THE ANNALS OF “DUNĂREA DE JOS” UNIVERSITY OF GALAȚI
FASCICLE V, TECHOLOLOGIES IN MACHINE BUILDING, ISSN 1221-4566
2007

Identification of the Composite Surfaces with the Application to the Casting and Deep Drawing Dies

A. Epureanu, F. Susac, I. Constantin,
F. Buruiana, M. Banu

University "Dunarea de Jos" of Galati, Faculty of Mechanical Engineering, 800201 Galati, Romania

ABSTRACT

This article proposes a new method for the generation of concave casting surfaces of the dies for the casting parts, which in most of the cases, are very complex. This proposed method is designed to improve the accuracy of the casting dies manufacturing in order to avoid future corrections. Generation of the die surface is based on a polynomial equation having two variables – x, y. For each known values of x and y we will obtain z coordinate of each point on the concave die surface.

Keywords: *composite surfaces, generation algorithm, casting part, analytical solution*

1. Introduction

Die-casting is similar to permanent die casting except that the metal is injected into the die under high pressure of 10-210MPa. This results in a more uniform part, generally good surface, finished and with good dimensional accuracy. For many parts, post-tooling must be totally eliminated, or very light tooling may be required to bring dimensions to size [1].

From a design point of view, it is the best to design parts with uniform wall thicknesses and cores of simple shapes. Heavy sections cause cooling problems, trapped gases causing porosity. All corners should be radiused generously to avoid stress concentration.

2. Analytical generation of the complex surface

Cast manufacturing concerned some disadvantages, as cast dimensional accuracy, which is generally reduced than in the case of parts obtained throught other processes.
Abidance of the parts and the part shape parameters (liniar and angular) is an essential condition for their quality. There is no possibility to obtain the dimensions which define the part geometry for their nominal value (theoretical value) because of the fabrication and measurement errors. Only a dimension with an approximate accuracy toward the nominal specified dimension can be realized with technological processes. Also, measurement methods don't allow an accuracy measurement because of the control or reading information errors, or because of the measuring apparatus errors, and because of the processed surface relief or because of the other reasons [2].

From this point of view it can be distinguished:
- the accuracy of the casting macrogeometry which refers to:
  - dimensional accuracy;
  - shape accuracy;
  - various geometrical elements position accuracy;
  - waves.
- the accuracy of the casting microgeometry which refers to:
  - surface roughness.

The dimensional accuracy consists in obtaining the dimensions between some limits imposed by the condition that, the characterized quantity by this dimension, to comply with the functional purpose.

The geometric shape accuracy consists in accurate generation of the entire surfaces which define the casting.

In the casting process, there is not generated one or more surfaces of the part like in the cutting or plastic deformation processes (partial), but there are generated all surfaces simultaneous. In this case, it can be considered that the casting has an unique surface, very complex and shuted, which is the result of an unique generation process, with an unique set of process parameters.

In the casting, there isn't any reference surface (locating surface, niping surface) which helps to fix the blank and to measure the part. In this case, the only reference surface which we dispose it is the surface of the concave die, because relatively we can analyse the casting surface. The concave die shape is considered to be programmed surface and the part surface is considered to be real surface. The difference between this two surfaces representes the process error, because it is generated by the physical phenomena, which appears during the process (thermal deformation, elastic deformation, cast seams and wears).

$$f\left(x_{i_{real}}, y_{i_{real}}\right) = Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J = z_i \quad (1)$$

If the derivative of the equation (1) is calculated with respect to every unknown quantity, which are *A, B,..., J,* we obtained the following linear system with nine equations and nine unknown quantities.

Using the Gauss's method we solved the system (2) and calculated the unknown quantities, which differ from a surface to other.

The casting surface is smoothed in every point, the function that describes the geometry is continuous and twice derivative.

In the paper it is proposed to determine the mathematical model for concave die surface generation for the model presented in figure 1.

It is assumed that the casting part is measured using a reconfigurable articulated arm, and consequently, the concave die surface for the measured casting part, presented in the figure 1, can be described by $M_i\ (x_i,y_i,z_i)$ points.

