Improving Productivity on Working with CNC machine Tools

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Abstract: - In small and medium size production are used CNC machine tools which ensure a very good accuracy and productivity with a high level of flexibility. To obtain the required quality of parts on the CNC machine tools many factors are involved as: manufacturing strategies, cutting parameters, using of combined tools, etc. accuracy of the parts made on CNC machine tools depends on geometry of the active part of cutting tool, stiffness coefficient of machine tool and holding system of part and many other factors.In the paper is presented the influence of changing the insert nose radius on the accuracy of the part which is made on CNC machine tools and the application of the research results on two types of insert size which are used mainly in production of automotive parts.

Key-Words: - productivity, insert nose radius, accuracy, design, linear and circular interpolation

1 Introduction

The computer numerical control lathe is used to perform several operations on different surfaces of the workpieces with complex shapes. Usually these workpieces require a high surface finish and dimensional accuracy. In the program for numerical control are set up for different surfaces different cutting tools with different insert nose radius according with the accuracy that is asked by the technical documentation.

But for different reasons it is happen to work with a cutting tool with other insert nose radius that was set up in the initial machine program. This thing has influence on the dimensional accuracy of the workpiece that can be corrected by the operator to avoid waste parts.

According with the level of the dimensional modifications of the workpiece will be two type of interventions on the machine program. First is the intervention direct on the machine tool panel by the operator and the second is the modifications in the machine program itself when the part accuracy requires it. The influence of these modifications is applied mainly on linear and circular interpolation of the cutting tool trajectory.

In the calculation of the modifications that were needed were taking into account for the tool path the centre of the insert nose radius.

2 Problem Formulation

The modifications which are needed to be done in the machine program when is working with a cutting tool with other insert nose radius that differs from the initial program are shown in Fig.1, where β is the angle of insert shape and K_r is the entering angle.

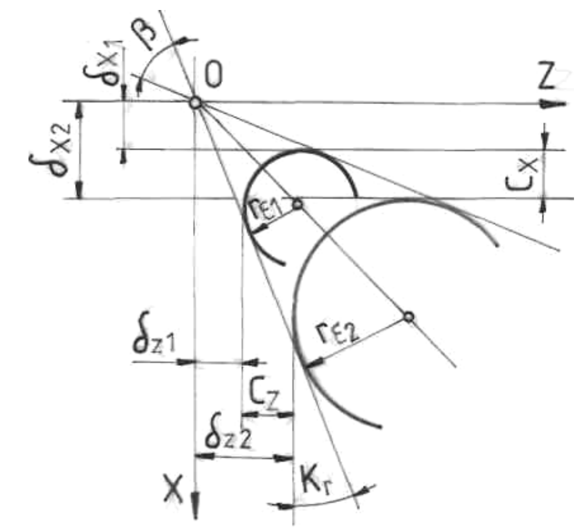


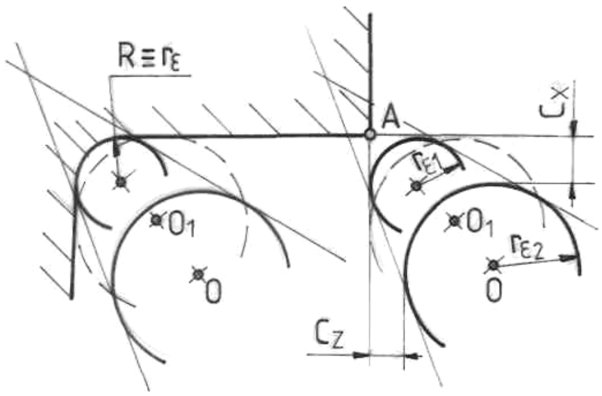
Fig.1 The calculation of the corrections C_x and C_z.

The values of the corrections C_x and C_z which have to be applied directly on the machine tool panel by the operator when is used an insert nose radius rε2 other than rε1 which was in the initial machine program have the next equations [1]:

