DETERMINING THE TEETH FRONT PROFILE OF CHAIN WHEELS MEASURED IN COORDINATE ON MACHINE "Smart CMM" - WENZEL

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ABSTRACT

The profile of chain wheels front teeth throughout paper work is presented_in two different directions, the front profile resulting from the calculations for determining the chain wheel geometry and the other direction represent the same profile (manufactured on gear hobbing machine "FD 500" - UM Cugir România) verified in coordinate of measuring on machine "Smart CMM" - Wenzel UK .

Keywords: teeth, front profile, chain wheels, gear hoobing machine, coordinate measuring machine

1. Introduction

The process of determining analytical and physical profile of the chain wheel front teeth is analyzed in the following steps:

- ○ Chain transmission calculation of which makes part studied chain wheel;
- ○ Manufacturing technology of chain wheel on gear hobbing machine "FD 500" - UM Cugir România;
- ○ Measuring teeth front profile of chain wheel (previously manufactured), in coordinates on „Smart CMM" – Wenzel UK;
- ○ Conclusions

2. Chain transmission calculation of which makes part studied chain wheel

To calculate chain transmission it was used KISSsoft – release 04-2010G - design software for engineers (High school license - Universitatea "Petru Maior" Tîrgu Mureş) from KISSsoft AG – Switzerland (Table 1).

Calculation of chain transmissions with roller chains in accordance with ISO 606 (also contains DIN 8187 and DIN 8188) with standardized roller chains from a database. The chain geometry (wheelbase, chain link count), transferable power, speed variation, through the polygon effect, etc. is calculated for single and multiple chains. Basis: DIN ISO 10823[8].

Table 1. Calculation of chain transmissions

KISSsoft – Release 04-2010G Hochschullizenz Universitatea Petru Maior		
File name:Changed by:user on:25.10.2011at: 14:42:33		
Chain drive - calculation method: DIN ISO 10823 (2006)		
6	**Chain type** Standard ISO 606 (2004) -Type 08B	
7	Number of strands	$[n_s]$ = 1
8	Pitch	[p] = 12.70 (mm)
9	Center distance	[a] = 297.99 (mm)
10	Chain length	[l] = 1041.41(mm)
11	Nr. of parts (of chain)	$[N_l]$ = 82
12	Speed of chain	[v] = 1.46 (m/s)
Geometry of chain:		
14	Max. roller diameter	$[d_1]$ = 8.51 (mm)
15	Max bearing pin body diam.	$[d_2]$ = 4.45 (mm)
16	Min width between inner plates	$[b_1]$ = 7.75 (mm)
17	Max. width over inner link	$[b_2]$ = 11.30 (mm)
18	Total width of chain	$[b_{tot}]$ = 17.00 (mm)
19	Max inner plates depth	$[h_2]$ = 11.81 (mm)
20	Sectional area of2 inner plates	$[A_i]$ = 18.97(mm²)
21	Ratio	$[t_h/t_s]$ = 1.00
Geometry of chain sprocket 1:		
23	Min. tooth flank radius	$[R_{2min}]$ = 48.27 (mm)
24	Med tooth flank radius	$[R_2]$ = 36.90 (mm)
25	Max tooth flank radius	$[R_{2max}]$ = 25.53 (mm)
26	Min roll-seating radius	$[R_{1min}]$ = 4.30 (mm)
27	Med roll-seating radius	$[R_1]$ = 4.37 (mm)
28	Max. roll-seating radius	$[R_{1max}]$ = 4.44 (mm)
29	Min. roll-seating angle	$[delta_{min}]$ = 116.09 (°)
30	Med. roll-seating angle	[delta] = 126.09 (°)
31	Max. roll-seating angle	$[delta_{max}]$ = 136.09 (°)
32	Min. outside diameter	$[D_{emin}]$ = 96.57 (mm)
33	Med. outside diameter	$[D_e]$ = 98.60 (mm)
34	Max. outside diameter	$[D_{emax}]$ = 100.63 (mm)
35	Root diameter	$[D_i]$ = 84.76 0/-0.3 (mm)

