PAPER REF: 4763

DIMENSIONAL CONTROL CASE STUDY IN A PUNCHING CELL

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ABSTRACT

This work presents a dimensional control method based on the definition of critical control points, in order to establish standards that allow the adjustment of the feedback information in the context of a several stages punching cell manufacturing.

Systematics is the detection of these checkpoints, i.e. values arising from the CAD model. Later information is captured from the cell itself or from the punching pieces resulting from the process. The method of capture is 3D scanning and contactless.

Keywords: Control, Inspection, STL, Punching, Training

INTRODUCTION

This work presents a method of punching cell manufacturing control, detecting the capability of the reverse engineering process uses in its design and development. Reverse engineering is a term known by the engineering processes that starts from the product, as opposed to traditional engineering which starts with the graphical representation of the product, i.e. its planes. These reverse engineering processes always start with a stage, called scanning, in which information is obtained from the geometry of the work piece. Among the various applications of reverse engineering, in this case, special attention is given to the 3D comparison between models designed by computer (CAD model), generated in the design center, and the model obtained in the scanning process, that comes from the production center. The objective of this work is not to perform an error analysis of the laser and contact scanners employees, if not detect if the proposed procedure for manufacturing control is valid for industrial application.

METODOLOGÍA

Checkpoints and reference CAD model.

For this work we have selected a punching cell in four stages, as shown in Figure 1.

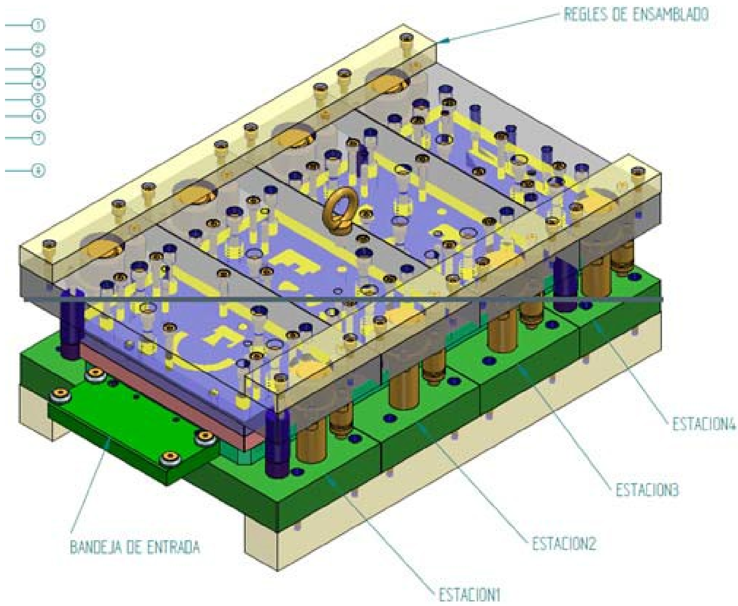

Figure 1. Punching cell in four stage.

The assembly is modeled with a CAD / CAM software with particular design specifications. The punching plate of the fourth stage is the example used in this work. In figure 2 are marked dimensional control points selected. This is the vertex of the folding punch (groove bottom), and one of the vertices of the gear punching in this stage. The distance between them is the control parameter.

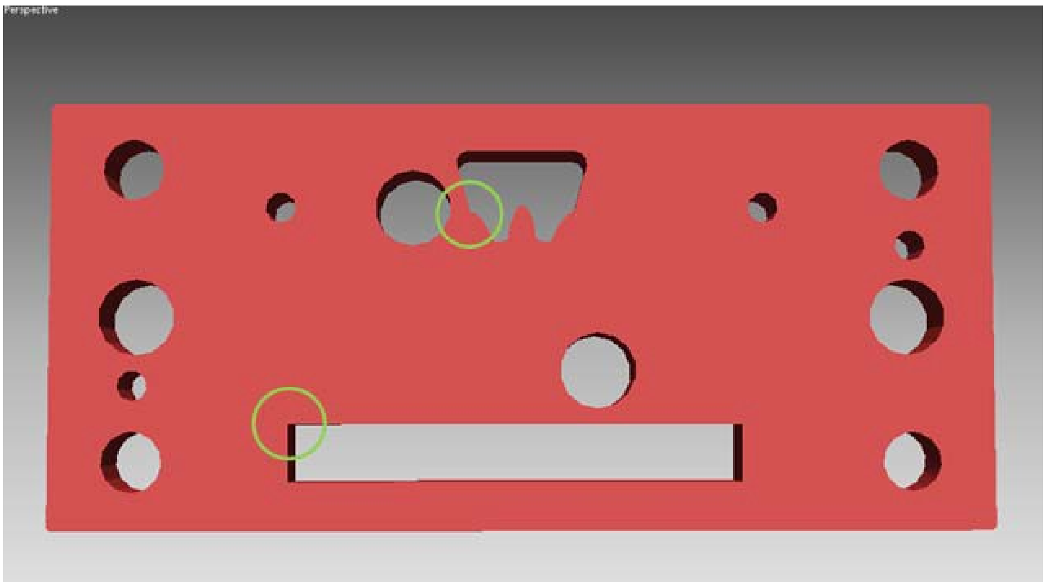

Figure 2. Checkpoints Puchings plate of the fourth stage.

