

April 7, 1964

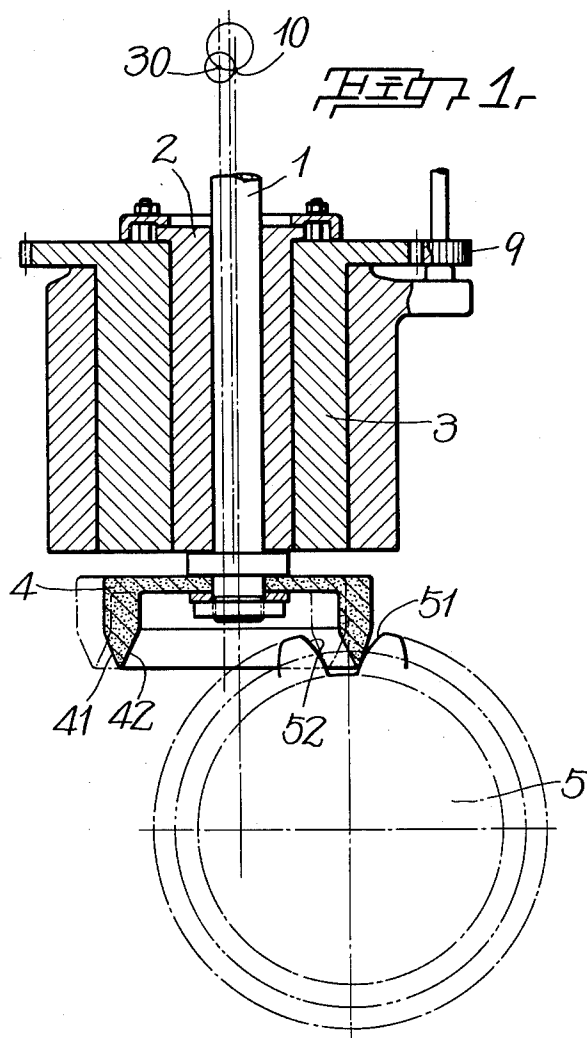
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GRINDING METHOD AND GRINDING HEAD FOR GRINDING TOOTH  
SURFACES OF GEARS WITH CIRCULAR TOOTH TRACE

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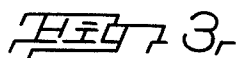
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## GRINDING METHOD AND GRINDING HEAD FOR GRINDING TOOTH SURFACES OF GEARS WITH CIRCULAR TOOTH TRACE

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3 Claims. (Cl. 51—90)

This invention relates to a grinding method and a grinding head for grinding tooth surfaces of gears with circular tooth trace.

The gears with circular tooth trace including spur gears and bevel gears may be ground and finished by means of a cup-shaped grinding wheel which has an outer cone surface and an inner cone surface adapted to grind concave tooth surfaces and convex tooth surfaces of the gear respectively. However, in case of the conventional grinding of the gear by the cup-shaped grinding wheel, there has often occurred grinding burn, crack or scratches on the surfaces of gear, owing to the following cases.

- (1) As the path of grinding edge of abrasive is too long, much chip thrown from the work fills up chip pockets of the grinding wheel, and correct grinding action is disturbed.
- (2) Application of coolant to the grinding spot is very difficult.

In case of so called "plunge grinding," the effects of the above causes are especially intense as the contact between the tooth surface and the grinding wheel is "area to area" one; chip can not escape from the grinding spot and coolant can not reach the grinding spot, while the grinding action is taking place.

The main object of the present invention is to provide a method for grinding tooth surfaces of gears with circular tooth trace without accompanying those defects above explained.

According to the present invention, so as to accomplish the above object, there is given a method for grinding tooth surfaces of gears with circular tooth trace characterized in that a cup-shaped grinding wheel, wherein radii of wheel curvature a little smaller or a little larger than those of the circular tooth traces are given for an outer cone surface and an inner cone surface, is revolved around an axis parallel to the axis of the grinding wheel and the contact point between the grinding wheel and the tooth surface of the gear runs rapidly along the tooth trace as the grinding wheel revolves.

Further, according to the present invention, to execute the above method there is given a grinding head for grinding tooth surfaces of a gear with circular tooth trace comprising a cup-shaped grinding wheel with an outer cone surface and an inner cone surface, the radii of curvature of the former cone surface and that of the latter cone surface being selected a little smaller or a little larger than those of the concave tooth trace and the convex tooth trace of the gear respectively, and a double eccentric means adapted to revolve the spindle of the grinding wheel around an axis parallel to the spinning axis, the radius of revolution of the grinding wheel being adjusted to be equal to the amount of difference between the radii of curvature of the circular tooth traces of the gear and the corresponding radii of the curvature of the cone surfaces of the grinding wheels by said means.

The features of the present invention will be apparent in the following description taken with the accompanying drawings in which:

FIG. 1 is a longitudinal section view of a grinding head according to the present invention;

FIG. 2 is a view which shows the relation between the

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tooth surfaces of the gear and the grinding wheel shown in FIG. 1 in an exaggerated state.

FIG. 3 is a view for the explanation of "plunge grinding" of a bevel gear by means of a grinding head according to the present invention.