36	Root diameter tolerance
37	Minimum tooth height over ref circle $[h_{amin}]$ = 2.09 (mm)
39	Medium tooth height over reference circle $[h_a]$ = 3.11 (mm)
41	Maximum tooth height over reference circle $[h_{amax}]$ = 4.12 (mm)
43	Face width of a tooth $[b_{f1}]$ = 7.21 h14 (mm)
44	Face width over all teeth $[b_{ftot}]$ = 0.00 (mm)
45	Measuring-pin diameter $[d_1]$ = 8.51 (mm)
46	Tolerance measuring-pin diameter (mm)
47	Measure over pins $[M_R]$ = 101.56 (mm)
Geometry of chain sprocket 2:	
49	Min. tooth flank radius $[R_2min]$ = 156.31 (mm)
50	Med. tooth flank radius $[R_2]$ = 102.66 (mm)
51	Max. tooth flank radius $[R_{2max}]$ = 49.02 (mm)
52	Min. roll-seating radius $[R_{1min}]$ = 4.30 (mm)
53	Med. roll-seating radius $[R_1]$ = 4.37 (mm)
54	Max. roll-seating radius $[R_{1max}]$ = 4.44 (mm)
55	Min. roll-seating angle $[delta_{min}]$ = 118.04(°)
56	Med. roll-seating angle [delta] = 128.04 (°)
57	Max. roll-seating angle $[delta_{max}]$ = 138.04 (°)
58	Min. outside diameter $[D_{emin}]$ = 189.85 (mm)
59	Med. outside diameter $[D_e]$ = 191.66 (mm)
60	Max. outside diameter $[D_{emax}]$ = 193.47 (mm)
61	Root diameter $[D_i]$ = 177.59 0/-0.3 (mm)
62	Root diameter tolerance
63	Minimum tooth height over reference circle $[h_{amin}]$ = 2.09 (mm)
65	Medium tooth height over reference circle $[h_a]$ = 3.00 (mm)
67	Maximum tooth height over reference circle $[h_{amax}]$ = 3.90 (mm)
69	Face width of a tooth $[b_{f1}]$ = 7.21 h14 (mm)
70	Face width over all teeth $[b_{ftot}]$ = 0.00 (mm)
71	Measuring-pin diameter $[d_1]$ = 8.51 (mm)
72	Tolerance measuring-pin diameter (mm)
73	Measure over pins $[M_R]$ = 194.61(mm)

		Gear 1	**Gear 2**
75	Speed(1/min)	$[n_1]$=300.00	$[n_2]$=150.00
76	Nr. of teeth	$[z_1]$ = 23	$[z_2]$ = 46
77	Reference diam. (mm)	$[d_1]$ = 93.27	$[d_2]$=186.10
79	Loop (°)	162.08	197.92
80	Torque (Nm)	$[T_1]$ = 38.20	$[T_2]$ = 76.22
81	Axis force (N)	$[Fa_1]$:826.78	$[Fa_2]$:822.92

83	Nominal power $[P_n]$ = 1.20 (kW)
84	Application factor $[f_1]$ = 1.30
85	Factor for number of teeth $[f_2]$ = 0.81
66	Operating power $[P_{max}]$ = 1.27 (kW)
87	Speed correction factor $[K_{PS}]$ = 1.00
88	Nominal power plate fatigue resistance
	$[P_{c1}]$ = 1.94 (kW)
90	Nominal power roll-/bush fatigue $[P_{c2}]$ = 151.70 (kW)
92	Nominal power pin/bush wear $[P_{c3}]$ = 102.58 (kW)
94	Max. transmittable Power $[P_{zul}]$ = 1.94 (kW)
Maximal possible variation for the input speed (due to polygon effect):	
97	Minimal speed $[n_{min}]$ = 150.00 (1/min)
98	Maximal Speed $[n_{max}]$ = 151.76 (1/min)
99	Lubrication proposal: Drip feed (coefficient v*p^ 0.56 6.06)
	Utilization [A] = 65.58 (%)
	Formula: $A = P_{max} / P_{zul} * 100$
	P_{zul} = min(Pc1,Pc2,Pc3)
	$Pmax = P_n * f_1 * f_2$
End report	lines: 105

