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GRINDING TOOLS AND GRINDING WHEELS FOR SHAPING CNC GRINDING MACHINE

Abstract. Production of screws with the optimal profile in terms of mesh properties is still in focus of worm gear manufacturers. The overall problem of tool edge designing is divided in few parts. This post only partly solves the problem of optimal tool shape design to produce the screws. In this paper is solved the problem of the abrasive wheel forming to produce screws with the logic operation of management system of tool grinder and calculation of profile curve on tooth heel.
Key words: shape, profile, tool grinder, worm gear, operation.

INTRODUCTION

Overall problem of optimal worm profile manufacturing depend on technically acceptable calculations (usable in practise) for manufacturing of optimal tool cutting shape, respectively profile of abrasive wheel. To carry out simulations in terms of optimal tooth pairs gearing, we must analyze many calculating techniques for tool cutting shape design in terms of manufacturing capabilities. [1-8]

Analysis and computational relations are solved using computer technique, because it is the fastest and cheapest way to achieve the best results. The tool grinder KON-250 CNC can manufacture shapes of cutting edges, exact shapes of templates for abrasive wheel forming and different geometrical shapes and profiles.

For tool cutting edge is described methodology of management system programming for CNC tool grinder, based on which we can manufacture shapes of tool cutting edges and templates for dressing of abrasive wheels. In this article are described operating principles of tool grinder KON-250 CNC which are needed to familiarization with basic parameters and principles and re-consider them in determining of the algorithm. [1-8]

CHARACTERISTICS OF THE GRINDER

Grinding machine KON-250 CNC is designed for grinding of shaped surfaces. Control unit with memory is additional device. Different shape grinding using this

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grinding machine can be made by:

- manual shift control according to the template in the scale
- machine shift control according to specified NC program

NC program can be saved on eight-track punch tape or inputted by alpha-numeric keypad. Adjustments can be made in the program which is already in the memory.

The machine allows, using special equipment, to draw the profile, which will be grinded, to check the accuracy by visual observation. Also it is possible to prepare NC program for the external control unit hole tape. Grinding machine can grind geometric shapes such as: line, circle and circuit bends, general curves replaced by a number of points or circles and their centres. Grinding precision is ± 0,005 mm.

GRINDING OF CUTTING SECTION SHAPE AND TOOL PROFILE FOR WORM GEARS PRODUCTION

We need to specify end point of line for grinding of linear shape tools. If the shape is composed of angled lines (created by combining of several straight lines), this lines must follow-up (line number “i” end point is starting point of line number “i+1”). For circle grinding it is necessary to enter the end point of circular arch and the centre point.

For grinding of general curves it is necessary to enter a set of points of the curve. The coordinates of these points should be graduated to 0,01÷0,05 mm to achieve sufficient accuracy of curve and smooth transition between points [1].

In fig. 1 is an example of cutting edge shape creating and representation of abrasive wheel, point and its path from point “0” through the points (1,2,3…) till point “N+2”. This is example of linear shape (points 2 and 3), circular arc (points 3 and 4) and general curve (points 4 to N) programming [1].

