

CLASSIC AND MODERN TECHNOLOGIES FOR THE DESIGN AND PROCESSING OF A PART WITH MEDIUM DIAMETERS BASED ON MEASUREMENTS IN 3D COORDINATES

Elena Stela Muncut(Wisznovszky)^{1*}, Aurel Mihail Țițu^{2,3*}, Lavinia Ioana Culda⁴ and Geza Mihai Erdodi⁵

¹ University “Aurel Vlaicu” of Arad, B-dul Revoluției Nr. 77, România. P. O. BOX 2/158 AR, muncutstela@yahoo.com

² “Lucian Blaga” University of Sibiu, Faculty of Engineering, Industrial Engineering and Management Department, 10 Victoriei Street, 550024 Sibiu, Romania; mihail.titu@ulbsibiu.ro

³ Academy of Romanian Scientists, 3 Ilfov Street, Bucharest, Romania; mihail.titu@ulbsibiu.ro

⁴ University “Aurel Vlaicu” of Arad, B-dul Revoluției Nr. 77, 310130, România. P. O. BOX 2/158 AR, lavyvy_99@yahoo.com

⁵ University “Aurel Vlaicu” of Arad, B-dul Revoluției Nr. 77, România. P. O. BOX 2/158 AR, geza.erdodi@gmail.com

ABSTRACT: The present paper presents a parallel between the classic and modern technologies used to obtain a part with medium diameters. The part for which this case study is done is a planetary end. To obtain the benchmark, the following is used: the CTXBeta1250 4A machining centre, which is a turning centre with two main-motor shafts (main and secondary) ISM 76, with a power of 25/32 KW (33.5/42.88hp) (100/40% d.c.). The machining procedure is designed for both classic cutting machines and CNCs. The measurement is performed on the Mitutoyo 9106 measuring machine according to the measurement procedure and will allow the recording of: limit deviation, limit size, control limits and means of measurement. All the technological flow presented is based on quality assurance and all operations are accompanied by a procedure that ensures the traceability of the entire process of making the part.

KEYWORDS: processing, CNC, 3D measurement, quality assurance procedure, technology

1. INTRODUCTION

This work presents the classic and modern technological joints used to obtain a planetary end piece with medium diameters.

The car planetary gear (v. fig. 1) is a vital part of the car, which has the role of transmitting the kinetic energy from the engine to the wheels.

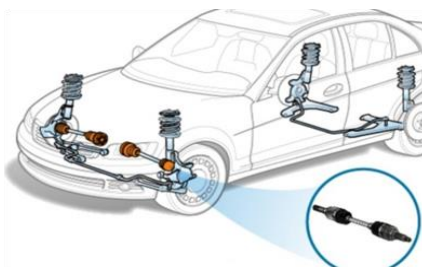


Figure 1. Planetary gear position [14]

To obtain the processing steps, it started from the reference received from the customer, for which 3D measurements used in the manufacturing process were generated

The measurement will be done on the Mitutoyo 9106 CMM (v. fig. 2) which is a vertical axis coordinate measuring machine and is designed for fast and accurate in-line measurement. [10]

The work pieces can be transported via the CMM either front/back or left/right. This makes it a very flexible and easy to integrate system. A great benefit is the fact that it realizes and transmits pre/post

processing feedback to the machine tools for adjusting the process.

The measurement errors are greatly reduced due to the scanning probe which is stabilized by keeping the probe stationary for a short period of time whenever the pen tip makes contact with the work piece. This leads to the elimination of dynamic measurement errors.[1]

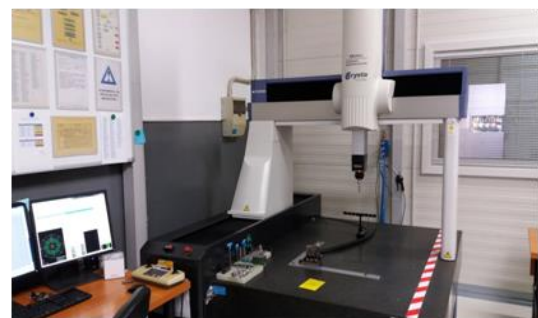


Figure 2. Mitutoyo 9106 CMM

The instruments used in the measurement process are: variable control means (PrMi), 3D coordinate measuring machine, 1D\2D vertical measuring device (Micro-Hite), outside\inside micrometer (tolerance < 0.1 mm), calliper, device for measuring roughness (Ra, Rz)[10]

