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# The Error Modelling for Rolling Surfaces Generation II. Applications

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**SUMMARY**

*The realization of the profiles, in most cases, is affected by errors which distort the shape and dimensions of the tool's profiles. In this paper, we showed the application of the proposed algorithm for errors modelling in case of generation with rack-gear, gear shaped and rotary cutter tools [1], [2], [4].*

***Keywords:*** *errors, modelling, rolling centroids, the in-plane trajectory method*

## 1. Introduction

The proposed algorithm for errors modelling with specific software, is based by the idea that the software used for tool's profiling may used for the profiling of the piece, knowing the tool's profile, if the generation scheme is reversed [1], [2], [3].

Par example if we know the profile of a rack-gear tool, we can determine the profile of the piece, considering the tool's profile as profile to obtain and applying the software for rotary cutter tool [2], [4].

The software read the file which contained the profile of the tool, known by his point and calculates the piece's profile.

The point belong of the piece are write in a new file. Next this file is read and for each of this point is calculated the distance (fig. 1) from this to the piece's theoretical segment. This distance to the piece's segment is considered as geometrical **deviation** (d) and is calculate with equation (see fig. 1):

$$d=\frac{(Y_A-Y_{Mi})(X_A-X_B)-(X_A-X_{Mi})(Y_A-Y_B)}{(Y_A-Y_B)\sin\beta+(X_A-X_B)\cos\beta}, \quad (1)$$

where

$$\beta=\arctan\frac{|Y_B-Y_A|}{|X_B-X_A|}. \quad (2)$$

If the respective point is inside of the theoretical profile the deviation is considered as positive and if this is outside the deviation is considered as negative.

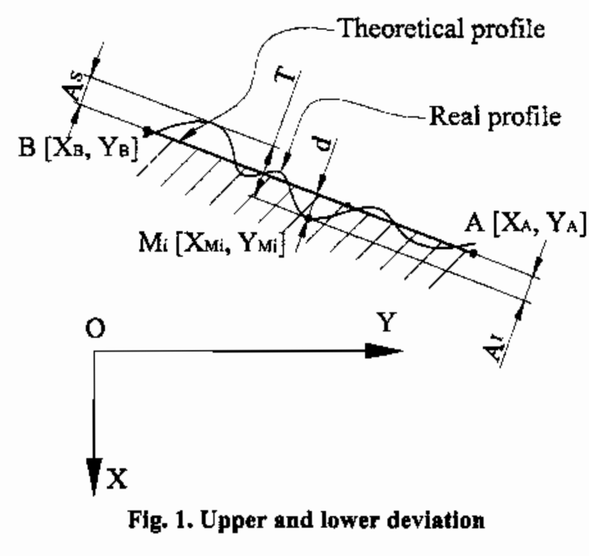


**Fig. 1. Upper and lower deviation**

The maximum value of the deviations is the upper deviation ($A_S$) and the minimum value is the lower deviation ($A_I$). The sum of these two absolute values is considering the tolerance (T) of the obtained profile.

## 2. Error modelling for rack-gear tool

In the following, this algorithm is applied for a spline shaft generated with rack-gear tool.

The geometrical dimensions for this shaft are Re=40 mm, Ri=30 mm, b=5 mm.

In table 1, are showed the theoretical and the real profile of the rack-gear tool.

**Table 1.**

| Theoreatical rack-gear | | Real rack-gear | |
|---|---|---|---|
| ξ [mm] | η [mm] | ξ [mm] | η [mm] |
| 14.7593 | 13.3238 | 13.4495 | 12.7106 |
| 13.6617 | 12.3547 | 12.4359 | 11.7768 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| 7.81738 | 8.13902 | 7.0737 | 7.70787 |
| 6.58843 | 7.44561 | 5.95721 | 7.03571 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| 0.47992 | 5.09113 | 0.51807 | 4.68418 |
| -3E-05 | 5.01311 | 0.07328 | 4.57841 |

In table 2, are showed the points of the piece profile obtained with the real tool and the distance from these points to the theoretical piece's profile (see fig.2).