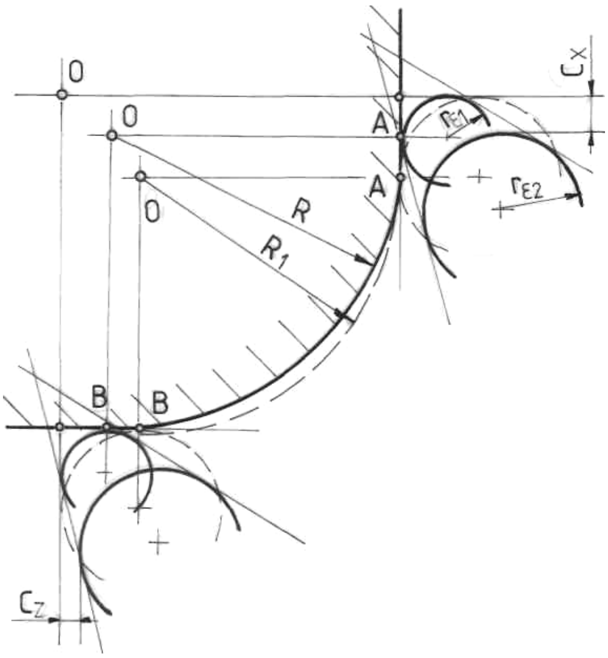
$$C_x = (r_{\varepsilon 2} - r_{\varepsilon 1})(ctg\frac{\beta}{2}\cos\gamma - \sin\gamma - 1), \tag{1}$$

$$C_z = (r_{\varepsilon 2} - r_{\varepsilon 1})(ctg\frac{\beta}{2}\sin\gamma + \cos\gamma - 1), \tag{2}$$

The changing of insert nose radius can have modifications of the part shape as is shown in Fig.2 a and b.



a)



b)

Fig.2 The influence of changing the insert nose radius on the linear dimensions (a) and on the circular dimensions (b).

In Fig.2a is shown the modification of the part radius R according with the new insert nose radius, but other linear dimensions remains unchanged. In Fig.2b it can be seen that the modification of insert nose radius result in the modification of the part radius from R in R_1.

After were made the corrections C_x and C_z to compensate the difference between the insert nose radius in linear interpolation on the part that is machining, appear two deviations A_x and A_z whose values are given by the next equations [1]:

$$A_x = \left(r_{\varepsilon 2} - r_{\varepsilon 1}\right)\left(1 - tg\frac{90^0 - \alpha}{2}\right), \tag{3}$$

$$A_z = \left(r_{\varepsilon 2} - r_{\varepsilon 1}\right)\left(1 - tg\frac{\alpha}{2}\right), \tag{4}$$

where, α is the angle of linear interpolation.

Also in [1] were presented the values of P_{x1}, P_{x2} and P_{z1} and P_{z2} of modifications of the initial machine program to maintain the desired shape of workpiece if after were applied the corrections C_x and C_z the errors which appear are bigger than the part tolerance.

In the case of circular interpolation the corrections Q_x and Q_z that have to be made when is used the insert nose radius $r_{\varepsilon 2}$ instead of $r_{\varepsilon 1}$ are shown in Fig.3, where Δ_r is the difference between $r_{\varepsilon 2}$ and $r_{\varepsilon 1}$.

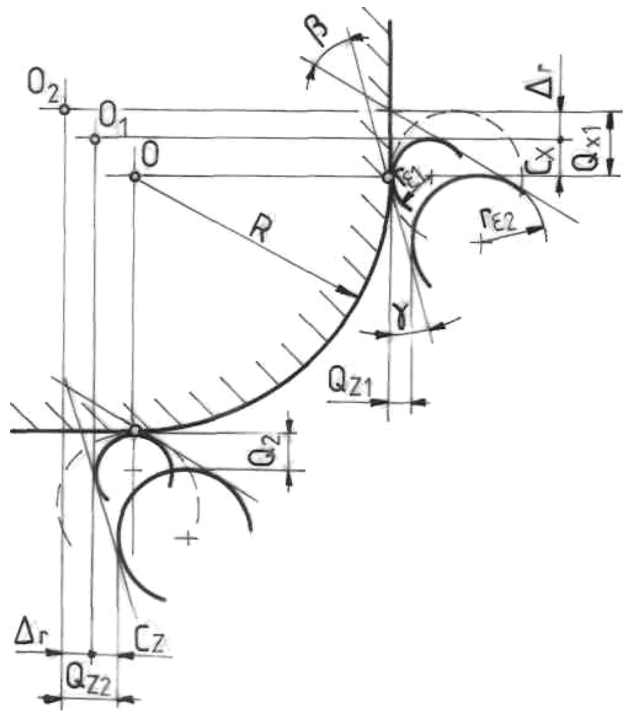


Fig.3 The corrections Q_x and Q_z in the case of circular interpolation.

The corrections Q_x and Q_z are needed to be made to obtain the radius R that is required by the technical drawing.