The attributive means of control (PrMi) are: gauges (thread, rings, rays), projector, microscope (Magnifier), visual (reference roughness gauge), visual (reference roughness gauge).[10]

Based on the measurements made, a file is generated that will form the basis of the landmark processing process (v. fig. 3).[9]

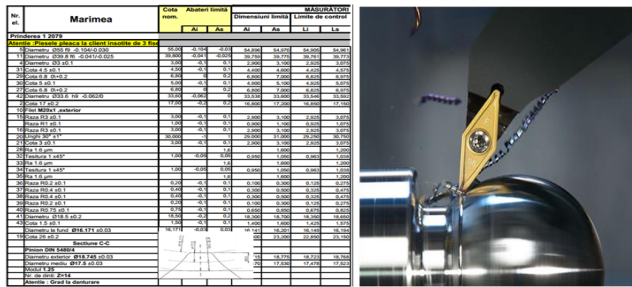


Figure 3. a) Sheet that will be the basis of the machining process b) Study of the piece

1.1 The choice of the technological parameters

The parameters are considered according to:

Component:

- Dimensional analysis and requirements imposed by surfaces, roughness
- Type of operations: turning, milling, threading, etc.
- Number of passes correlated with machining allowance

Tolerances

Material:

- Workability
- Semi-finished product preparation
- The type of chips
- The hardness
- Alloying elements

The correct identification of the material to be processed helps us to choose the correct cutting insert - the type of carbide and the optimal geometry of the tool

ISO-Ps are typically long-length materials and have a continuous, relatively even flow of chip formation. Variations within ISO-P usually depend on carbon content. Low carbon content = hard sticky material, high carbon content = friable material. The cutting forces and power required vary very little.[5]

Depending on the size, type of material, setting and processing method, a different choice of tools is necessary (turning, milling, drilling, etc.).[7]

There is usually a relationship between material hardness and tool life, as well as machining data and type of geometry and grade. The higher the hardness, the shorter the tool life and the faster the wear on the cutting edge.[6]

Two major factors influence the application outcome, namely the use of cutting fluid or a dry condition. As it is well known that carbide can take a lot of heat and also that it reaches its maximum when it maintains a constant high temperature, the dry condition should be the first choice, but there are also

grades specially developed for a wet environment, such as in the soleplate of irons that have traditionally been processed dry.[8]

An exception is drilling where the coolant is required to ensure effective chip evacuation from the edge and through the tube in a DHD application or through the chip whistles in an SHD application. Drilling applications are almost 100% done with some kind of cutting fluid. (v. fig. 4) [6]

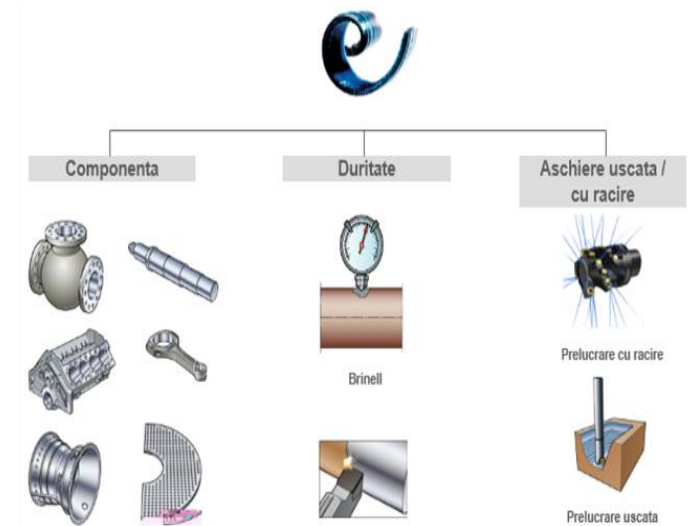


Figure 4. The influence of working conditions on the chip

2. THE TECHNOLOGY OF PROCESSING A SHAFT-TYPE PIECE ON CLASSIC CUTTING MACHINES

The material used is a general-purpose carbon steel 1.0501 C35 with the following properties [11]:

The property	The value	The unit of measure
The modulus of elasticity	$2,1 \cdot 10^5$	N/mm ²
Poisson's ratio	0,28	N/A
Breaking strength	900	N/mm ²
Flow resistance	700	N/mm ²
Density	7800	Kg/m ³

