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CHAIN SPROCKETS MANUFACTURING, ON VERTICAL MACHINING CENTER GDV400PM1F4 UPDATED WITH NUMERICAL CONTROL NCT®2000M

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Abstract

The paper content comprise a few aspects regarding processing of chain sprockets on vertical processing center GDV400PM1F4 updated by changing the original equipment CNC-2S42-65 (1Я3.035.090) with NCT®2000M, which includes in short characteristics of two CNC, the old and the new one, the constructive elements of chain sprockets processed, enunciation of mains stages of manufacturing process adopted. The aim is to manufacture chain sprockets with classic tools, bypassing the need to design and build a sprocket hob in accordance with specified chain sprockets geometry, processing is performed on a machine which technological parameters have been improved.

Key words: chain sprockets, processing centre, numerical control, manufacture, toothing

1. Introduction

An overview with on the series processing, by of chain sprockets cutting, shows the following ways of manufacturing:

- **On chain sprockets toothing with sprocket-hob by rolling**, both sprocket hob as well as the semi-finished product for this type of wheel, are performed with continuous rotary motion and uniform, without the need for special movement by the dividing and by return to the original position. To a number of revolutions of sprocket hob, equal to the number of teeth of the wheel to be processed, which at this time make a single rotation, the tool has past once all over the wheel teeth. And in this case should be fully realized kinematic relationship by meshing between the sprocket hob and chain sprocket toothing. [3] It should be stressed that a significant inconvenience of this method consists in the fact that the manufacturing process of particular tool cutting – sprocket hob, to produce each new benchmark, increase the main cost of product. [4]

- **Toothing chain sprocket by mortising with knife-wheel** is based on generating the profile's with gearwheel generating. Knife-wheel is of form a conjugate gearwheels with gearwheel processed, having an particular geometry's of toothing , which should's allow machining trough cutting. [3] Themselves meets and here the same inconvenience as at sprocket, the necessity to manufacture a new knife-wheel to every new benchmark.

- **Manufacture the chain sprocket by mortising with the knife-comb** it is a method of processing trough rolling, with the dividing. Generating rack is materialized by knife-comb which it's a tool of form of an rack with detalonate flanks. Toothing with knife-comb is characterized trough obtaining of some gearwheels of higher precision. [3] And here occurs the same disadvantage, design and manufacture of a new knife-comb to every new benchmark requested.

- **Broaching chain sprockets** is a very productive process and high accuracy, just at a large series production that can cushion tools construction. Broaching can be achieved tooth with tooth, from a single pass of the tool, which has the profile on opening of flanks and the cant by at tooth at tooth, or may be an group of brooches that also in a single pass will the retrieve the more teeth. [3]

- **Designed chain sprocket with integrated application of CAD system.** Sequential control of the technological cycle of manufacturing has allowed

stars to obtain the following results:

- Using Modules CAD / CAM / CAE minimizes the cost of temporary registration in accordance with the standard documentation as the design (building products), and the development of a single process;

- Application of CAD has allowed a production of sprockets by using a universal cutting tool - end mill. From an economic point of view, a departure from the special tool in the factory will create a significant reduction in the cost of parts due to the fact that the hob requires preliminary design and construction for the studied stars in the individual production;

- Implementation of electronic document in the project process cycle a product is organizing an effective synchronous design and technology in enterprises, thereby enhancing the culture of production.

Manufacture of chain wheels with 16[1] and 19 teeth[2], on the vertical machining centre GDV400PM1F4, updated on the workshop of Malu Serv S.R.L. of Tîrgu Mureş, by replacing the original with a digital control CNC NCT®2000M [2], is the subject of this paper.

Elements that made up manufacture of chain wheels mentioned above, aspects clarifies dealt with throughout this paper, and are as follows:

- Aspects on technical parameters of GDV400PM1F4 [5, 6] vertical machining centres, used in manufacturing;
- The main technical characteristics of numerical controls 2S42-65 [1] and NCT®2000M [7];
- Constructive elements of the two sprockets;
- The main stages of manufacturing process adopted;
- Conclusions of the manufacturing process studied.