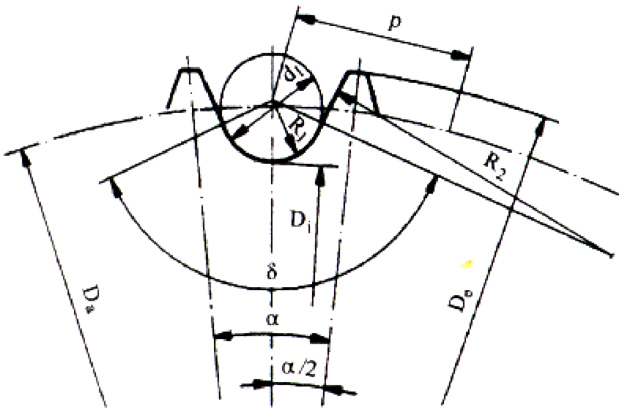

Fig. 1 - Geometry of the sprocket front profile [5]

3. Manufacturing technology of chain wheel on gear hobbing machine "FD 500" - UM Cugir România

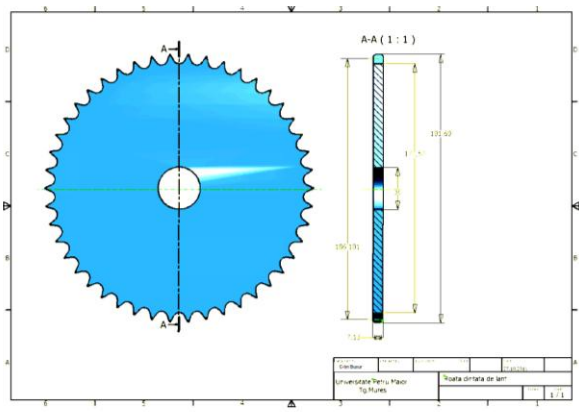

Fig. 2 - Drawing of execution the chain wheel [1],[3],[8],[9]

In this work, processing of chain wheel crown teeth is performed on gear hobbing machine "FD 500" - UM Cugir România[4].

Fig. 3 - Checking axial beatings of sprockets semi-finished fixed for processing the teeth crown [7]

The material of being processed those three sprockets is called Textolite and is recommended by the company producing SC CEPROINV SA Focşani - România, thus:

Main features are: High resistance to wear; Good resistance to water, oil and lubricants; Good machinability; Stiffness and ductile qualities between -6 ° C to + 100 ° C; Very good dimensional stability: 100% humidity and 70 ° C, dilation is below 0.10%. Delivery: bars or plates.

Textolite is a laminate fabric-based cotton and phenolic resin, being in accordance with the following international standards: IEC 60893 PFCC 202; IN 7735 Hgw 2082.5; NEMA LI 1 EC.

Few applications: ...Textolite is also used in applications such as gear pairs and of friction wheels or surfaces of friction.

Textolite can be used in places where good dimensional stability and compressive strength of thermoplastics materials for general use is not satisfactory. Examples:...Carcasses and items of equipment; Organs of machines to heavy loads; Bearings, gears and guides to press machines.[16]

Sprocket hob is the third element participating in the toothing.

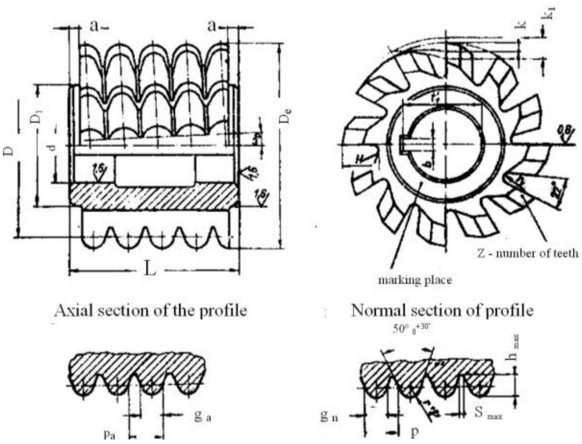

Fig. 4 - Shape and dimensions of the sprocket hob[6]

Shape and dimensions of the sprocket hob are be found in Figure 4 and Table 2 [6].