The piece we have to make (v. fig. 5, 6):

- A round semi-finished product of $\varnothing 65\text{mm}$ L384mm will be used
- Machines used in classical processing: SNA



Figure 5. Normal automatic lathe

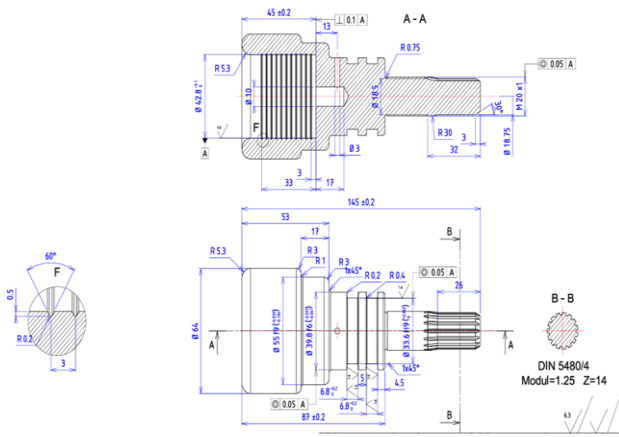


Figure 6. Planetary head

2.1 Establishing the technological route

Machining steps are shown according to table 1.

[7] [3]

Table 1. Steps by chipping

1. Front turning for finishing L147.5 mm	16. Radius R3
2. External roughing turning Ø57 L109	17. Chamfering 1x45°
3. External finishing turning Ø55 L109	18. Grooving Ø33.6 L6.8
4. External roughing turning Ø41 L92	19. Grooving Ø33.6 L6.8
5. External finishing turning Ø39.8 L92	20. Radius R0.2
6. External roughing turning Ø21 L58	21. Radius R0.4
7. External finishing turning Ø20 L58	22. L145 finishing front turning
8. Grooving	23. Drilling Ø40x45
9. External roughing turning Ø19 L26	24. Drilling Ø10x62
10. External finishing turning Ø18.76 L26	25. Internal finishing turning Ø42.8 L45
11. Profile turning R30	26. Grooving
12. Threading M20x1 L58	27. Radius R5,3
13. Chamfering 3x30°	28. Radius R5,3
14. Chamfering 2x45°	29. Drilling Ø3 L20
15. Radius R3	30. Channel milling

2.2 Technological route

The technological data sheet of the piece processing, according to table 2. [7] [3]

Table 2. The technological data sheet

Operation number	Operation and phases of operations	Outline of the operations	machin e tools	SOVs	Cutting modes		
					v _c	f _z	a _p
1x	Finishing turnings Front turning for finishing L147.5 mm and arbors		SNAr	Knife at 45° Caliper 200mm	31%	1,2- mm/rots	2- mms
2x	Turning roughings External roughing turning Ø57- L109#		SNAr	Side-knife Caliper 200mm	101- m/min	1,2% mm/rots	2% mms
3x	Finishing turnings External finishing turning Ø55- L109#		SNAr	Side-knife Caliper 200 mm	99- m/min	1,2% mm/rots	2% mms
4x	Turning roughings External roughing turning Ø41- L92#		SNAr	Side-knife Caliper 200mm	111- m/min	1,2% mm/rots	2% mms
5x	Finishing turnings External finishing turning Ø39.8 L92#		SNAr	Side-knife Caliper 200mm	92.5- m/min	1,2- mm/rots	2% mms
6x	Turning roughings External roughing turning Ø21- L58#		SNAr	Side-knife Caliper 200mm	104- m/min	1,2% mm/rots	2% mms
7x	Finishing turnings External finishing turning Ø20- L58#		SNAr	Side-knife Caliper 200mm	92- m/min	1,2- mm/rots	2% mms
8x	Woodturning Grooving		SNAr	Grooved knives	m/min	mm/rots	mms
9x	Turning roughings External roughing turning Ø19- L26#		SNAr	Side-knife Caliper 200mm	111- m/min	1,2- mm/rots	2% mms
10x	Finishing turnings External finishing turning Ø18.76 L26#		SNAr	Side-knife Caliper 200mm	92.5- m/min	1,2- mm/rots	2% mms