2. Aspects on technical parameters of GDV400PM1F4 vertical machining centre, used in manufacturing [5,6]

The model GDV400PM1F4 can make multi-sense horizontal hole, milling, boring and is designed for complex processing of in an ensemble of positions and boundary modes from the program management;

First year of manufacturing: 1987;

Class of accuracy according to GOST 8-82 car is, (N, P, B, A, C): P;

Minimum speed of rotation main shaft: 40 [rot/min];

Maximum speed of rotation main shaft: 4500 [rot/ min];

Main motor power: 7.4 [kW];

The number of tools from repository: 30 [pcs.].

[1] ISO standard 16-B1 • 25:40 Pas [mm]
[2] ISO standard 16-B1 • 25:40 Pas [mm]

Fig. 1: GDV400PM1F4 vertical machining centers [14]

3. The main technical characteristics of numerical controls 2S42-65 [1] and NCT®2000M [7]

NC Programme initially used "2S42-65"

Numerical control NC "2S42" is used to control metalworking machines. Having regard geometric data processing device is a contour-position free programming algorithms;

Number of simultaneously controlled axes with linear interpolation - 4;

Number of simultaneously controlled axes with circular interpolation - 2;

The number of digital-to-analogue converter connected to the movement sensor - 8;

The unit provides a control unit for transmitting power to the following:

1. Linear Encoder IPT-N;
2. Encoders TMV-1M, ISP-18, BS-155A;
3. Pulse linear and angular displacements company Haidenhain.

Delivery device provides analogue signals from -10 to + 10 volts DC feed control and main unit shaft;

The device provides analogue input voltage from -10 to + 10 volts DC for 2-channel adaptive control;

The number parts of the digital signal - up to 224;

Ability RAM - 48 [Kbyte], 8 [Kbytes] of them, preserving information;

Capacity PROM - 48 Kbytes;

The maximum displacement axes - 9999.999 mm;

Reference value 0.01 [mm] or 0.001 moving, 0.01° and 0.001°.

Main characteristics of NCT 2000 , 100 up to 104 [6]

Different types and year editions of NCT controls have similar operation and programming systems. There are no separate turning and milling controls. The turning system software and the milling system software runs on the same hardware.

The system software, PLC, part programs, tool corrections are stored in one FLASH memory and loaded easily to empty controls by user who decides whether to use the purchased control for turning or milling machine by choosing the system software.

The control panel is connected to the Logic Unit (LU) through digital channel. Each control panel can be connected to each Logic Unit.

By connecting extension cards the least exspensive configurations can be transformed into the most sophisticated systems. Adaption to changing demands - in the course of machine production or at the user - is secured by the subsequent mounting of expansion card.

Selection can be made at machine parameter whether to connect NCT controls to servo drives as well as to main drive in a traditional analog way (+/- 10V) or through the most up-to-date digital way or both ways.

4. The constructive elements of the two chain sprockets

Table 1: Geometrical elements of the chain sprockets[8]

Nr. crt.	Geometrical elements of the chain sprockets			
	Denomination	The symbol and measure unit	Chain wheel with Z = 16 teeth[9]	Chain wheel with Z = 19 teeth[10]
	I	II	III	IV
1.	Chain step	p [mm]	25,40	25,40
2.	Nom.diameter of roll d_1	d_1 [mm]	16	16
3.	The distance between interior link of the chain a_{min}	a_{min} [mm]	17	17
4.	Unghiular step	$j_{1,2}$ [°]	22,5	18,9
5.	Terms of division diam.	$Dd_{1,2}$ [mm]	130,25	154,87
6.	Top diameter (exterior)	$De_{1,2}$ [mm]	144	170
7.	Tooth height	h [mm]	14,87	15,56
8.	Bottom diameter	$Di_{1,2}$ [mm]	114,25	138,87
9.	The angle of place roll	$d_{1,2}$ [°]	125	125
10.	Tooth flank radius	$R_{2\ 1,2}$ [mm]	53	65
11.	Tooth width	B_1[mm]	16	16
12.	Bevelling tooth	f [mm]	3,3	3,3
13.	Raza of connection (chamfer) of flank R3 tooth	R_3 [mm]	26	26
14.	Raza of connection to wheel rim	R_4 [mm]	0,4	0,4
15.	Wheel rim diameter	D_5 [mm]	122,3	122,3
16.	Place roll raza	R_1 [mm]	8,15	8,15

5. The main stages of the manufacturing process adopted

Programming Manual for the chain sprocket manufacture with 19 teeth [10], using the ISO programming language involves the construction of the machine main program (O0158), which includes the entire manufacturing process and three subprograms for centering-drilling (P0154), roughing (P0155) and finishing (P0156).