Fig. 5 - Sprocket hob mounted on mandrel for gear hobbing machine [7]

Table 2. Shape and dimensions of the sprocket hob

The main dimensions of the sides DIN 8187: Pace p	The main dimensions of the sides DIN 8187: Outer roll diam. $d_{1\,max}$	De h16	d H7	b	t_1 H11	D_1 h16	L h15	a	r_1
Dimension in [mm]									
12.7	8.51	80	27	$7^{+0.17}_{+0.08.}$	29.8	45	60	3	1,5
Z – (number of teeth) = 12									

Fig. 6 - Appearence frontal - radial of sprocket position in the process toothing [7]

Technological parameters of the processing of sprocket [4]:

1. Adjustment tool speed: n = 112 [rpm];
2. Adjustment lira division: Z = 46, Za = 48, Zb =70, Zc =70, Zd = 46, Ze = 28, Zf = 56;
3. Adjustment lira differential: - it blocking spindles rotation;
4. Adjustment of working advance axial: a = 0.5 [mm / piece rotation];
5. Axial distance from sprocket hob to piece: [A] = 135.7 [mm];
6. Milling adjusting depth (of tooth): t_1 = 4 [mm], t_2 = 3 [mm].

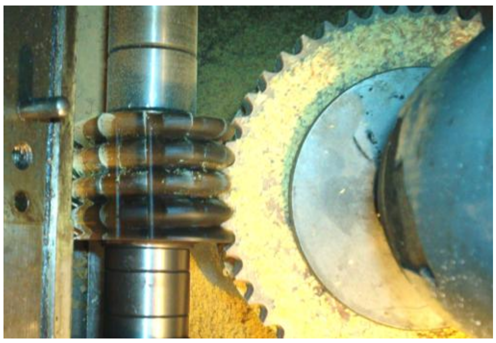

Fig. 7 - Toothing - view from frontal sprocket position [7]

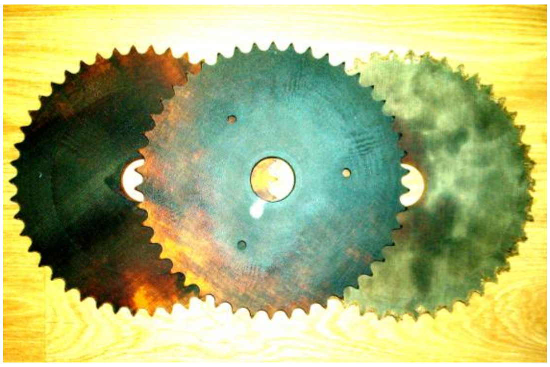

Fig. 8 - Chain wheels after toothing on gear hobbing machine "FD 500" - UM Cugir România

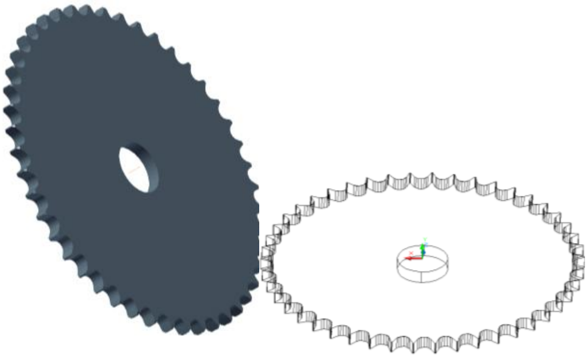

Fig. 9 - Modeling the chain wheel with Inventor ® and AutoCAD ® - CAD design tools 2D and 3D of Autodesk® Company USA [1],[2],[3],[9],[10]

4. Measuring teeth front profile of chain wheel (previously manufactured), in coordinates on „Smart CMM" – Wenzel

The „Smart CMM" from Wenzel Company is available with a range of Renishaw sensors the Smart CMM is at home using a touch trigger probe or a full analogue scanning probe.[11]

Few features are presented:

○ Shop-floor measuring device for measuring small and medium size components

○ All guideways protected/enclosed for use even in rough environments

○ Only an electricity outlet required (no air bearing)

○ The measuring volume is freely accessible from 3 sides

○ Flexible use through high temperature tolerance[11]

a. Light-weight

○ Oustanding kinematics due to ultra light-weight

construction (FEM design strain-optimized)

b. Z Column

○ Made of carbon fibre

○ Flexible adjusting for used probe size,

c. Controler and PC

Compact construction through integrated system

d. Precision linear guideways

○ High life expectancy

○ Low maintenance

○ No air supply required

The optimized software solution

○ Click'n Measure

Measuring automatism inclusive of collision check

○ Graphic measuring protocol with configurable point boxes

○ Automatic call of measuring programs through speed loading window

○ Freely configurable statistics:

Overview, trend diagrams, rule cards, histograms, process capability and more.

