tool is called generating initial contour.

Since the tool tooth head forms the tooth root of the cut wheel, the height of the head of the generating initial contour is made following the height of the tooth root of the usual initial contour, i.e., the generating initial contour has a tooth symmetrical in height concerning the dividing line.

To increase the tool life, the cutting edge of the tooth at the top has a rounding. The amount of rounding is determined by the height factor of the rounded area h_k*=0.25.

Another significant advantage of the rolling method is that with the same tool, on the same machine (at no additional cost), it is possible to use different parts of the involute for profile formation on wheels with the same number of teeth, significantly changing the shape of the teeth and the properties of the wheels and gears [14,15,16]. This is achieved by changing the position of the tool relative to the workpiece when cutting the wheel (Fig. 1).

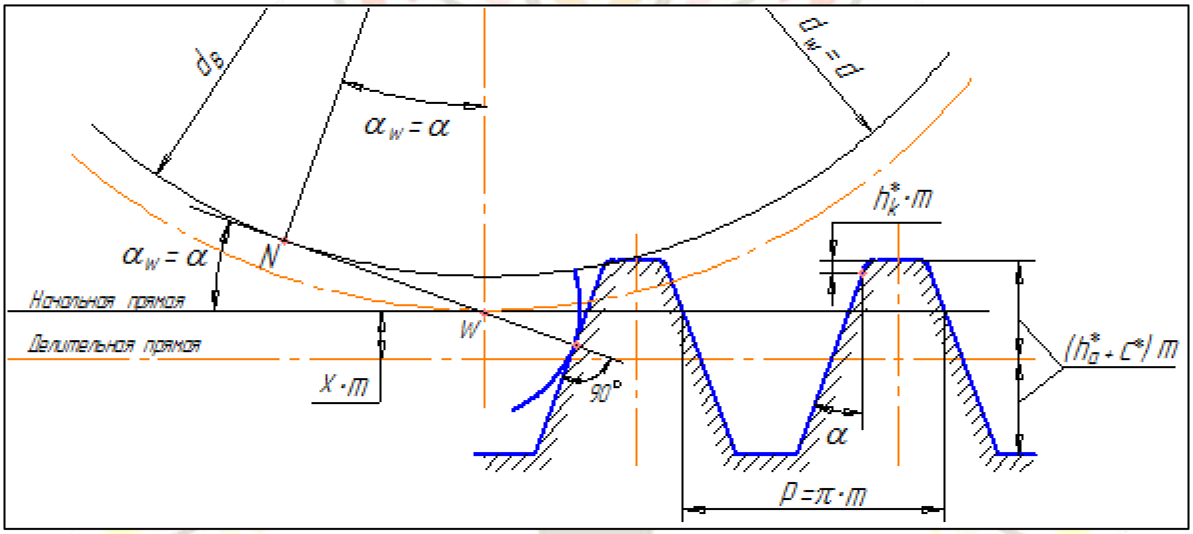

Fig.1. Machine engagement.

Figure 1 shows the machine engagement of the generating initial contour with a cut wheel (rack and pinion engagement).

In this case, the engagement line is tangent to the main circumference of the cut wheel and perpendicular to the rack tooth profile. The point of its intersection with the centre line (in this case, the centre line is a straight line passing through the centre of the wheel and perpendicular to the dividing straight line of the rack) is the engagement pole W, through which the initial circle of the cut wheel passes in machine engagement.

The straight line of the rack, tangent to the initial circle of the wheel at the pole of engagement, is the initial straight line. Since the initial straight line during the cutting process rolls without slipping along the initial circle of the wheel (the initial lines are centroids in relative motion), then all dimensions from the initial straight line to the true value are transferred to the initial circle of the wheel being cut, including the pitch.

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The step on the initial straight rail is the standard value, which should be on the pitch circle of the wheel. Therefore, when engaging with a standard rail, the pitch circle of the wheel always acts as the starting circle, and the engagement angle is equal to the standard profile angle of the initial contour ($\alpha w = \alpha = 20°$).

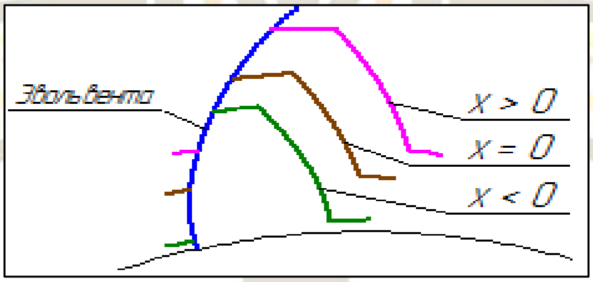
The position of the tool is characterised bias factor "x":

 the displacement is considered zero (x=0) if during cutting the pitch line of the rack touches the pitch circle of the wheel (coincides with the initial straight rail);

 the offset is positive (x>0) if the pitch line passes outside the pitch circle of the cut wheel (the tool moves away from the centre of the workpiece - this is the case shown in Figure 1);

 with a negative offset, the tool approaches the centre of the workpiece, and the pitch line of the rack intersects the pitch circle of the wheel.

Figure 2 shows how the shape of the tooth changes with a change in the displacement factor.



Rice. 2. Changing the shape of the tooth.

It can be seen from the figure that the same evolvent is formed in all cases. When changing the position of the tool, the section of this involute used for the tooth profile changes. As the displacement factor increases, the tooth becomes thicker, more rigid, and more bending-resistant.

An increase in the radii of involute curvature in higher sections also leads to an increase in the contact strength of the teeth. The use of a negative offset allows you to reduce the dimensions of the cut wheels.

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