Development of a New Approach for Calculating 3d Manufacturing Tolerances under the Random Dispersion Constraint

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Abstract - *This paper presents a new approach for calculating 3D manufacturing tolerances under the random dispersion constraint. An experimental study was carried out for the calculation of the geometrical defects of the table and the choice of an optimal isostatic position. These results were used for the determination of rotation deviations (ALPHA, BETA, GAMMA) and translation deviations (U, V, W) under the small displacement torsor method. finally, a 3DMATOL tool has been developed for the automatic generation of manufacturing tolerances for nominal dimensions along the three X, Y and Z axes.*

Keywords—*Tolerance , 3D, Error, Manufarturing, Random Dispersion*

I. Introduction

The study of the generated defects on manufactured parts shows the difficulty to maintain parts in their positions during the machining process and to estimate them during the pre-process plan.
Several studies have been devoted to tolerancing problems in the design and manufacturing, Bourdet [1] has developed a computational model of tolerance unidirectional based on machining dispersions. Thimm [2] has proposed rules for 3D tolerance transfers. Jayaratnan [3] has developed VBR (Virtual Boundary Requirements), an approach seeking to translate geometric tolerance into a mathematical form. Romulus [4] proposed a calculation method for the three-dimensional analysis of tolerances by considering the main dispersions of the processes and the errors due to the machine tool. Cheikh [5] developed a modeling of the optimization of functional tolerances by the dispersion method. Wei [6] presented a study Study on general analytical method for CNC machining the free-form surfaces . Mojtaba [7] proposed resolution methods associated with the Model of Manufactured Part (MMP) model developed by Vignat and Villeneuve.The work of [8] is to study the influence of the systematic dispersion on manufacturing tolerances. Sebaa [9] proposed a mathematical model to calculate the distribution of Fulcrums. Rahou [10] developed a Modeling of Machining Errors on the NC Machine Tool. Messaoud [11] has developed a new method for the optimization of manufacturing errors under the six sigma constraint. G. Fu et al [12] presented a new automatic modeling of single geometric error component based on F test and error compensation in five axis machine .A. W. Khan and W. Chen [13] proposed a method for systematic geometric errors compensation in five axis machine tools, the developed technique is based on the table errors, which are modeled by using HTM, then removing the machine errors and reproducing new NC code. C. Zhang et al [14] studied the thermal errors due to environmental temperature variation; the thermal error transfer function of the machine obtained by using heat transfer mechanism was used to develop a thermal error model.

II. Experimental Study

The purpose of this step is determining the optimal position isostatic. To achieve this objective, a series of 100 tests for measuring defects in positioning load by varying the distance between the normals on a gauge block of dimensions 100 x 35 x 9 mm was done (figure 1).

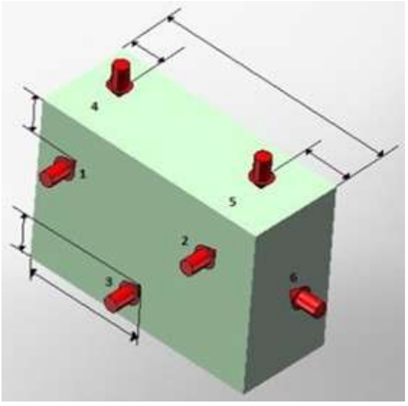

Fig 1: Support variation

Figure 2 shows an example of a statement of metrological errors into normal position due to the support plan.