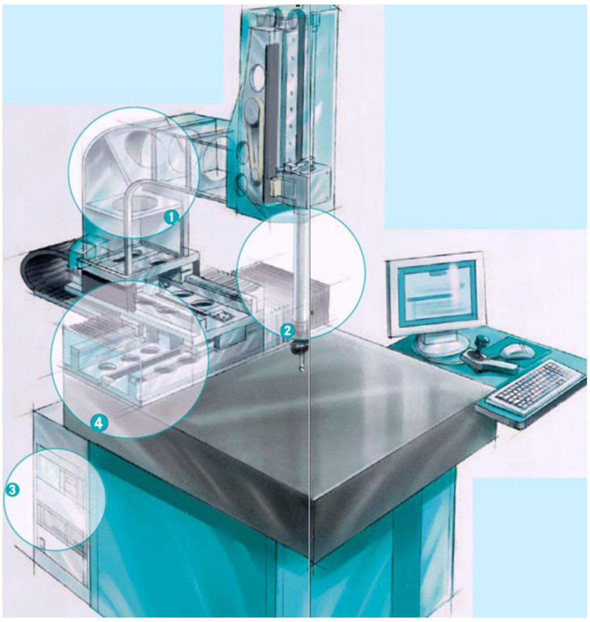

Fig. 10 - „Smart CMM" –Wenzel Company: Points 1 – 4 [13]

Technical characteristics [13]

[mm] Table 3

X	Y	Z
500	450	400
1000	450	400

Measuring uncertainty according to DIN EN ISO 10360-2

Temperature range 16-28ºC, max 2 K/h

MPE_E[µm]: 4,5 + L/250 (L in min)

MPE_p[µm]: 4,5

Temperature range 18-22ºC, max 1 K/h

MPE_E[µm]: 3,5 + L/300 (L in min)

MPE_p[µm]: 3,5

Kinematics:

v_{max} = 650 [mm/s]

a_{max} = 2000 [mm/s]

Specified measuring uncertainty with TP200 probing.

Measuring teeth front profile of chain wheel, was performed at S.C. Turbocam România S.R.L. Târgu Mureş.

Fig. 11 - „Smart CMM" - Wenzel at S.C. Turbocam România S.R.L. Târgu Mureş [15]

For measuring the wheel, it was used OpenDMIS™ (designed and developed by Xspect Solutions, became a Wenzel product when they acquired Xspect Solutions in the fall of 2007 [12]) software of „Smart CMM" with point-to-point option.

Quotas of chain wheel processed on gear hobbing machine "FD 500" - UM Cugir România in Machine tool Laboratory of University "Petru Maior" - Târgu Mureş were measured in the following order: 1. Root diameter, 2. Outside diameter, 3. Roll-seating diameter and 4. Profile front wheel chain in 25 points.

The results are listed in Table 4.

Table 4. Measuring results of sprocket (in coordinate X,Y,Z)

	Inspection Report (extract) Company: TAPS-C2688 Operator: - Date: Tuesday, October 25, 2011; Time: 6:54:55 PM to 8:00:33 PM
	The measured diameters - XY plane
5	**1. Root diameter = 177.9458 (mm)** Time: 6:54:55 PM CIR1 - MCS/MM/ANGDEC/CART/XYPLAN
8	**2. Outside diameter = 191.3951(mm)** Time: 7:24:08 PM CIR1 - MCS/MM/ANGDEC/CART/XYPLAN
11	**3. Roll-seating diameter (mm)** = **8.6089(mm)** Time: 8:00:33 PM CIR2 - MCS/MM/ANGDEC/CART/XYPLAN
	Measuring the teeth front profile of sprocket by measuring surface profile in 25 points of XY plane Time: 8:00:33 PM CRD1/MM/ANGDEC/CART/XYPLAN

