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GEOMETRIC RECONFIGURATION OF THE MULTIPOINT FORMING DIES USING REVERSE ENGINEERING

Viorel Paunoiu, Virgil Teodor

Dunarea de Jos University of Galati, Manufacturing Science and Engineering Department, Romania
email: viorel.paunoiu@ugal.ro

ABSTRACT

Forming with reconfigurable multipoint dies is a flexible manufacturing stamping technology which it uses discrete punches to materialize the continuous 3-D surface of the active working surfaces. In the paper is presented a method for geometrical reconfiguration of the multipoint die based on reverse engineering and finite element analysis. By combining these techniques, the method assures the virtual compensation of the springback in multipoint forming and could be applied in practice.

KEYWORDS: multipoint forming, reverse engineering, modelling, FEM

1. INTRODUCTION

The reconfigurable multipoint forming (RMPF) is a flexible sheet metal manufacturing method used in small batch production. The technology is known also as MPF - Multipoint Forming [6, 7, 9, 10, 15] or DDF - Digitized Die Forming [1-3].

In this manufacturing method a pins matrix approximate the continuous active surfaces of a conventional die. In the pins matrix each pin is vertically aligned according with the part geometry.

In this context controlling the height of each pin is one of the main technological problems which assures the geometry of the part and avoids in general the dimpling phenomenon when RMPF without interpolator is applied. The network of small dimples (Fig. 1) affects the surface quality, mainly if such type of parts are used in automotive and aeronautical industry for exterior parts or in medicine.

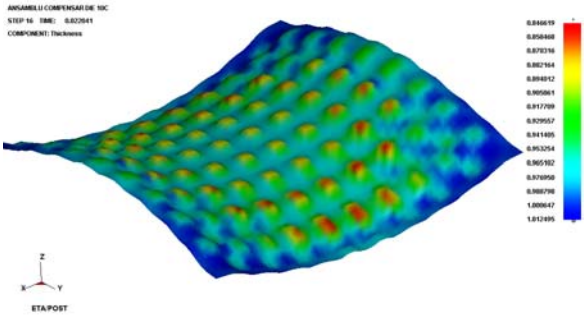

Fig. 1. Dimple phenomenon in RMPF

For other applications such as in civil and industrial construction, architecture and shipbuilding the appearance of such dimples is not the main problem. In these cases the problem of springback is more important and must be compensated.

To compensate for springback different algorithms could be applied.

In the paper a reconfigurable scheme and a method for smoothing the RMPF surface is presented. The examples presented above are applications of the scheme and method proposed.

2. CORRECTION OF THE ELASTIC SPRINGBACK

In order to correct the elastic springback of the part is necessary to determine the value of this springback in some points on the deformed surface of piece.

Due of the dimpling the nominal and real piece's surfaces, calculated by FEM software, need to be smoothed as it will be presented in the next chapter.

It must notice that in double curved application, the surfaces obtained are smaller on *X* and *Y* direction that the dimension need to calculate the pin position and is necessary to extend these surfaces on both direction in order to calculate the pin position on the external rows and columns. This extension not affects the final calculation because it was used the same function as for smoothness.

After these it is established the distance between the nominal piece's surface and the surface after springback, along the normal at the surface, in all the nodes give by the analyses software.

It will be reconstruct another target surface deformed regarded the nominal surface with these distances but considered in the opposite sense along the normal. This target surface will be regarded as a new nominal surface and the pin positions will be calculated for this new surface.

The nodes positions of the new target surface are calculated with:

$$X_n = 2 \cdot X_t - X_r; \quad Y_n = 2 \cdot Y_t - Y_r; \quad Z_n = 2 \cdot Z_t - Z_r, \tag{1}$$

where index n reefers to the new target surface, index t reefers to the theoretically surface and the index r reefers to the real surface after spring back calculation.

The FEM analyse will be resumed until the springback surface is closed enough to the nominal surface to be technically acceptable.

The workflow of this algorithm is presented in figure 2.