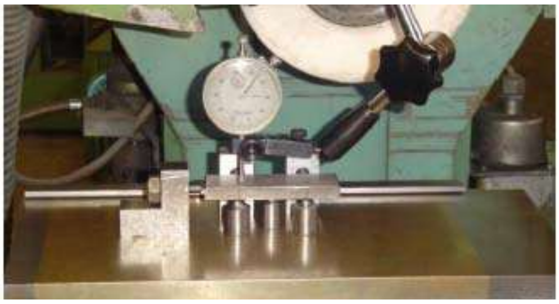

Fig 2: Example of measurement

Figure 3 shows the defects of each support. We note that the most important error is at the level of Fulcrum 3

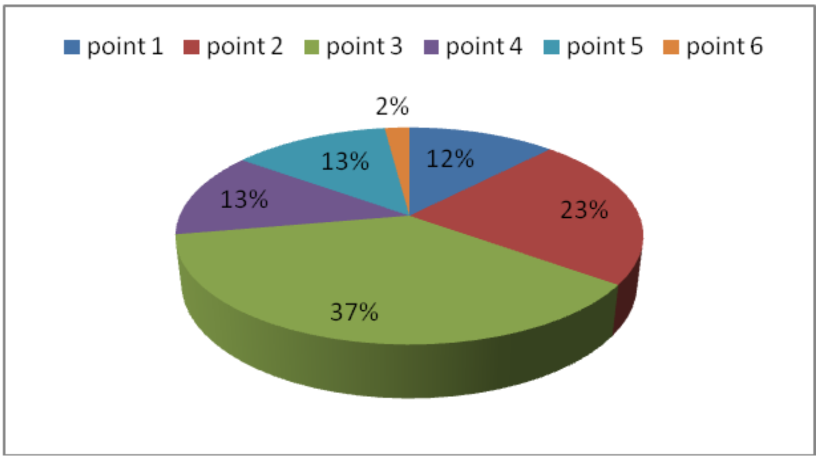

Fig 3: Defects of each fulcrum

III. Modeling of positioning defects

In this section we used the small displacement torsors for the modeling of the positioning errors . The concept of the torsor of small displacements was developed in the 70s by Pierre Bourdet and André Clément. It makes it possible to define at every point M a rigid body a small displacement.

The displacements of a solid can be characterized at a point O by a translation vector and a rotation matrix, formula.

$$\overrightarrow{D_M} = \vec{t_o} + \overrightarrow{MO} \wedge \vec{\omega} \qquad (1)$$

We apply the formula (5) to find the deviations dx, dy, dz (equations (2), (3) and (4)).

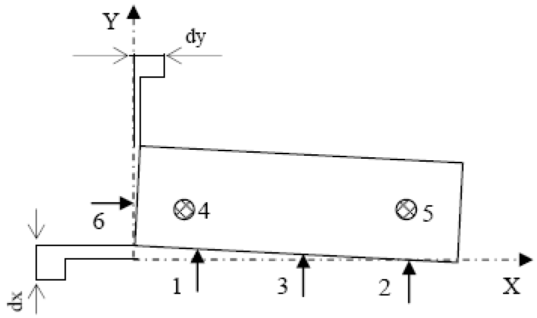

Fig 4: Positioning defects

$$dz = \begin{bmatrix} du \\ dv \\ dw \end{bmatrix} + \begin{bmatrix} d\alpha \\ d\beta \\ d\delta \end{bmatrix} \Lambda \begin{bmatrix} x \\ y \\ z \end{bmatrix} \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix}$$

$$dz = dw + (d\alpha.y - d\beta.x) \qquad (2)$$

$$dy = \begin{bmatrix} du \\ dv \\ dw \end{bmatrix} + \begin{bmatrix} d\alpha \\ d\beta \\ d\delta \end{bmatrix} \Lambda \begin{bmatrix} x \\ y \\ z \end{bmatrix} \begin{bmatrix} 0 \\ 1 \\ 0 \end{bmatrix}$$

$$dy = dv - (d\alpha.z - d\delta.x) \qquad (3)$$

$$dx = \begin{bmatrix} du \\ dv \\ dw \end{bmatrix} + \begin{bmatrix} d\alpha \\ d\beta \\ d\delta \end{bmatrix} \Lambda \begin{bmatrix} x \\ y \\ z \end{bmatrix} \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix}$$