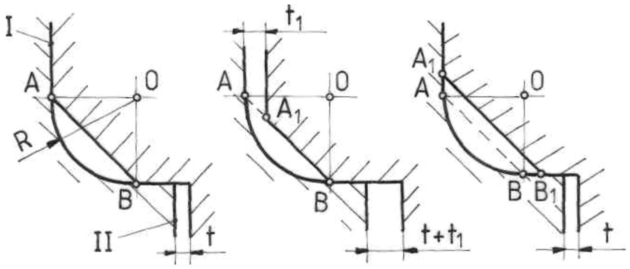
The equations of the corrections C_x and C_z are given below:

$$C_x = (r_{\varepsilon 2} - r_{\varepsilon 1})\left(ctg\frac{\beta}{2}\cos\gamma - \sin\gamma \right), \quad (5)$$

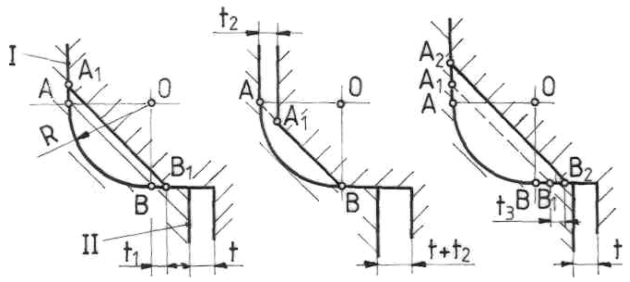
$$C_z = (r_{\varepsilon 2} - r_{\varepsilon 1})\left(ctg\frac{\beta}{2}\sin\gamma + \cos\gamma \right), \quad (6)$$

The value Q_{x1} is the sum of correction C_x and the deviation Δ_r, Q_{x2} is identically with correction C_x, Q_{z1} is identically with correction C_z and Q_{z2} is the sum of correction C_z and deviation Δ_r.

The results of machining with the insert nose radius $r_{\varepsilon 2}$ other than $r_{\varepsilon 1}$ for linear interpolation are shown in Figs.4 a, b.



a)

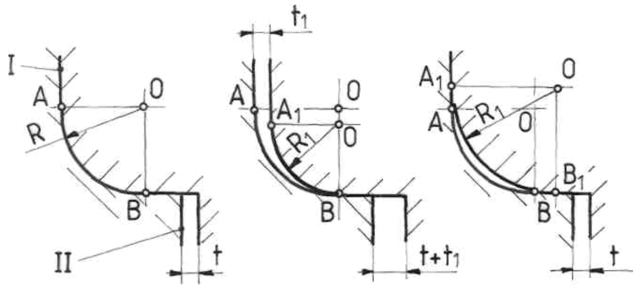


b)

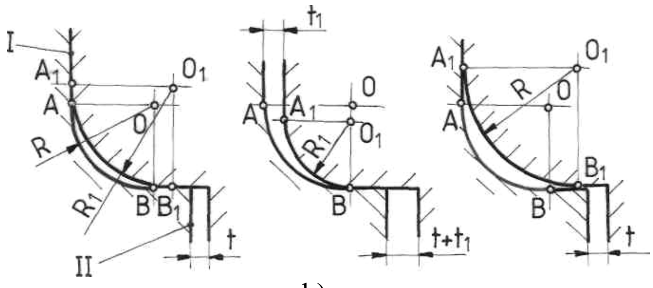
Fig.4 The effect of machining with different insert nose radius in linear interpolation.

In Fig.4a is shown an assembly of two parts, one has a radius *R* and one an inclined surface AB. These parts must have contact on surface I and a little space *t* on surface II. Here the inclined surface has the points A and B in the place where start the radius *R*. If is working with other insert nose radius $r_{\varepsilon 2}$ instead of $r_{\varepsilon 1}$ it is possible to obtain an inclined surface A_1B smaller than AB, or A_1B_1 bigger than AB. In the first case will appear a distance t_1 on the surface I which is not desired and a bigger distance $t+t_1$ on the surface II. This situation is not admitted.
In the second case we have contact on the surface I and the distance *t* remains unchanged. This situation is accepted [3].