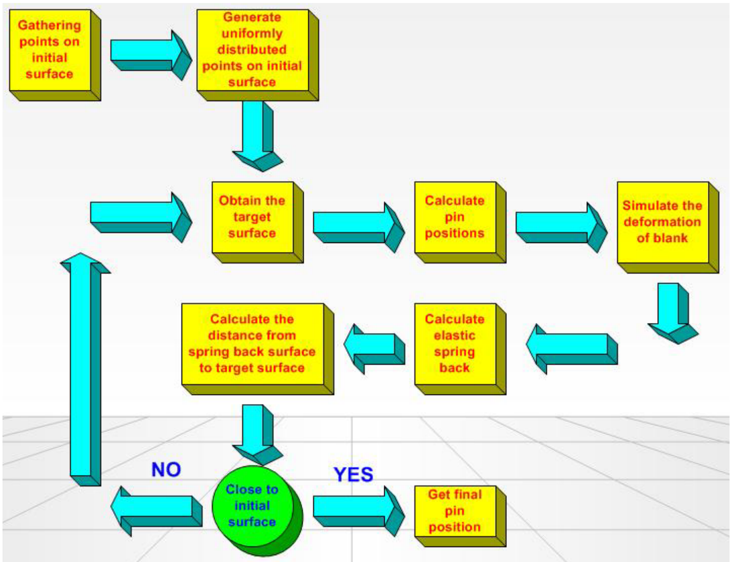

Fig. 2. Algorithm's workflow

3. GEOMETRIC RECONFIGURATION ALGORITHM

The first step is to measure the obtained surface and to determine the theoretically surface. By points measuring we obtain an unevenness points cloud. In order to determine the theoretically surface we use the MatLab program which, based on its capabilities, allow obtaining a mesh with points uniformly distributed (see Fig. 3).

In following we use this meshed surface to determine the pin position for the deformation of the blank.

Due of the dimpling effect, the meshed surface will be not a smooth surface and will have unevenness which dramatically affect the model of surface to be obtained.

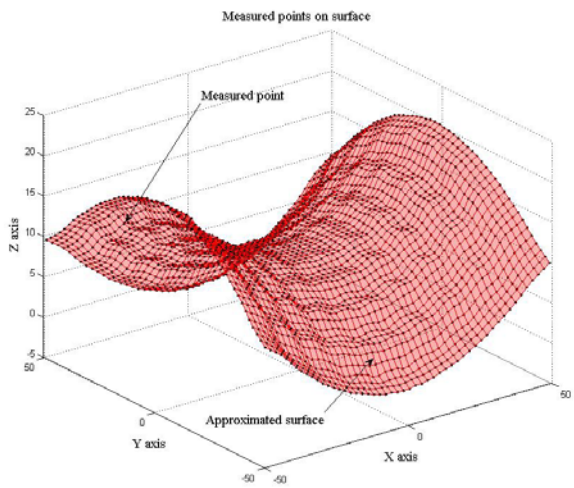

Fig. 3. Measured points and approximated surface

In order to correct the dimpling the model of surface need to be smoothed. Depending of the surface form it will be selected one of the MatLab functions for curve fitting and this function will be applied on the rows (X direction) and columns (Y direction) of the mesh to calculate the value on Z direction (Figs. 4 and 5). We make the notice that the smoothing on only one direction is not enough to obtain a good model.