$$dx = du + (d\beta.z - d\delta.y) \qquad (4)$$

IV. FLOWCHART OF THE MODULE DEVELOPED

Figure 5 shows the flow chart of the module developed

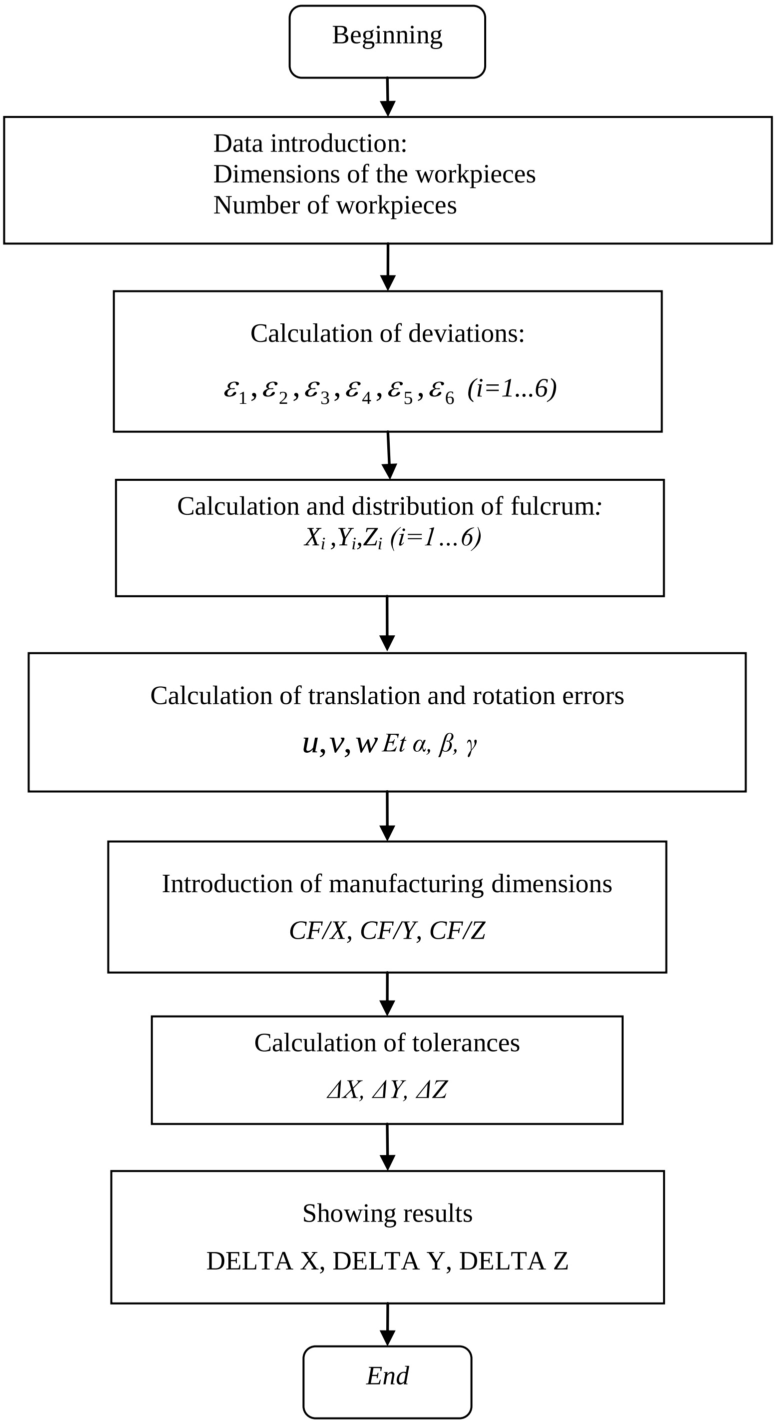

Fig 5: flow chart of the module developed

The figure 6 shows an example of the 3D manufacturing tolerance calculation.