11x	Finishing turnings Profile turning R30#		SNAr	Side-knife Caliper 200mm	92- m/min	1,2- mm/rots	2% mms
12x	Woodturning Threading M20x1 L58#		SNAr	Threading knives	68- m/min	1- mm/rots	2% mms
13x	Woodturning Chamfering 3x30#		SNAr	Knife at 45°	83- m/min	3- mm/rots	2% mms
14x	Woodturning Chamfering 2x45#		SNAr	Knife at 45°	68- m/min	3- mm/rots	2% mms
15x	Woodturning Radius R3#		SNAr	Side-knife	-	-	-
16x	Woodturning Radius R3#		SNAr	Side-knife	-	-	-
17x	Woodturning Chamfering 1x45#		SNAr	Knife at 45°	-	-	-
18x	Woodturning Grooving Ø33.6 L6.8#		SNAr	Sharp knives	91.3- m/min	0,2- mm/rots	6.8% mms
19x	Woodturning Grooving Ø33.6 L6.8#		SNAr	Sharp knives	91.3- m/min	0,2- mm/rots	6.8% mms
20x	Woodturning Radius R0.2#		SNAr	Sharp knives	-	-	-
21x	Woodturning Radius R0.4#		SNAr	Sharp knives	-	-	-
22x	Finishing turnings L145 finishing front turning		SNAr	Knife at 45°	26.9- m/min	0,2- mm/rots	2% mms
23x	Woodturning Drilling Ø40x45#		SNAr	Bore Ø40#	-	-	-

24x	Woodturning Drilling Ø10x62#		SNAr	Drill-bit Ø10#	-	-	-
25x	Finishing turnings Internal finishing turning Ø42.8 L45#		SNAr	x	86.5- m/min	0,3- mm/rots	2% mms
26x	Woodturning grooving		SNAr	x	94.7- m/min	0,2- mm/rots	2% mms
27x	Woodturning Radius R5,3#		SNAr	Profiled-knife	-	-	-
28x	Woodturning Radius R5,3#		SNAr	Profiled-knife	-	-	-
29x	Drilling machines Gap		x	Drill-Ø3#	-	-	-
30x	mill	Channel-millings	x	Router mode 1.25#	-	-	-

2.3 CNC processing technology

The part that will be made in the project will be of the shaft type with processing in two 2 clamps.

The machine on which the processing is done is CTX beta 1250 4A code 159457.

The processing is done in two grips and the tools used are the following:

- Choose from the CNC program the tools for the machining stages by chipping on the first grip [5]

The parameters of the CNC processing technology are set on the first clamping 1 (v. fig. 9).[3] [7]

Loc.	MT LO.	Type	Tool name	ST	D	lgh	Z	Radius	Loc. leng
1			4_EBOS_EXT	1	157.986	1.200		95.0	80
2			4_FINIS_EXT	1	157.741	0.400		93.0	55
3			4_FIN_39.8f6	1	157.851	0.400		93.0	55
4			4_CANAL_3_EB	1	116.993	0.400	3.000	5.0	5.0
5			4_CANAL_3_FIN	1	117.430	0.400	3.000	5.0	5.0
6			4_CANAL_1.57	1	150.904	0.785	1.570	5.0	5.0
7			4_FILET_P1	1	116.338	0.200		0.0	0.0
8			4_CENTRUITOR	1	1	0.000	1.000	118.0	
9			4_BURGHUIU_D3	1	1	0.000	1.500	118.0	
10			4_FREZA_DISC	1	1	0.000	26.500	19	
11			4_CENTRUIT_D2.5	1	123.960	1.250	118.0		

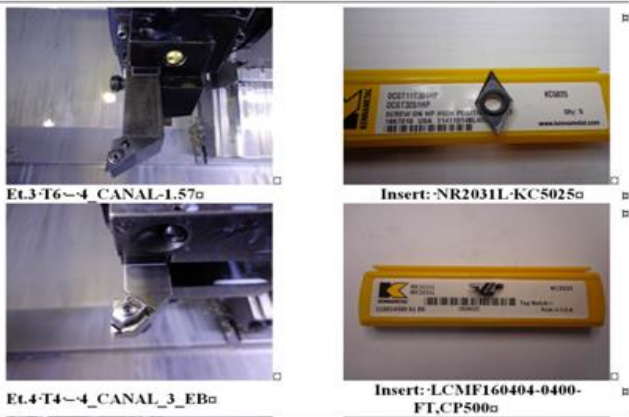
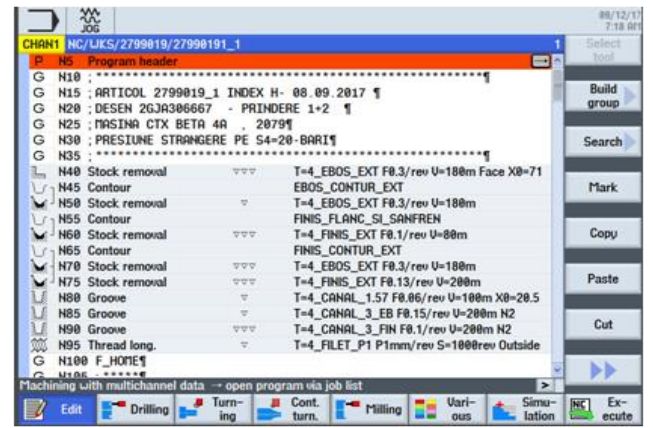