**Table 2.**

| Theoretical piece's profile | Real piece's profile | | Deviation [mm] |
|---|---|---|---|
| | X [mm] | Y [mm] | |
| $X_A$=-29.5804 mm<br>$Y_A$=5 mm<br><br>$X_B$=-39.6863 mm<br>$Y_B$=5 mm | -29.953 | 5.40968 | **0.40968** |
| | -30.356 | 5.37439 | 0.37439 |
| | -30.76 | 5.33908 | 0.33908 |
| | -31.163 | 5.30375 | 0.30375 |
| | -31.567 | 5.26847 | 0.26847 |
| | -31.97 | 5.23314 | 0.23314 |
| | -32.374 | 5.19785 | 0.19785 |
| | -32.778 | 5.16251 | 0.16251 |
| | -33.182 | 5.12717 | 0.12717 |
| | ⋮ | ⋮ | ⋮ |
| | -36.821 | 4.80871 | -0.19129 |
| | -37.227 | 4.77322 | -0.22678 |
| | -37.633 | 4.7377 | -0.26230 |
| | -38.039 | 4.70215 | -0.29785 |
| | -38.446 | 4.66654 | -0.33346 |
| | -38.853 | 4.63089 | -0.36911 |
| | -39.26 | 4.5952 | -0.40480 |
| | -39.667 | 4.55962 | **-0.44038** |

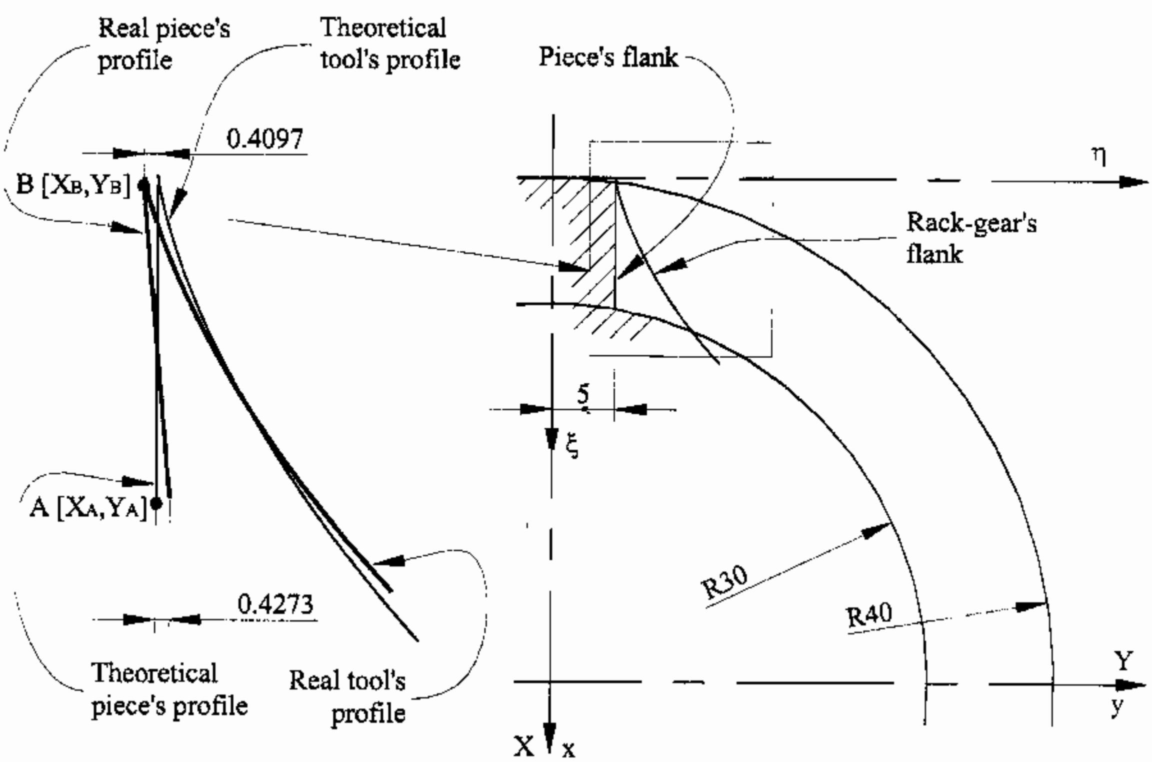


**Fig. 2. Theoretical and real profile for rack-gear tool**

Figure 3 showed the message obtained from the software in order to demonstrate the concordance between the software's result and the values of modelling