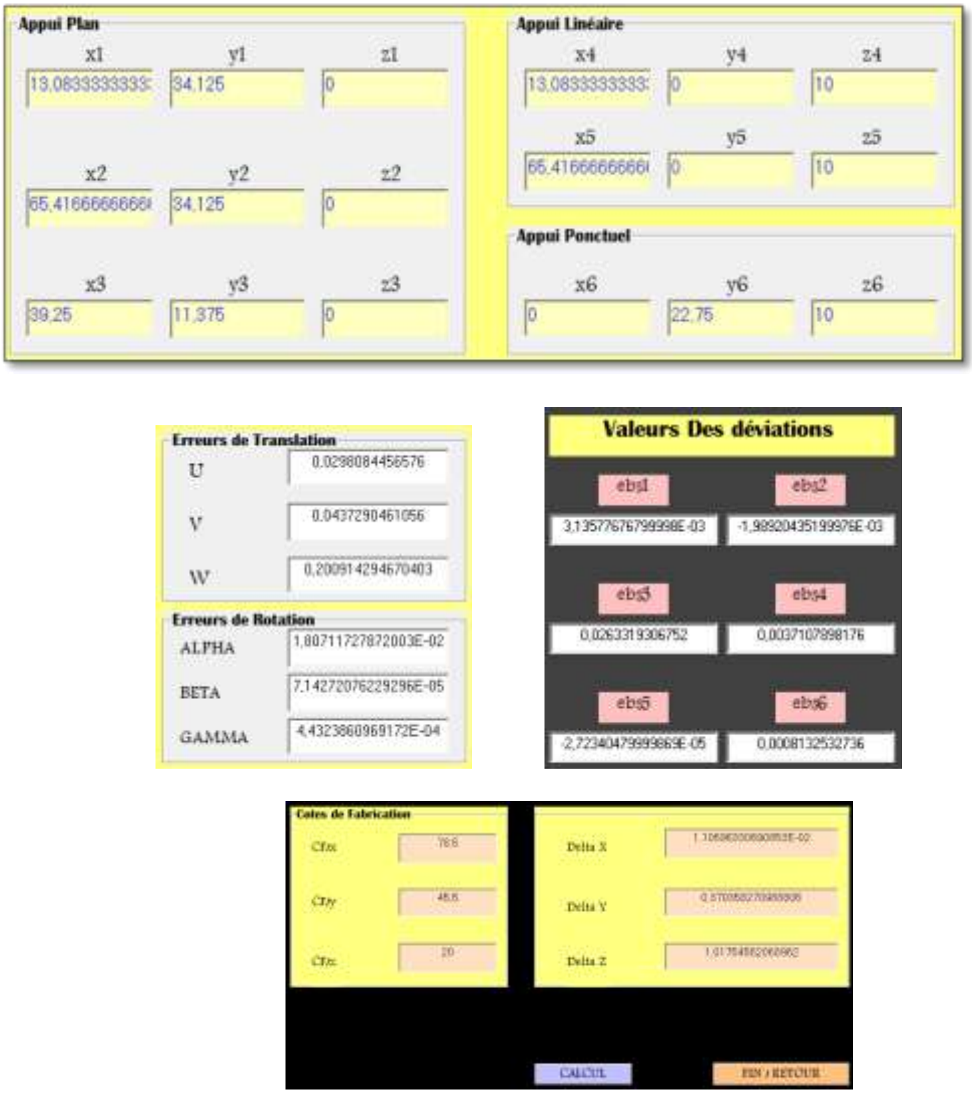

Fig 6: Example of the 3D manufacturing tolerance calculation.

V. CONCLUSION

In this paper, we presented a new approach for calculating 3D manufacturing tolerances. This approach is based on modeling and optimization of manufacturing errors. In this study we treated the problem or the error due to the positioning of the workpiece.

We found that the optimal distribution of normals as a function of length (L), height (H) and thickness (E) is as follows: (0, 16 .L) for normals 1, 2, 3, (0.18 H) for normal 4 and 5 and (0.5 .E) for normal 6. These results have been exploited to develop a 3D manufacturing tolerance calculation module.

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