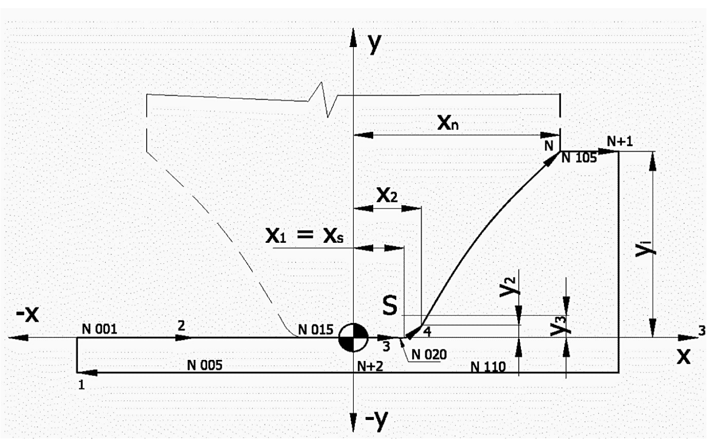

Fig. 1. Programming of line and geometric shapes

For grinding of the shape shown in fig. 1 we can use following program:
(Note: coordinates of points in program are only general)

```
N    005 G    90 G    00    X-50000     Y-3000
N    010 G    90 G    00    X-15000     Y 0      M 00
N    015 G    90 G    01    X 10000     Y 0      F 60
N    020 G    90 G    02    X 20000     Y 15000  I 10000  J 18000  F 60
N    025 G    90 G    01    X . . .     Y . . .  F 60
 .
 .
N    105 G    90 G    01    X . . .   Y . . .   F 60
N    110 G    90 G    00    X 0       Y-3000    M 30
```

the characters have following meaning:

N 005, N 010 … N 110 – number of sentences,
G 90 – absolute coordinate system,
G 00 – fast infeed to program point,
G 01 – management method, which uses information inside the sentence to create straight line,
G 02 – circular interpolation management, which uses information inside the sentence to create circular arc; tool movement relative to the workpiece is clockwise,
G 03 – circular interpolation management, which uses information inside the sentence to create circular arc; tool movement relative to the workpiece is against the direction of clockwise,
X, Y – coordinates of points 1, 2 … N+2 in m,
M 00 – unconditional stop after finishing of instructions in the sentence,
M 30 – end of punch tape, end of program,
F 60 – grinding process,
I – x coordinate of curvature centre,
J – y coordinate of curvature centre.

Each program must start with two rectangular coordinates and it is necessary to define radius of abrasive wheel “R”. Based on NC program for defined radius of abrasive wheel, control unit makes of determination of an appropriate path, which refers for the radius of abrasive wheel.

Profile made on grinding machine can be e postponed in order to achieve the specified tool width (Fig. 2). Abrasive wheel moves by equivalent path (increased or decreased) shifted by the value described by decimal switch. Decimal switch is independent for x and y coordinates [2].

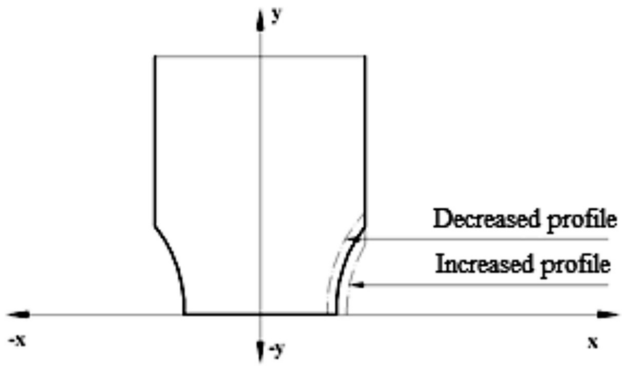

Fig. 2. Profiling of tooth side

DETERMINATION OF CENTRE CURVATURE CUTTING EDGE TOOL COORDINATES

Analytical description of screw surfaces we get from computer cutting edge shape (its coordinates) in normal or axial section. This shape is bounded by footer and head diameter. There is a problem in tool cutting edge grinding on grinding machine KON-250 CNC to define the centre of curved cutting edge shape, whose size is chosen according to certain standards by [2]:

$$\rho_{ko} = 0{,}20m \text{ až } 0{,}30m$$

where: m – gear module.