In Fig.4b is the situation when the inclined surface AB is bigger than radius *R* as the drawing asked. Also here we can have two cases when is working with the insert nose radius different from that in initial machine program. In the first case the inclined surface obtained A_1B is smaller than AB and appears a distance t_2 on the surface I which is not accepted and a distance $t+t_2$ on the surface II that is not so important. In the second case when the inclined surface A_2B_2 is bigger than A_1B_1 we have contact between two parts on the surface I and the distance *t* on the surface II remains unchanged. This situation is accepted. The inclined surface A_1B_1 can be smaller than in drawing with the distance t_1 till when the assembly is correctly [2].
In Fig.5 is shown the assembly of two parts when both of them has a radius *R* on the surface AB in circular interpolation.
In Fig.5a the two parts have the same radius *R* on the path AB. On the surface I must have contact between them and on the surface II the drawing requires a distance *t*. her appears two cases. In the first case when is working with an insert nose radius $r_{\varepsilon 2}$ other than $r_{\varepsilon 1}$ and the radius obtained is R_1 smaller than *R* , a distance t_1 appears on the surface I which is not accepted and on the surface II the distance between two parts is increased to a value of $t+t_1$.
If the radius obtained R_1 is bigger than *R* as is shown in the second case the situation is accepted on the both surface I and II.



a)



b)

Fig.5 The effect of machining with different insert nose radius in circular interpolation.

In Fig.5b is shown the situation when the two parts have different radius on the contact surface *R* and R_1. In the first case the radius obtained R_1 is smaller than *R*. This situation is not accepted because appears a distance t_1 on the contact surface I and a distance $t+t_1$ on the surface II. If the radius obtained R_1 is bigger than *R* the assembly is working in normal conditions and this situation is accepted.

It is possible to use the results of these researches in making tables with the values of the corrections for linear and circular interpolation when is working with different insert nose radius of different shape of the inserts. These tables are usefully for the operator to make interventions on the machine tool panel or to make modifications in the initial machine program.
An example of using these researches is shown below in the case of working with the insert shape TNMG (Fig.6) and KNUX (Fig.7). Table 1 shows the corrections and deviations values for an insert with triangle shape and the entering angle $K_r = 90^0$.

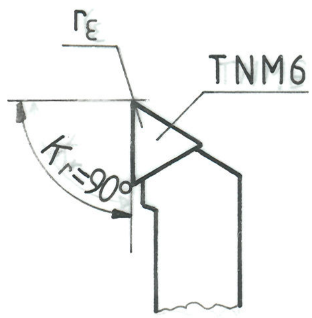


Fig.6 Turning tool with triangle insert shape.

Table 1. Corrections and deviations values for an insert with triangle shape and the entering angle $K_r = 90^0$.

$\Delta_r = r_{\varepsilon 2} - r_{\varepsilon 1}$	$\alpha[^0]$	C_x	C_z	A_x	A_z
0.4	15	0.29	0	0.09	0.35
	30	0.29	0	0.17	0.29
	45	0.29	0	0.23	0.23
	60	0.29	0	0.29	0.17
	75	0.29	0	0.35	0.09
	90	0.29	0	0.40	0
0.8	15	0.59	0	0.19	0.69
	30	0.59	0	0.34	0.59
	45	0.59	0	0.47	0.47
	60	0.59	0	0.59	0.34
	75	0.59	0	0.69	0.19
	90	0.59	0	0.80	0
1.2	15	0.88	0	0.28	1.04
	30	0.88	0	0.51	0.88
	45	0.88	0	0.70	0.70
	60	0.88	0	0.88	0.51
	75	0.88	0	1.04	0.28
	90	0.88	0	1.20	0

Table 2 shows the corrections and deviations values for an insert with rhombic shape special design and the entering angle $K_r = 93^0$.

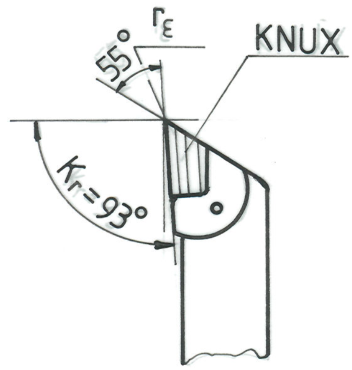


Fig.7 Turning tool with rhombic insert shape.

Table 2. Corrections and deviations values for in rhombic insert shape and entering angle $K_r = 93^0$.

$\Delta_r = r_{\varepsilon 2} - r_{\varepsilon 1}$	$\alpha[^0]$	C_x	C_z	A_x	A_z
0.5	15	0.43	0.05	0.12	0.43
	30	0.43	0.05	0.21	0.37
	45	0.43	0.05	0.29	0.29
	60	0.43	0.05	0.37	0.21
	75	0.43	0.05	0.43	0.11
	90	0.43	0.05	0.50	0
1	15	0.87	0.10	0.23	0.87
	30	0.87	0.10	0.42	0.73
	45	0.87	0.10	0.59	0.59
	60	0.87	0.10	0.73	0.42
	75	0.87	0.10	0.87	0.23
	90	0.87	0.10	1	0

4 Conclusion

The results of this research is usefully in practical applications when is working with different insert nose radius than was in initial machine program.

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