Referring to the drawings, in FIG. 1, the grinding head comprises a spindle 1, an eccentric bushing 2, a rotating cylinder 3 and a cup-shaped grinding wheel 4. The grinding wheel 4 is fixed onto the spindle 1 which is rotatively mounted on the eccentric bushing 2. The bushing 2 is fitted snugly to an eccentric hole of the rotating cylinder 3 and is fixed so as to give a desired eccentricity between the spindle 1 and the rotating cylinder 3. The rotating cylinder 3 is supported by a bearing provided on the casing of the grinding head. The spindle 1 is driven by an electric motor (not shown) mounted on the bushing 2, while the rotating cylinder 3 is driven by a pinion 9 which meshes with a gear provided on it.

Thus a spinning motion about its own axis 10 and a revolving motion around the axis 30 of the rotating cylinder 3 will be given to the grinding wheel 4. A gear 5 to be ground is rolled to cause an ideal motion to engage with a rack by a known mechanism.

In case of the heretofore known grinding head, as the cup-shaped grinding wheel is not accompanied with the above mentioned revolution, said rack is given by the cup-shaped grinding wheel itself. But in case of the grinding head according to the present invention said rack is given as an imaginary one owing to the revolution of the grinding wheel. The cup-shaped grinding wheel 4 has an outer cone surface 41 adapted to grind the concave tooth surfaces 51 of the gear and an inner cone surface 42 adapted to grind the convex tooth surface 52 of the gear. In FIG. 2, an envelope surface 41' of the revolving outer cone surface 41 and an envelope surface 42' of the revolving inner cone surface 42 are shown. The former envelope surface 41' and the latter envelope surface 42' will give the imaginary rack surface that will mesh with a convex tooth surface 51 and a concave tooth surface 52 of the gear 5 respectively. It should be noticed that in FIG. 2, the axis of the spindle 1 is shown in two angular phases of the grinding wheel, as represented by the numerals 11, 12, and that the cone surface 41 and the tooth surface 51 are represented in a state when the axis is in an angular position represented by 11. The radius of curvature  $r'_1$  of the concave tooth trace of the surface 51 is a little larger than the radius of curvature  $r_1$  of the outer cone surface 41 and the radius of curvature  $r'_2$  of the convex tooth trace of the surface 52 is a little smaller than the radius of curvature  $r_2$  of the inner cone surface 42, maintaining a relation of  $r'_1 - r_1 = r_2 - r'_2 = e$ , wherein  $e$  is a radius of revolution of the grinding wheel.

Each cone surfaces 41, 42 of the grinding wheel contacts with the tooth trace of the gear at one point and this contact point moves along the tooth trace following to the revolution of the grinding wheel. In front and in rear of the contact point, there exist wedge-shape gaps that will be helpful for the leading in of coolant onto the grinding point and for the removal of the ground chip.

Coolant drawn into the leading wedge-shape gap by the grinding wheel lubricates and cools the point positively wherein grinding is just taking place. The above point, that is to say, the contact point between the grinding wheel and the tooth surface of the gear travels rapidly along the tooth trace preventing accumulation of heat on the work. Thus the occurrence of grinding burn and heat crack can be avoided perfectly.

Among the wedge-shape gaps, the trailing one gives a clearance to permit the removal of ground chip and is useful for preventing the occurrence of scratches on the work.

In the embodiment shown in FIG. 1 and FIG. 2, the concave surface 51 and the convex surface 52 of the gear 5 are alternatively ground at the same time following the revolution and the spinning of the cup-shaped grinding wheel 4, however, it may be easily understood that each of the tooth surfaces may be ground independently by a proper cup-shape grinding wheel under a suitable radius of revolution.

The grinding method and the grinding head according to the present invention are especially effective in case of so called "plunger grinding" wherein a gear to be ground is fed in the direction of the axis of the grinding wheel and is plunged against the wheel.

FIG. 3 shows "plunge-grinding" of a spiral bevel gear A by the grinding method and the grinding head B according to the present invention. In this figure, the construction and the function of the grinding head are the same with those shown in FIG. 1 and the mechanism for moving the spiral bevel gear is the same with that which is heretofore known. In case of grinding of the gear shown in FIG. 1, there has been accompanied with a generating motion in the direction of the tooth profile but, in case of "plunge-grinding" there is accompanied with no generating motion. Accordingly in case of the "plunge-grinding" by the heretofore known method wherein no revolving motion of the grinding wheel is given, the grinding surface contacts to the entire tooth surface and grinding burn occurred frequently owing to an accumulation of heat. It will be easily understood that the grinding head and the grinding method shown in FIG. 3 are especially useful for the elimination of occurrence of the grinding burn.

What I claim is:

1. In a method for grinding the tooth surfaces of gears

with circular gear trace, the improvement which resides in imparting a continuous high speed revolving motion the radius of which is limited to the space between adjacent gear teeth around an axis parallel to the axis of a cup-shaped grinding wheel having a tapered grinding surface, the contact point between the grinding surface of the grinding wheel and the tooth surface of the gear running rapidly along the tooth trace of the gear as the grinding wheel revolves.

2. A grinding head for use in grinding the tooth surfaces of a gear with circular tooth trace which comprises a cup-shaped grinding wheel having a tapered grinding surface, means mounting said grinding wheel eccentrically within a supporting cylinder for rotation of said grinding wheel about its own axis, means for continuously rotating said cylinder about its axis to thereby effect a circular motion of the rotational axis of said grinding wheel about the axis of said cylinder, and means for adjusting the degree of eccentricity of said grinding wheel.

3. A grinding head as defined in claim 2 wherein said means for adjusting the degree of eccentricity of said grinding wheel is constituted by an adjustable bushing mounted eccentrically within said cylinder, said grinding wheel also being mounted eccentrically within said bushing, and means for rotatably adjusting said eccentric bushing within said cylinder.

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