Radial gap size on the worm wheel tooth space is recommended to choose according to the relationship:

$$c_a = 0{,}20m$$

In justified cases is allowed change to:

$$c_a = 0{,}15m \text{ až } 0{,}30m$$

In case of simple determining the coordinates of curative centre S (Fig. 3) it is advisable to choose the radius of curvature and radial (head) gap as:

$$c_a = \rho_{ko}, \text{ or } c_a \cong \rho_{ko} \quad (1)$$

Coordinates of point S are counted by:

$$x_s = x_B - \rho_{ko}$$
$$y_s = y_B \quad (2)$$

where: x_B. y_B – coordinates of end (head) point of side cutting edge curve (Fig. 3), if $\rho_{ko} > c_a$

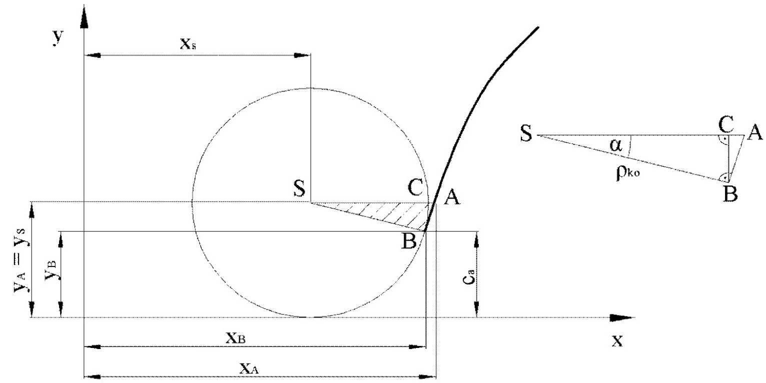

Fig. 3. Tooth surface and root profile surface in manufacturing of worm wheels [1]

We determinate the coordinates of curvature centre by the following calculation. For sufficinetly small segment AB we can replace profile curve with specific accuracy. Triangle SBC (Fig. 3) shows:

$$\cos\alpha = \frac{\overline{SC}}{\rho_{ko}} \tag{3}$$

set $\rho_{ko} = r$, then

$$\overline{SC} = r.\cos\alpha$$

$$\overline{BC} = r.\sin\alpha \tag{4}$$

As shown on fig. 3:

$$\tan\alpha = \frac{x_A - x_B}{y_A - y_B} \tag{5}$$

then:

$$\alpha = arc\tan\frac{x_A - x_B}{y_A - y_B} \tag{6}$$

For curvative coordinates is:

$$x_S = x_B - \overline{SC}$$

$$y_S = y_B + \overline{BC} \tag{7}$$

substituting we get:

$$x_S = x_B - r.\cos\left(\frac{\arctan(x_A - x_B)}{y_A - y_B}\right)$$

$$y_S = y_B + r.\sin\left(\frac{\arctan(x_A - x_B)}{y_A - y_B}\right) \tag{8}$$

where: coordinate x_A is subtracted from the coordinates output from computer corespondenting to coordinate y_B.

SUMMARY

Shaped cutting edge programming is implemented in G code, shape of profile is caltulated using program created manualy or by automatic programing. Profile is charakterized by the calculated coordinates in the ortogonal plane as the intersection of maindsal and frontal areas. Profile curve, which creates radius on the heel tooth screws is important for the full calculation of cutting edge shape. This metod of calculation is inly aproximate, but sufficient. Radius of the heel tooth worm wheel is not in contact with the screw, the simplification can be accepted.

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NARZĘDZIA SZLIFIERSKIE I TARCZE SZLIFIERSKIE DO SZLIFIEREK KSZTAŁTUJĄCYCH CNC

Streszczenie

Produkcja ślimaków o optymalnym profilu pod względem właściwości siatki pozostaje wciąż w centrum uwagi producentów przekładni ślimakowych. Ogólny problem projektowania ostrzy narzędzi jest podzielony na kilka części. Artykuł ten tylko częściowo rozwiązuje problem optymalnego projektowania kształtu narzędzi do produkcji ślimaków przekładni ślimakowej. W pracy rozwiązano problemu formowania tarczy ściernej do produkcji ślimaka i obliczenie krzywej profilu na stopie zęba.

Słowa kluczowe: kształtowanie, profilowanie, ostrzarka, przekładnia ślimakowa, operacja.