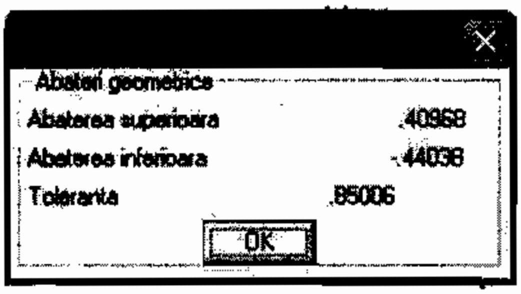


**Fig. 3. The result obtained by software**

## 3. Error modelling for gear-cutter tool

The algorithm for errors modeling is applied for a squared bush generated with gear-cutter tool.

The geometrical dimensions for this bush are a=56,5685 mm, $R_{RP}$=40 mm, $R_{RS}$=30 mm.

In table 3, are showed the theoretical and the real profile of the rack-gear tool.

**Table 3.**

| Theoretical gear-cutter | | Real gear-cutter | |
|---|---|---|---|
| ξ [mm] | η [mm] | ξ [mm] | η [mm] |
| -15.00002 | 25.98080 | -17.40668 | 26.52434 |
| -15.55056 | 23.81426 | -17.77727 | 24.25421 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| -18.16365 | 5.10716 | -18.65681 | 5.20416 |
| -18.24094 | 3.06330 | -18.53862 | 3.15942 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| -15.55056 | -23.81426 | -13.37357 | -23.16995 |
| -15.00002 | -25.98080 | -12.64914 | -25.23030 |

In table 4, are showed the points of the piece profile obtained with the real gear-cutter tool and the distance from these points to the theoretical piece's profile (see fig. 5).

**Table 4.**

| Theoretical piece's profile | Real piece's profile | | Deviation [mm] |
|---|---|---|---|
| | X [mm] | Y [mm] | |
| $X_A$=-28.2843mm $Y_A$=28.2843mm $X_B$=-28.2843mm $Y_B$=-28.2843mm | -30.5522 | 25.92251 | **2.26793** |
| | -30.35501 | 23.66866 | 2.07074 |
| | ⋮ | ⋮ | ⋮ |
| | -28.58053 | 3.38639 | 0.29626 |
| | -28.38333 | 1.13243 | 0.09906 |
| | ⋮ | ⋮ | ⋮ |
| | -26.01643 | -25.92148 | -2.26784 |
| | -25.81917 | -28.17627 | **-2.46510** |

In figure 4, is showed the message obtained as result of the software.