Figure 7. Choosing the tools for the first grip

The tools are chosen from the CNC program for the machining stages by chipping on the 2nd grip.[3] [7] (v. fig. 7, 8)

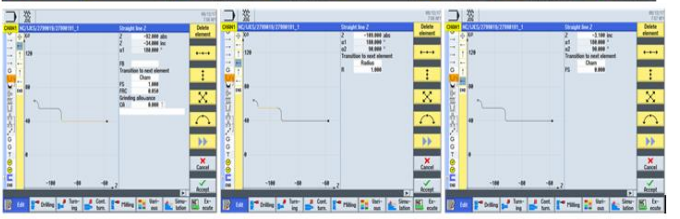
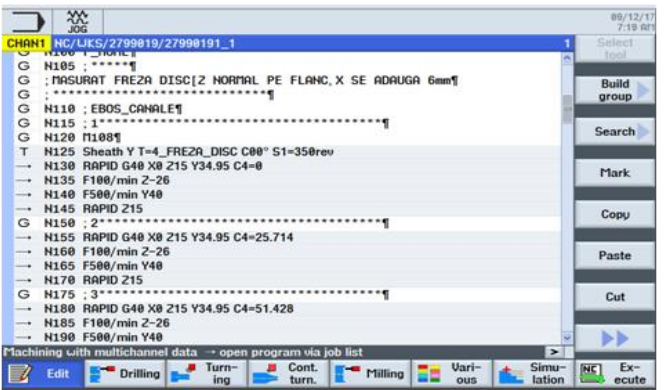


Figure 9. Parameters of the CNC on the first clamping 1

Loc.	MT LO.	Type	Tool name	ST	D	lgh	Z	Radius	Loc. leng
1			3_EBOS_EXT_0.8	1	1.7730	0.800		93.0	80
2			3_FINIS_EXT_0.4	1	1.7815	0.400		107.0	55
3									
4			3_CUTIT FILET	1	1	0.505	0.000	1.000	3.0
5			3_EBOS_INT	1	1.3.015	0.800		93.0	80
6			3_FINIS_INT	1	1.7.628	0.400		93.0	55
7			3_FREZA_D20	1	1.8.386	10.000	4		
8									
9			BURGHUIU_D10	1	1.2.216	5.000	118.0		
10									
11			3_BURGHUIU_D30	1	1.5.824	15.000			

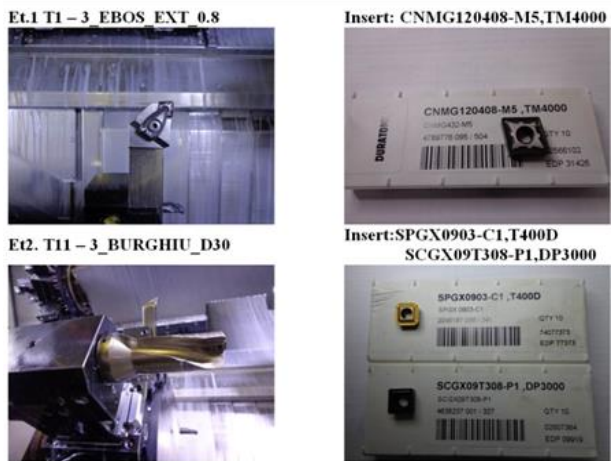


Figure 8. Choosing the tools for the second grip

The parameters of the CNC processing technology are set on the second grip 2, according with figure 10.[4]