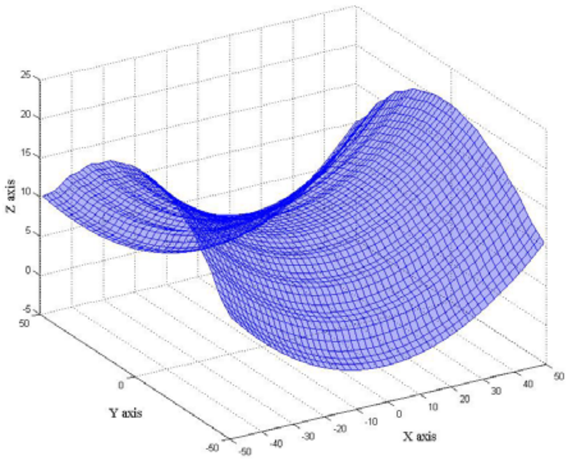

Fig. 4. Smoothed surface on one direction

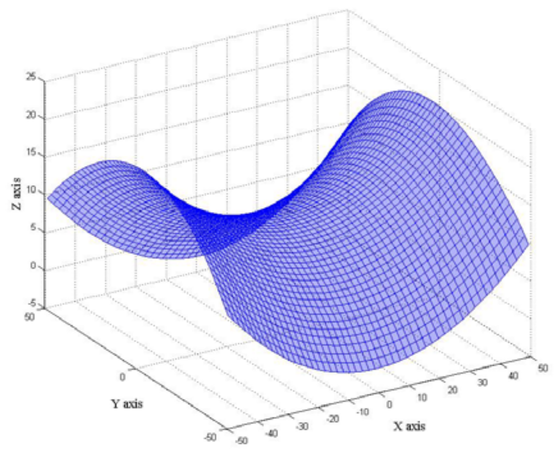

Fig. 5. Smoothed surface on two directions

On each of the mesh node is calculated with MatLab program the normal direction at the surface. We have to calculate two thus equidistant corresponding to the upper and lower half-die.

With MatLab capabilities is generate two new surfaces (S_{US} and S_{LS}) overlapped to surfaces S_U and S_L, with nodes at even pitch on x and y directions.

The calculus is presented in [16].

3.1. Numerical example

To proof the method we apply this algorithm to a surface with equations:

$$\frac{x^2}{a^2} - \frac{y^2}{b^2} - 2 \cdot z = 0 \qquad (2)$$

where a=8; b=8.

The pin radius is $R = 10\sqrt{2}$ mm and the blank thickness is g=1mm.

The surfaces have dimensions 200x200 mm[2] and the pin grid is formed by 10x10 pin, with distance between ball ends of pin 10 mm.

For surface smoothing we use the polynomial approximation with a quadric polynomial on form:

$$Z_i = p_1 \cdot X_i^2 + p_2 \cdot X + p_3, \qquad (3)$$

where p_1, p_2 and p_3 are the polynomial coefficients calculated by MatLab software for each row of the coordinates array.

The measured points and the approximated curve for the middle row of the coordinates array are presented in Fig. 6.

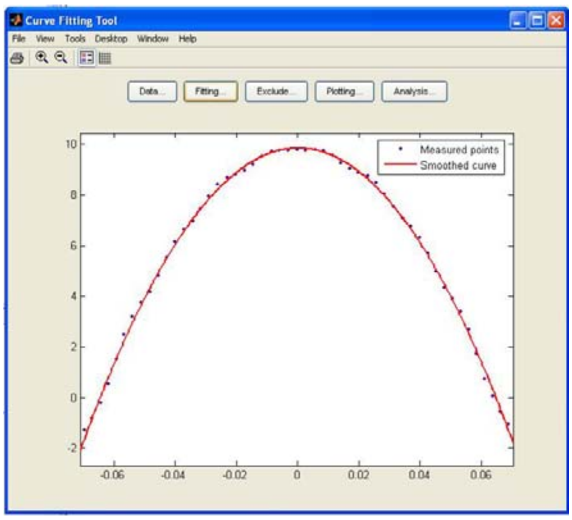

Fig. 6. Measured points and their approximation

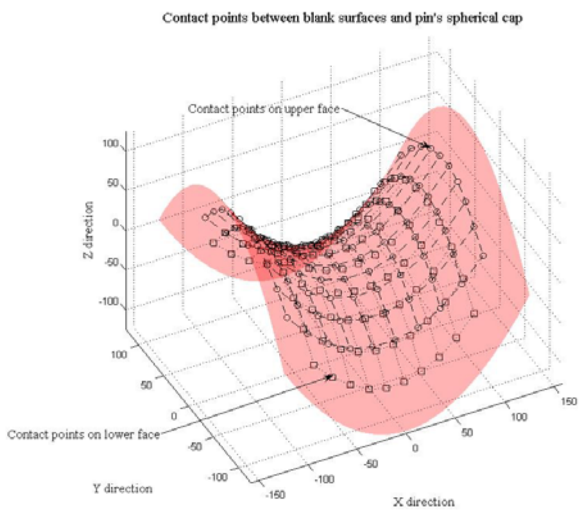

Fig. 7. Contacts points on the approximated surface

The contacts points between the pins and the approximated surface are presented in Fig. 7. The figure presents a rapid method for checking the calculated contacts points.

4. CONCLUSIONS

This paper presents a scheme for springback calculation and an algorithm for reconfigure the pins matrix. The algorithm is useful in the case of deformation without interpolator where the localized deformation reduced the surface quality of the part due to the presence of dimpling. The algorithm will be further applied for smoothing the deformed surface in order to apply the proposed springback scheme.

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