	Point Nr.	Coord. X (mm)	Coord. Y (mm)	Coord. Z (mm)
22 23	PT1	-121.5226	-373.0750	-450.1974
24	PT2	-121.4261	-372.5189	-450.1979
25	PT3	-121.1971	-371.6438	-450.2200
26	PT4	-121.0246	-370.8683	-450.2201
27	PT5	-120.9571	-370.5658	-450.1976
28	PT6	-120.7541	-369.6536	-450.1977
29	PT7	-120.5726	-368.9370	-450.1982
30	PT8	-120.2000	-368.0324	-450.2253
31	PT9	-119.7805	-367.4657	-450.2489
32	PT10	-118.0149	-365.8376	-450.2490
33	PT11	-117.6424	-365.6835	-450.2490
34	PT12	-117.2499	-365.5474	-450.2491
35	PT13	-116.8564	-365.4779	-450.2491
36	PT14	-116.3994	-365.4548	-450.2487
37	PT15	-115.8629	-365.4768	-450.2487
38	PT16	-115.3529	-365.5817	-450.2583
39	PT17	-114.9044	-365.7752	-450.2583
40	PT18	-113.4539	-367.0117	-450.2583
41	PT19	-114.0454	-366.3447	-450.2589
42	PT20	-113.6069	-366.8322	-450.2589
43	PT21	-111.8864	-368.6667	-450.2594
44	PT22	-111.6824	-368.8547	-450.2594
45	PT23	-111.2015	-369.3157	-450.2594
46	PT24	-110.5935	-369.8527	-450.2590
47	PT25	-109.9255	-370.4682	-450.2470
	Coordinate **Z = 450.2284 (mm)** it's considered the arithmetic average for all 25 points.			
End report				lines: 51

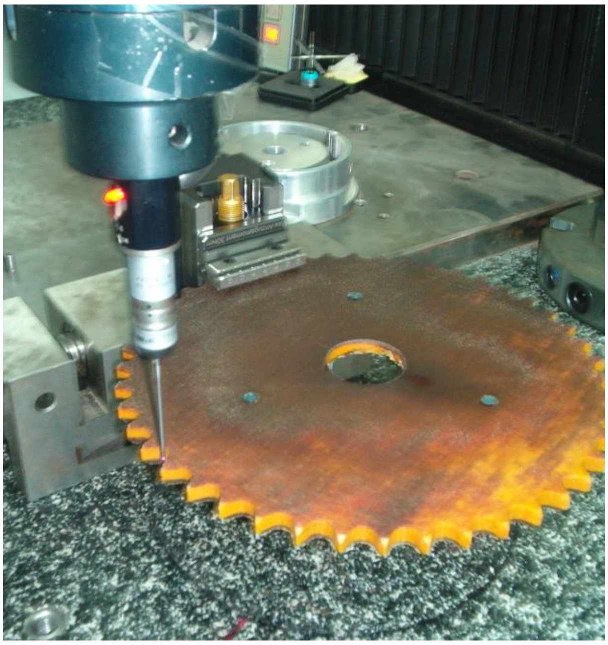

Fig. 12 - Frontal-radial aspect of measuring the chain wheel on "Smart CMM" [10]

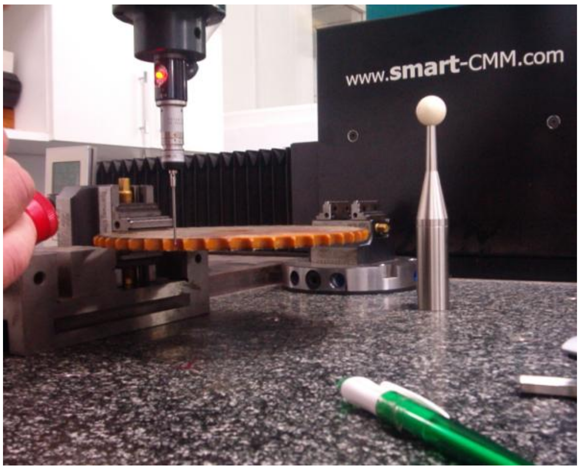

Fig. 13 - Axial aspect of measuring the chain wheel on "Smart CMM"[10]