We presume that the surface can be analytical simulated with an polynom of n degree, in the coodination system (x,y,z), and the analytical form is as following:

$$f(x,y) = Ax^2y^2 + Bx^2y + Cx^2 + Dxy^2 + Ey^2 + Fxy + Gx + Hy + J$$

$$z = f(x,y)$$

$$F(x,y,z) = 0$$

$$\sum_{i=1}^{n}(z_{calc} - z_{mas})^2 \Rightarrow eroare$$

$$f(x,y) = Ax^2y^2 + Bx^2y + Cx^2 + Dxy^2 + Ey^2 + Fxy + Gx + Hy + J - z = 0$$

In our case, their values are: *A = 3,3647·10⁻⁷*

$$\begin{cases}
2\sum_{i=1}^{n}\left(Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J - z_i\right)\cdot x_i^2y_i^2 = 0 \\
2\sum_{i=1}^{n}\left(Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J - z_i\right)\cdot x_i^2y_i = 0 \\
2\sum_{i=1}^{n}\left(Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J - z_i\right)\cdot x_i^2 = 0 \\
2\sum_{i=1}^{n}\left(Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J - z_i\right)\cdot x_iy_i^2 = 0 \\
2\sum_{i=1}^{n}\left(Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J - z_i\right)\cdot y_i^2 = 0 \\
2\sum_{i=1}^{n}\left(Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J - z_i\right)\cdot x_iy_i = 0 \\
2\sum_{i=1}^{n}\left(Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J - z_i\right)\cdot x_i = 0 \\
2\sum_{i=1}^{n}\left(Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J - z_i\right)\cdot y_i = 0 \\
2\sum_{i=1}^{n}\left(Ax_i^2y_i^2 + Bx_i^2y_i + Cx_i^2 + Dx_iy_i^2 + Ey_i^2 + Fx_iy_i + Gx_i + Hy_i + J - z_i\right)\cdot 1 = 0
\end{cases} \quad (2)$$

The unknown quantities coefficients of the system are given in tabel 1.

For each pair of coordinates (x_i,y_i) measured with reconfigurable articulated arm, it can be calculated z_i coordinate of M_i respective point.

Tabel 1. The unknown quantities coefficients in the liniar system

T Ec	1	2	3	4	5	6	7	8	9	Termen liber
1	x^4y^4	x^4y^3	x^4y^2	x^3y^4	x^2y^4	x^3y^3	x^3y^2	x^2y^3	x^2y^2	x^2y^2z
2	x^4y^3	x^4y^2	x^4y	x^3y^3	x^2y^3	x^3y^2	x^3y	x^2y^2	x^2y	x^2yz
3	x^4y^2	x^4y	x^4	x^3y^2	x^2y^2	x^3y	x^3	x^2y	x^2	x^2z
4	x^3y^4	x^3y^3	x^3y^2	x^2y^4	xy^4	x^2y^2	x^2y^2	xy^3	xy^2	xy^2z
5	x^2y^4	x^2y^3	x^2y^2	xy^4	x^4	xy^3	xy^2	x^3	y^2	y^2z
6	x^3y^3	x^3y^2	x^3y	x^2y^3	xy^3	x^2y^2	x^2y	xy^2	xy	xyz
7	x^3y^2	x^3y	x^3	x^2y^2	xy^2	x^2y	x^2	xy	x	xz
8	x^2y^3	x^2y^2	x^2y	xy^3	Y^3	xy^2	xy	y^2	y	yz
9	x^2y^2	x^2y^1	x^2	xy^2	y^2	xy	x	y	1	z

3. Experimental results

In this paper, the analytical solution for the surface of the concave die destined to the casting part presented in figure 1 was determined by calculation of the z_i coordinates for 398 equally spaced points, picked-up from the real surface of the casting part by discrete measuring.