Appropriate files have been used to support this study. Among the best options are the STL or SLC formats used by most teams RP (Rapid Prototyping) or as the case at hand, to perform metrological inspection processes. Between these two formats, the *.stl is the most widespread.

Thus the reference model is the STL file exported from 3D modeling process. This model is shown in Figure 3. The rope tolerance is 0.0191 mm and the angle control is 0.01 mm, values coherent with the precision machining to obtain 0.01 mm.

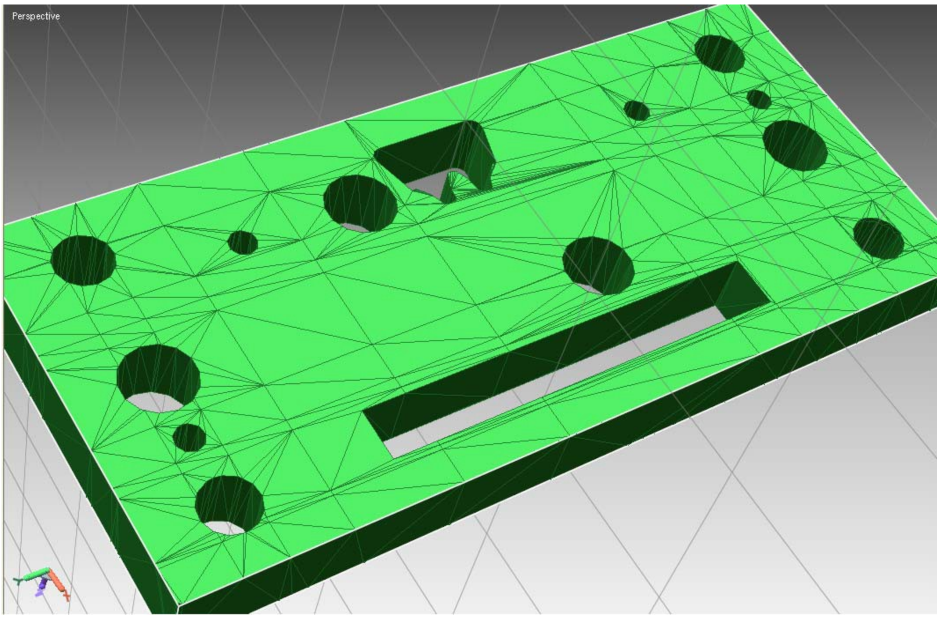

Figure 3. Punching plate. STL File

Digitization.

The laser scanner Roland LPX-250 used in this study uses laser technology point: a laser beam is projected onto the surface of the object being measured. The displacement of the impact point and its coordinates are measured by one or two CCD sensors.

The scanner is controlled by software called Dr PICZA. The software allows two scanning modes: rotary and flat. The maximum scan area is 254 x 406.4 mm. The resolution used in the process is 0.2 mm, the maximum available. This value as well as the rest of the configuration is fixed sign dialog shown in figure 4.

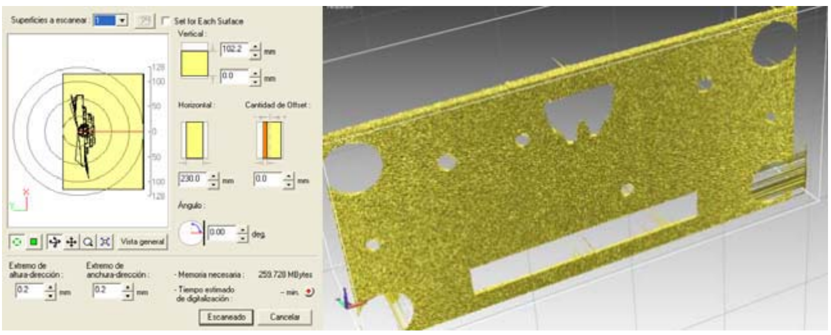

Figure 4. Configuring scanning parameters and binary STL file.

The machining requirements are high. The assembly has a high setting. It is necessary digitization of the part using a scanner contact PICZA Roland PIX-30 (Figure 5). This way you can make a higher resolution scan on checkpoints set.

Figure 5. Scanner contact.

The maximum scanning area is 304.8 mm (X), 203'2 mm (Y), 60.5 mm (Z). The scan resolution in the direction of axes X and Y is 0.05 mm respectively. Can be selected in increments of 0.05 mm and in the Z axis direction is 0.025 mm.

EXPERIMENTAL PROCEDURE

The routine in this process consists, firstly, in the edition of the meshes obtained from the scanning. Next following the inspection process of these meshes with CAD pattern.