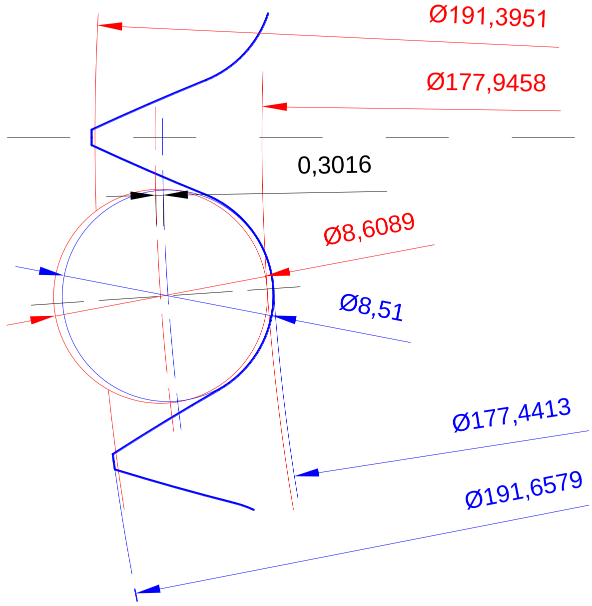

Fig. 14 - The drawing of sprocket profile computed and measured in frontal image show the profil difference of dimensions of computed sprocket in opposite with manufactured-measured sprocket . The difference is as shown the 0.3 [mm] (with blue is drawn up computed sprocket and with red is drawn the manufactured-measured sprocket) [2],[3],[8],[10],[15]

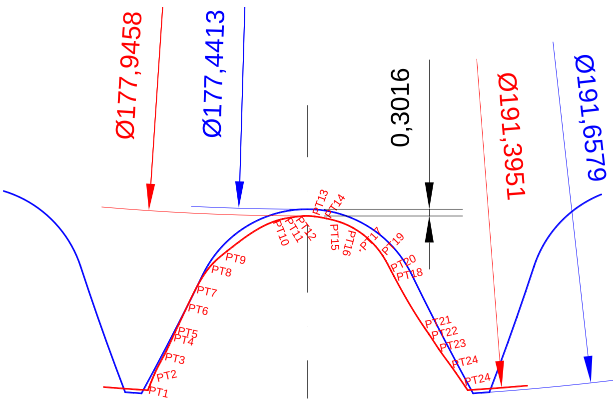

Fig. 15 - Picture of the measured profile is observed on "Smart CMM" - OpenDMIS ™ with „touch trigger probe" (namely 25 different points around the frontal surface of the profile) (with blue is drawn up computed sprocket and with red is drawn the manufactured-measured sprocket) [2],[3],[8],[10], [15]

5. Conclusions

○ It can be seen in Figure 15 (if it increases the image) that the point 17 is not on the front profile measured in 25 points distributed on the surface profile. If it is observed the machine manufacturer's recommendation "smart CMM" - "Specified measuring TP200 probing with Uncertainty." There is an rate error read, which may be due to the person who measured, with the current method of manually positioning the probe with the joystick.

○ For a better determination of the dimensions it's recommended introducing in software memory "Smart CMM", drawing of sprocket (in our case), for full analogue scanning probe to determining deviations from nominal dimensions.

○ The Coordinate Measuring Machine „Smart CMM" –Venzel, by the flexibility and precision it offers, can be used for determining geometrical characteristics of chain wheels.

○ From measurements made with the success was observed errors of manufacturing at sprocket studied.

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[4] FD – 500 Maşina de frezat dantura prin rostogolire, Instrucțiuni de deservire, U. M. Cugir, Ediția 2
[5] STAS 5013/5 – 91 Desene tehnice. Roți de lanț pentru lanțuri de transmisie cu bolțuri, bucşe sau role. Indicarea elementelor danturii
[6] STAS – 82 Freze-melc pentru roți de lanț
[7] Room A014 - Machine tool Laboratory of University "Petru Maior" - Târgu Mureş
[8] http://www.kisssoft.ch/
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