Fig. 2: KFT NCT program interface Version 3.2 [14]

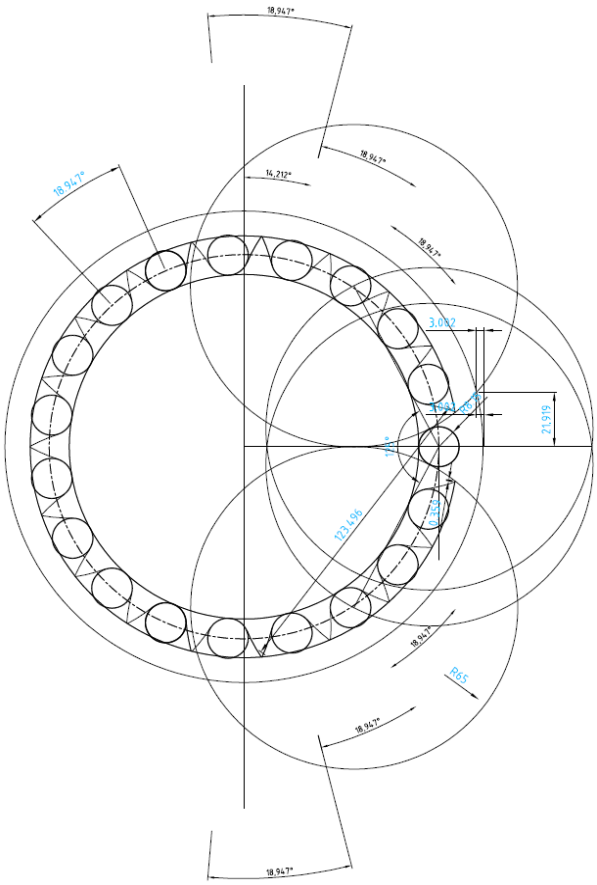

Fig. 3: Drawing sprocket with 19 teeth used to design processing program O0158 [10, 11, 12, 13]

Tools used in the processing of teeth:

- Centering tool Ø10;
- Drilling tool Ø12;
- End mill for roughing with 4 teeth Ø12;
- End mill for finishing Ø12 4 teeth;

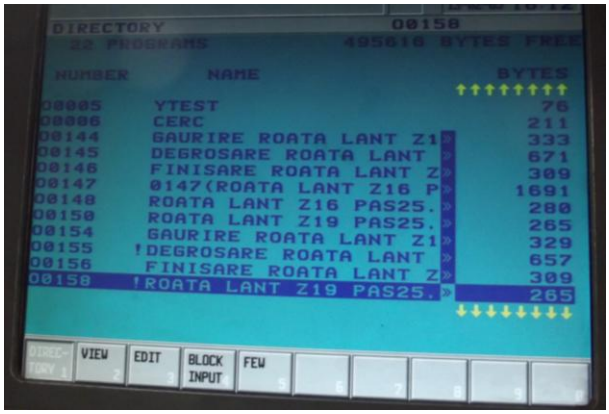

Fig. 4: The main processing program O0158- on monitor at the processing center [14]

O0158 - main program for processing the sprocket with 19 teeth on vertical machining center GDV400PM1F4 has the following configuration [15]:

%O0158 (CHAIN SPROCKET Z19 STEP 25.4)
N5 G0 G17 G90
N10 G58
N15 G0 X0 Y0 (CENTERING + DRILLING)
N20 M98 P0154 (CENTERING + DRILLING)
N25 G0 X0 Y0
N26 M1
N27(DEGROSARE)
N30 M98 P0155 L19 (ROUGHING)
N35 G69
N45 G90
N50 G0 Z150
N51 M1
N55(FINISARE)
N195 G0 X0 Y0
N200 M98 P0156 L19 (FINISHING)
N210 G69
N360 G90
N365 G0 Z150
N370 M30
%