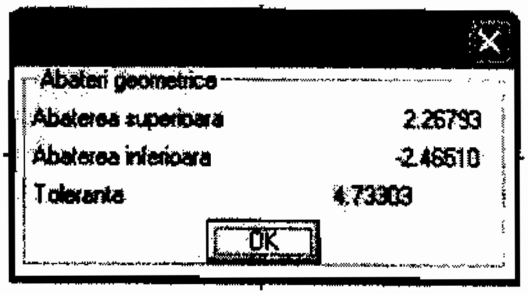


**Fig. 4. The result obtained by software**

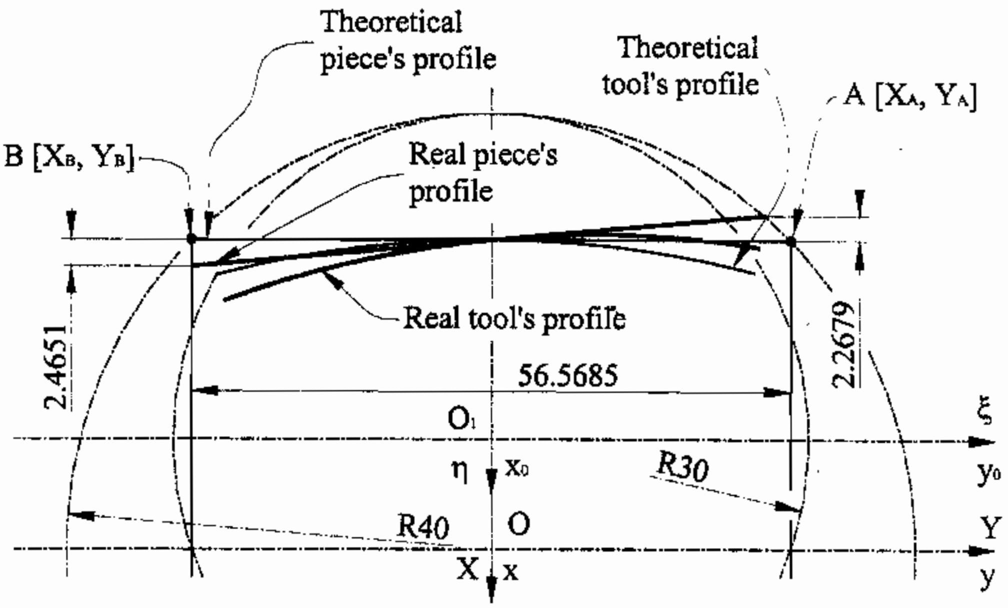


**Fig. 5. Theoretical and real profile for gear-cutter tool**

## 4. Error modelling for rotary cutter tool

In the following this algorithm is applied for a trapezoidal thread generated with rotary cutter tool.

The geometrical dimensions for this thread are h=10 mm, $R_{RS}$=40 mm., α=45°.

In table 5, are showed the theoretical and the real profile of the rack-gear tool.

**Table 5.**

| Theoretical rotary cutter's profile | | Real rotary cutter's profile | |
|---|---|---|---|
| ξ [mm] | η [mm] | ξ [mm] | η [mm] |
| -43.47878 | -4.17557 | -43.07797 | -4.35920 |
| -42.66222 | -3.05495 | -42.37014 | -3.21612 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| -39.57584 | 0.41529 | -39.61307 | 0.45208 |
| -39.29334 | 0.68225 | -39.35386 | 0.74512 |
| ⋮ | ⋮ | ⋮ | ⋮ |
| -36.78910 | 2.74028 | -36.99765 | 3.08695 |
| -36.51797 | 2.93209 | -36.73555 | 3.31500 |

In figure 6, is showed the message obtained as result of the software for generation with rotary cutter tool.

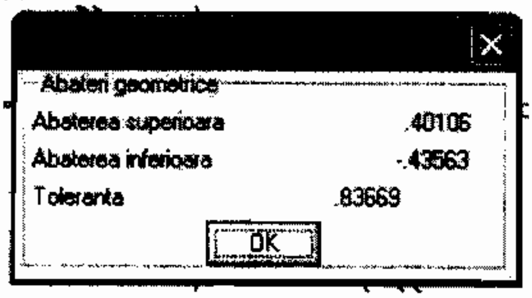


**Fig. 6. The result obtained by software**

In table 6, are showed the points of the piece profile obtained with the real tool and the distance from these points to the theoretical piece's profile (see fig.7).

**Table 6.**

| Theoretical piece's profile | Real piece's profile | | Deviation [mm] |
|---|---|---|---|
| | X [mm] | Y [mm] | |
| $X_A$=3.5355 mm<br>$Y_A$=3.5355 mm | 2.95781 | 3.525 | **0.401064** |
| | ⋮ | ⋮ | ⋮ |
| $X_B$=-3.535 5mm<br>$Y_B$=-3.5355 mm | 0 | 0 | 0 |
| | ⋮ | ⋮ | ⋮ |
| | -3.21269 | -3.82876 | **-0.43563** |

In figure 7, is showed the theoretical and the real tool and pieces profile modeled with the software.