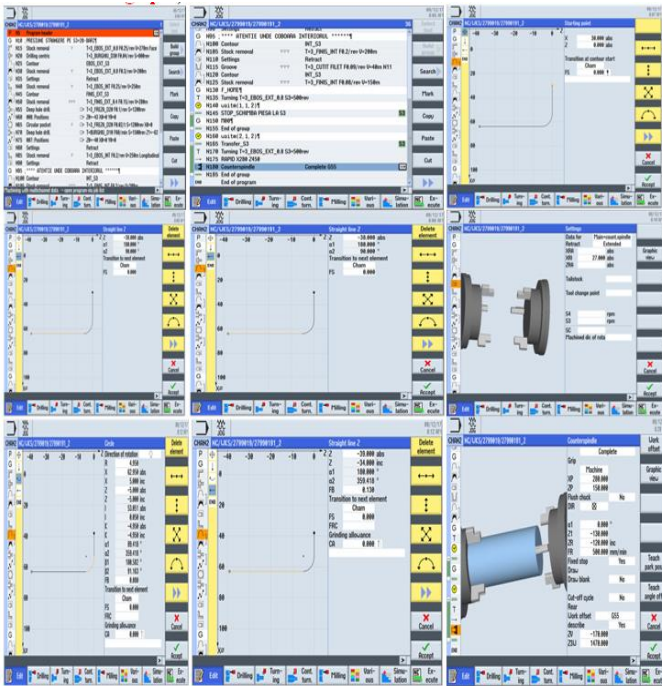


Figure 10. Parameters of the CNC on the first clamping 2

2.4 3D control measurement

As in the case of data acquisition, the measurement for the CTC account will be done on the Mitutoyo 9106 measuring machine according to the execution drawing.[10] The steps and measured values will be entered in the following measurement sheet.[1][2]

The parts go to the customer accompanied by 3 KMG measurement sheets / lot (for manual parts, the control plan is completed for 3 parts), [1][2]

The result of the measurements is presented in the appendix (v.table3) through a sheet in the initial phase (with problems with the measured values) and a sheet after the CNC adjustment (without deviations beyond the allowed ones).

3. CONCLUSION

One thing to consider is the cutting regime, which is determined by the dependence of the magnitude of the cutting force and the elements of the cutting regime: the processed material, the geometry of the tool and the cooling-lubricating fluids.

According to the study the cutting speed is inversely proportional to the cutting force. This implies that a greater force is obtained, under the same conditions, using a tool with more teeth.

Something difficult to achieve in classical machining where the lathe knife had only one cutting surface.

Table 3. 3D control measurement

Legătură	Mijloc de control variabile (RM)	Legătură	Mijloc de control atributive (RM)
KMG	Măsură de măsurat în coordonate 3D (Metrul)	MMK	Calibră (fiat, inele, raze)
MI	Aparat de măsurat pe verticală D.D (Miro-Hite)	CP	Proiector, Microscop (Lupa)
M	Micrometru de exterior interior (toleranță <0.1 mm)	VI	Visual (calibră rugozitate de referință)
MS	Șubler	KIR	Contornant
OEM	Aparat pt măsurarea rugozității (Ra, Rz)		

CATEGORIE DE CONTROL	MARIMEA LOTULUI				
	<5	5-20	20-50	50-100	>100
1	1	4	5	7	8
2	1	8	10	14	16
2R	1	16	20	28	32
3	Prima si ultima piesa. La schimbarea sursei diligaboniu				
4	In cazul acoperiilor, tratamente, etc se verifica o piesa la o sara				
*	Control 100%				
ATENȚIE!!!	Dupa Reglaje, Modificari parametri de lucru se verifica CELGATORUL la toate celele inferioare de modificari				