Fig. 5: The drillings execution of centering with the subprogram - P0154 [14]

It enters at the subprogram - P0154 for drillings execution of centering and for the other holes of Ø12 [mm] [15]:

%O0154 (DRILLING CHAIN SPROCKET Z19 STEP 25.4)
N5
N10 G58
N15 T1 (CENTERING)
N20 S500 M3
N25 G0 G43 Z150 H1
N30 G0 X0 Y0
N35 G16 G0 X77.439 Y-18.947
N40 G81 X77.439 YI18.947 R2 Z-5 F30 L19
N45 G80 G15
N50 G0 Z150 M5 M9
N53 M1
N55 T2 (DRILLING)
N60 S300 M3
N65 G0 G43 Z200 H2
N70 G0 X0 Y0
N75 G16 G0 X77.439 Y-18.947
N80 G73 X77.439 YI18.947 R2 Z-20 F20 Q4 E1 L19
N85 G80 G15
N90 G0 Z150 M5 M9
N95 M99
N10
%

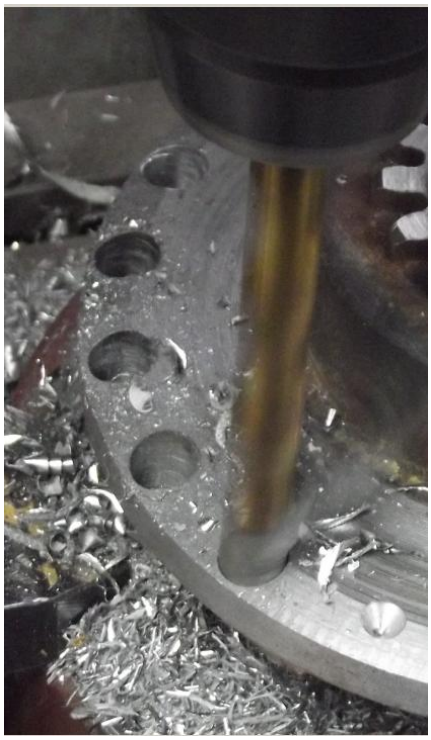

Fig. 6: Execution the holes of Ø12 with subprogram P0154 [14]

It re-enters the **main program O0158** and it is accessed the subprogram **P0155 for roughing [15]**:

%O0155 (ROUGHING CHAIN SPROCKETS Z19 STEP 25.4)
N5
N10 G58
N95 T5 (ROUGHING)
N100 S400 M3
N105 G0 G43 Z150 H5
N110 G0 X77.439 Y0

N111 G0 Z5
N115 G91
N120 G0 X18 Y0
N125 G1 Z-11 F500
N130 G1 G42 X-3.002 Y-21.919 D5 F500
N135 G3 X-18.761 Y14.69 R65 F30
N140 G2 Y14.458 R8.15
N145 G3 X18.761 Y14.69 R65
N150 G90
N155 G0 G40 Z5
N160 G0 X77.439 Y0
N165 G91
N170 G0 X18 Y0
N175 G1 Z-17 F500
N180 G1 G42 X-3.002 Y-21.919 D5 F500
N185 G3 X-18.761 Y14.69 R65 F30
N190 G2 Y14.458 R8.15
N195 G3 X18.761 Y14.69 R65
N200 G90
N205 G0 G40 Z5
N210 G0 X77.439 Y0
N215 G91
N220 G0 X18 Y0
N225 G1 Z-27 F500
N230 G1 G42 X-3.002 Y-21.919 D5 F500
N235 G3 X-18.761 Y14.69 R65 F30
N240 G2 Y14.458 R8.15
N245 G3 X18.761 Y14.69 R65
N250 G90
N255 G0 G40 Z5
N260 G0 Z150
N335 G68 X0 Y0 RI18.947
N340 M99
N10
%

Fig. 7: It used the end mill Ø12 with 4 teeth at Roughing with subprogram P0155 [14]

And it is finaly accessed **the finishing subprogram P0156 [15]**:

%O0156 (FINISHING CHAIN SPROCKET Z19 STEP 25.4)

N5 G58

N265 T6 (FINISHING)