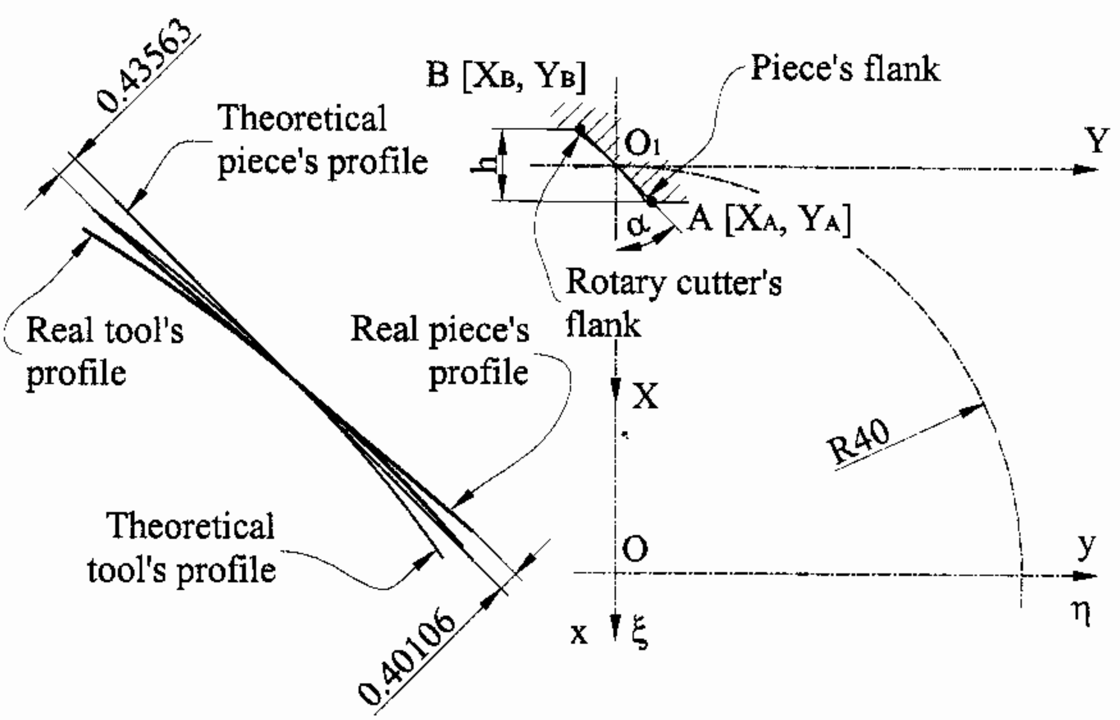


**Fig. 7. Theoretical and real profile for rotary cutter tool**

## 5. Conclusions

The algorithm for the error's modeling can be used to appreciate the value of the deviations due of the tool's profile.

The simulation of the generating process bring that the results obtained with the software are in concordance with the real values.

We note that, due of the calculus scheme of this software, the last point of the real profile can't be calculated in this way and the deviation of this point isn't represented.

However, for a big enough number of points, regarding the continuous shape of the profile, this deviation may be reduced enough to be ignorable.

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## Rezumat


Realizarea profilurilor sculelor achietoare, în cele mai multe cazuri, este afectată de erori care denaturează forma şi dimensiunile profilurilor sculelor.

Ca urmare, o primă posibilitate de generare eronată a suprafeţelor obţinute prin înfăşurare (şi nu numai) este datorată erorii geometrice a profilului efectiv al sculei.

Acestei erori îi sunt suprapuse, însumându-se vectorial, şi erori de altă natură datorate procesului efectiv de generare, erori ale maşinii-unelte, erori de reglare etc.

Ca eroare fundamentală, eroarea geometrică poate conduce singură, în unele cazuri, la erori de formă şi dimensionale suficient de mari ale suprafeţei de generare aşa încât acestea să depăşească toleranţele admise.

Astfel, modelarea numerică a erorii geometrice datorate muchiilor aşchietoare ale sculelor poate constitui o modalitate de apreciere a nivelului de eroare teoretic, cu care se va putea genera suprafaţa de prelucrat.


## Résumé


La realization des profiles des outils est dans le majorité des cases, affecté par erreurs qui on peut dénaturer la forme et les dimensions du profile d'outil.

Donc, uné erreur importante des sourfaces obtenu par roulagé est en raison de l'erreur géométrique du profil d'outil.

A cette erreur il s'ont additionner erreurs d'autre nature, causait par le procesus du execution.

Comme erreur fondamental, l'erreur géométrique peut conduire a l'erreurs de forme et dimensions, suffisant pour excéder les tolérances.

La simulation numerique d'erreur géométrique peut etre uné maniére d'évalution pour le niveau théorique du precision pour la sourface de génération.