Nr.	Marimea	Cota	Abateri limită nom.	MASURATORII							
				Dimensiuni limită		Limite de control					
				Al	As	Al	As	Li	Ls		
Predarea 1 2019											
Atenție: Piesele placă la client însoțite de 1 file											
5	Diametru Ø25 H7	25.00	±0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04
11	Diametru Ø28 H7	28.00	±0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04
4	Diametru Ø3 ±0.1	3.00	±0.1	0.1	0.200	0.1	0.200	0.1	0.200	0.1	0.200
31	Cota 4.5 ±0.1	4.50	±0.1	0.1	0.200	0.1	0.200	0.1	0.200	0.1	0.200
39	Cota 6.0 ±0.2	6.00	±0.2	0.2	0.400	0.2	0.400	0.2	0.400	0.2	0.400
30	Cota 5 ±0.1	5.00	±0.1	0.1	0.200	0.1	0.200	0.1	0.200	0.1	0.200
27	Cota 6.8 ±0.2	6.80	±0.2	0.2	0.400	0.2	0.400	0.2	0.400	0.2	0.400
42	Diametru Ø32 H7	32.00	±0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04
2	Cota 17 ±0.2	17.00	±0.2	0.2	0.400	0.2	0.400	0.2	0.400	0.2	0.400
10	File M20x1 anterior										
15	Raza R3 ±0.1	3.00	±0.1	0.1	0.200	0.1	0.200	0.1	0.200	0.1	0.200
16	Raza R1 ±0.1	1.00	±0.1	0.1	0.200	0.1	0.200	0.1	0.200	0.1	0.200
18	Raza R3 ±0.1	3.00	±0.1	0.1	0.200	0.1	0.200	0.1	0.200	0.1	0.200
20	Înălțime 30 ±0.1	30.00	±0.1	0.1	0.200	0.1	0.200	0.1	0.200	0.1	0.200
21	Cota 3 ±0.1	3.00	±0.1	0.1	0.200	0.1	0.200	0.1	0.200	0.1	0.200
28	Ra 1.0 μm			1.0	1.600			1.000	1.200		
32	Textură 1 ±0.5°	1.00	±0.5	0.5	0.900	0.5	0.900	0.5	0.900	0.5	0.900
33	Ra 1.0 μm			1.0	1.600			1.000	1.200		
34	Textură 1 ±0.5°	1.00	±0.5	0.5	0.900	0.5	0.900	0.5	0.900	0.5	0.900
35	Ra 1.0 μm			1.0	1.600			1.000	1.200		
36	Raza R0.2 ±0.1	0.20	±0.1	0.1	0.100	0.300	0.125	0.275			
37	Raza R0.1 ±0.1	0.10	±0.1	0.1	0.300	0.500	0.325	0.475			
38	Raza R0.1 ±0.1	0.10	±0.1	0.1	0.300	0.500	0.325	0.475			
39	Raza R0.2 ±0.1	0.20	±0.1	0.1	0.100	0.300	0.125	0.275			
40	Raza R0.1 ±0.1	0.10	±0.1	0.1	0.300	0.500	0.325	0.475			
41	Diametru Ø18 H7	18.00	±0.04	0.01	0.04	0.01	0.04	0.01	0.04	0.01	0.04
43	Cota 1.5 ±0.1	1.50	±0.1	0.1	0.200	0.1	0.200	0.1	0.200	0.1	0.200
19	Diametru la fund Ø16.071 ±0.03	16.071	±0.03	0.01	0.03	0.01	0.03	0.01	0.03	0.01	0.03
17	Cota 26 ±0.2	26.00	±0.2	0.2	0.400	0.2	0.400	0.2	0.400	0.2	0.400
Sectiune C-C											
Pinion DN 54004											
Diametru exterior Ø18.745 ±0.03											
Diametru mediu Ø17.5 ±0.03											
Modul 1.25											
Nr. de dinți Z=14											
Atenție: Grad la dantură											

Another thing therefore considered is the geometrical parameters of the tool. [12] When processing on a classic lathe, the size of the release angle being very large leads to an increase in the compression coefficient of the chip, which will implicitly lead to a decrease in the chipping forces.

In the case of CNC machining, this problem is compensated by using multiple teeth. The number of teeth is currently limited by the tooling stages.

Classic machining is simpler to do but requires a skilled turner, and the quality of the part depends to a large extent on the turner's knowledge and conduct.

The price of the machine is relatively low compared to a CNC. The price of classic tools is relatively low but requires a highly experienced operator to perform the sharpening and maintenance of the tools.

In the case of CNC processing, the time to complete the program is longer, it requires two people: one to complete the program (with a high

level of training) and one to supervise (with an average level of training). The quality of the part does not depend on the operator.

The big problem is also the high cost of the machine, but which is amortized in a very short time due to the high production and productivity.

Another disadvantage is the very high cost of tool holders and cutting tools, but the cost per part made is very low.

The most important problem realized with CNC machining is the very high quality class of the parts made. Currently, in the automotive industry, processing with 3 decimal places is mandatory, impossible to do manually. That is, according to the second processing.

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