Fig.1. Casting part

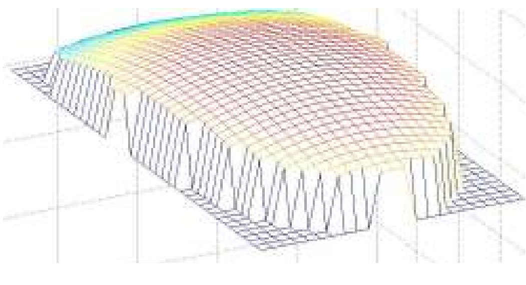

Fig.2. Representation of the discrete surface obtained following generation of the analytical solution

This analytical solution is used in the designing phase of the casting processes, in order to generate the CAD surface. Moreover, the mashining of the concave surface of the casting die is carried out through the CNC manufacturing that requests the discrete surface of the part. By analytical description of the casting part, the programming of the CNC machine become very easy task and the task of the CNC user is easier. This type of surface generation is suitable for description of the very complex surfaces – named as composite surfaces, and eliminats the error of the designing because it starts from the real surface. The error that usually occur between the target surface and the programmed surface are eliminated. The analytical solution gives very good results in
comparison to the real surface. In fig. 2 it is presented the discrete surface obtained by solving the equation system 2. This method can be applied independent of the complexity of the surface, dur to the simplicity of the polinomial function that describes the surface.

4. Conclusions

In this paper, an algorithm for obtaining the discrete surface of the complex parts is proposed and applied to the casting parts with the target of casting die designing. The complexity of the casting dies generated by the continuing improving of the geometry of the parts become an easy task due to the simplicity of the analytical solution that uses a plynomial function of n degrees.

The application was done for a casting part presented in figure 1 and the results of the analytical solution are presented in fig. 2. Between the target surface and the designed surface it is a very good correlation, that is verified by differentiating the maeasured z coordinates of the points on the real surface (fig. 1) with the calculated values (fig. 2). This algorithm could be applied to any complex surface of the dies named composite surfaces.

Aknowledgements

The research was carried out within National Research Contracts CEEX no. 22/2005 and CNCSIS no. 520/2007 financed by the Romanian Ministry of Education and Research.

References

1. **Chira, L. Sofroni, V. Brabie** – *"Procedee speciale de turnare"*, Editura Didactică şi Pedagogică, Bucureşti, 1980.

2. **L. Stoian, A. Palfalvi, N. Vintilă, A. Maniu** – *"Tehnologia materialelor"*, Editura Didactică şi Pedagogică, Bucureşti, 1980.

3. **Taqui Shaik, Zulfiqar Khan, Brian Lehaney** – *„Improving cost model development process using advanced data generation and data analysis"* Int. J. of Networking and Virtual Organisations 2007 - Vol. 4, No.3 pp. 280 - 289.

4. **Chongdu Cho, Woojung Kim, Bonghak Choi, Siyoung Kwak, Qiang Pan** – *„A finite element mesh management in casting simulation"*, Int. J. Of Computational Materials Science and Surface Engineering 2007 – Vol. 1, No. 1 pp. 4 - 17.

5. **Leszek A., Dobrzanski, Mariusz Krupinski, Jerry Sokolowski, Piotr Zarychta** – *„The use of neuronal networks for the classification of casting defect"* Int. J. Of Computational Materials Science and Surface Engineering 2007 – Vol. 1, No. 1 pp. 18 - 27

Identificarea suprafețelor compozite cu aplicații în cazul matrițelor de turnare şi ambutisare

Rezumat

Articolul propune o nouă metodă de generare a suprafețelor formelor de turnare a pieselor turnate, care, în cele mai multe cazuri, sunt foarte complexe. Metoda prezentată are ca scop obținerea de piese turnate de o precizie foarte mare şi care să nu mai necesite prelucrări ulterioare. Metoda are la bază o ecuație polinomială cu două variabile – x, y şi pentru orice valori cunoscute x şi y, vom obține coordonata z corespunzătoare fiecărui punct de pe suprafața formei de turnare.

Identifizierung der Zerlegbaren Oberflächen mit dem Aplication zu dem Das Gussteil stirbt und dem Tiefe Zeichnung Stirbt

Zusammenfassung

Dieser Artikel schlägt eine neue Methode für die Generation von zerlegbaren Oberflächen für die sich werfenden Teile vor, die in den meisten Fällen, sehr kompliziert sind. Diese Zweck-Methode wird dafür entworfen sich zu verbessern die Genauigkeit des Formstücks stirbt, um zukünftige Korrekturen zu vermeiden. Die Methode beruht auf einer polynomischen Gleichung, die zwei Variablen hat x, y. Für jeden bekannte Werte von x und y werden wir vorherrschen Z-Koordinate jedes Punkts auf dem Kasten formen Oberfläche.