N270 S1300 M3

N275 G0 G43 Z150 H6

N280 G0 X77.439 Y0

N283 G0 Z5

N285 G91

N290 G0 X18 Y0

N125 G1 Z-27 F500

N130 G1 G42 X-3.002 Y-21.919 D6 F500

N135 G3 X-18.761 Y14.69 R65 F30

N140 G2 X0 Y14.458 R8.15

N145 G3 X18.761 Y14.69 R65

N320 G90

N325 G0 G40 Z5

N330 G0 Z150

N335 G68 X0 Y0 RI18.947

N340 M99

%

Fig. 8: Finishing toothing with end mill Ø12 having 4 teeth with subprogram P0156 [14]

... and with the M30 in the main program O0158 - that is the final command of program, implicit for the chain sprocket manufacturing with 19 teeth, it is the end process of manufacturing.

Fig. 9: Chain sprocket with 19 teeth [9], after the heat treatment of browning [14]

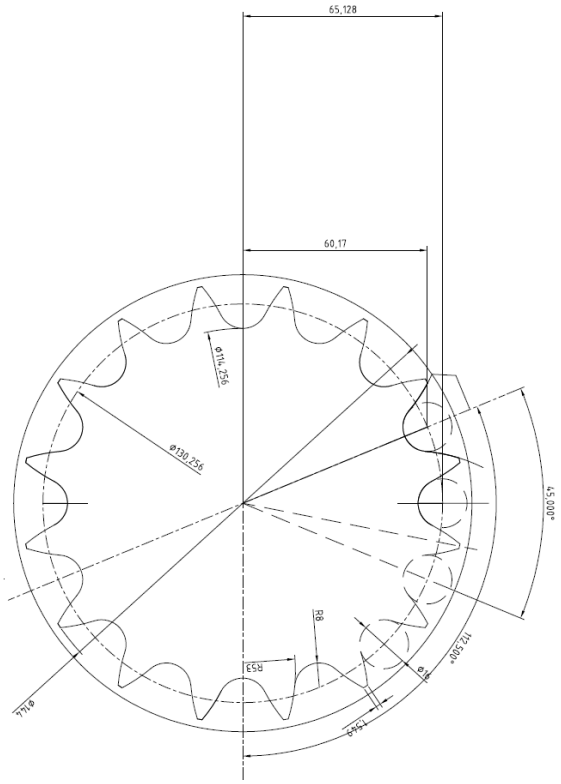

Fig. 10: Drawing sprocket with 16 teeth used to design processing program O0148 [9, 11, 12, 13]

6. Conclusions on the manufacturing process studied

About NCT numerical command:

- Installation of NCT numerical command on a machine tool can be achieved in a relatively short time and build PLC program is logical and compact than other brands of the industry, being able to easily write in text editor (For example - Notepad);

Fig. 11: Chain sprockets with 16 and 19 teeth, processed according to the steps exposed in this article [14]

- Has a more precise control of the machine, ensuring a quality / best price compared to other numerical control systems, it is more accessible and reliability is not in doubt;

- ISO programming language contributes at ease of accommodation with commands of machine;

- Manual programming at the machine for which it's opting at the case described above, generates the shorter programming compared to using one CAM program, on terms of program length listed, this fact it is owe parameterized work cycles with which working (G 81 - drilling without disruption of cuttings, G73 - drilling with breaking the cuttings, and adjustment of subprogram with L parameter) it significantly shorten the number of characters in the work program, thus it requires more less storage space and it gaining in a professional mode.

Regarding manufactured chain wheels on this machine:

Advantages:

- Setting the machine is carried out in a short time and setting on the machine table is rapid semi (fishing tap lock);

- It addresses to a flexible manufacturing because it has been easy to past from program with 16 tooth a chain sprocket to one with 19 teeth;

- Minimum investment on required tools for manufacture, because it is not a type of special tools such as a sprocket hob, knife-wheel or knife-comb , not to mention broaching, where several tools are needed for the component of an set of broaching.

Disadvantages:

- Relatively productivity low, considerable execution time and the number of tools used it is large (four tools: centering, drill, end mill for roughing and end mill for finishing);

- Advanced knowledge of programming, because it wasn't used CAM software in the case described in the article.

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