Due to the geometrical characteristics of this piece, any edition of the model may involve changes in geometry. These changes are difficult to quantify. The increase in measurement uncertainty would not be controlled

Inspection

The inspection term related to the concept of test [4] is: "Conformity assessment by observation and judgment accompanied pattern-matching, measuring and test"

So we evaluate the conformity of production following these actions:

- Comparison. The *. stl file coming from the digitization of the part to control, with the standard of measurement, in this case the *. stl file from the modeling set.
- Measurement. Using the tools of editing software.
- Observation and resolution. Using statistical tools.

Registration mesh

The models in STL format are imported into data processing software. This software provides powerful functions for common tasks in the 3D data processing. It also has interactive tools for selecting, editing and measurement.

One of these tools is the RPS register: is a system based on reference points [5] to obtain the assembly of the two meshes. The calculation of registration is done by two pairs of homologous points and proper orientation of the axes of both models (Fig. 6).

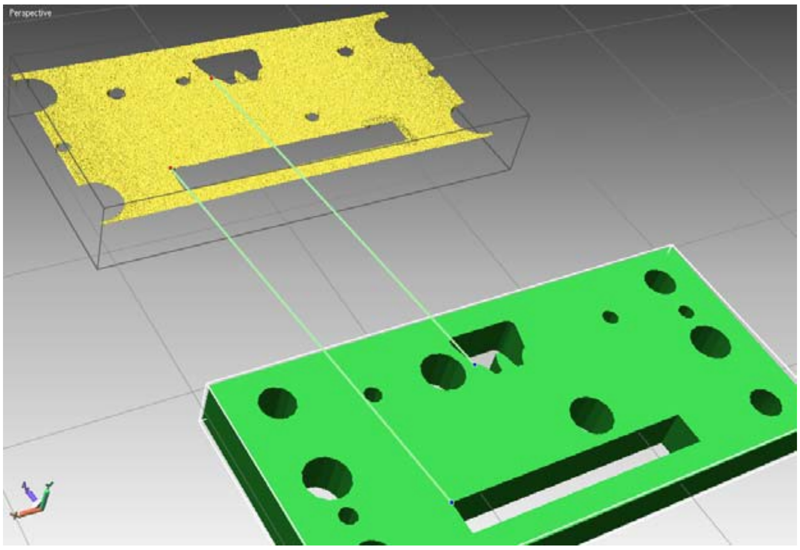

Figure 6. RPS register: CAD model and Scanning model.

After registration operation begins a process of analyzing the results. This analysis is performed in two stages: The first is a discrete dimensional analysis to define numerically the deviations between the two meshes. The second stage consists of a continuous analysis of the complex formed by the two coupled models consisting of the application of statistical calculation tools.

Analysis of discrete variables.

The distance between the pairs of homologous points (Figure 7) selected for registration can be seen in Table 1.

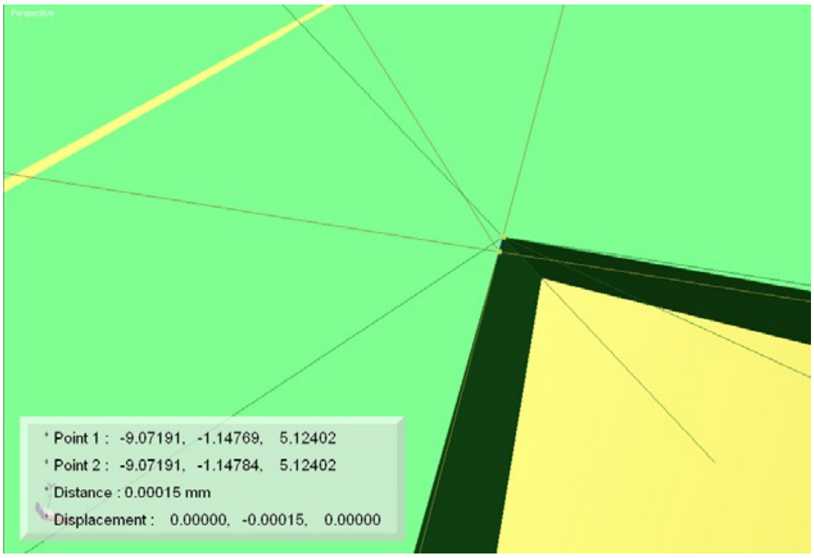

Figure 7. Distance between the pairs of homologous points

Table 1. Average value of the distance between reference points.
Distance (mm)

Par 1: 3 – 1	0.00015
Par 2: 4 – 2	0.00027

These results indicate that the errors in adjustment, at least in discrete terms, are well below the ranges of manufacture therefore it can be considered as valid assembly.

Analysis of continuous variables.

The software provides a tool for the analysis of full deviation. This tool uses the analysis of a statistical population whose universe are the values of deviation between the two surfaces being evaluated. Figure 8 shows the results of this analysis.

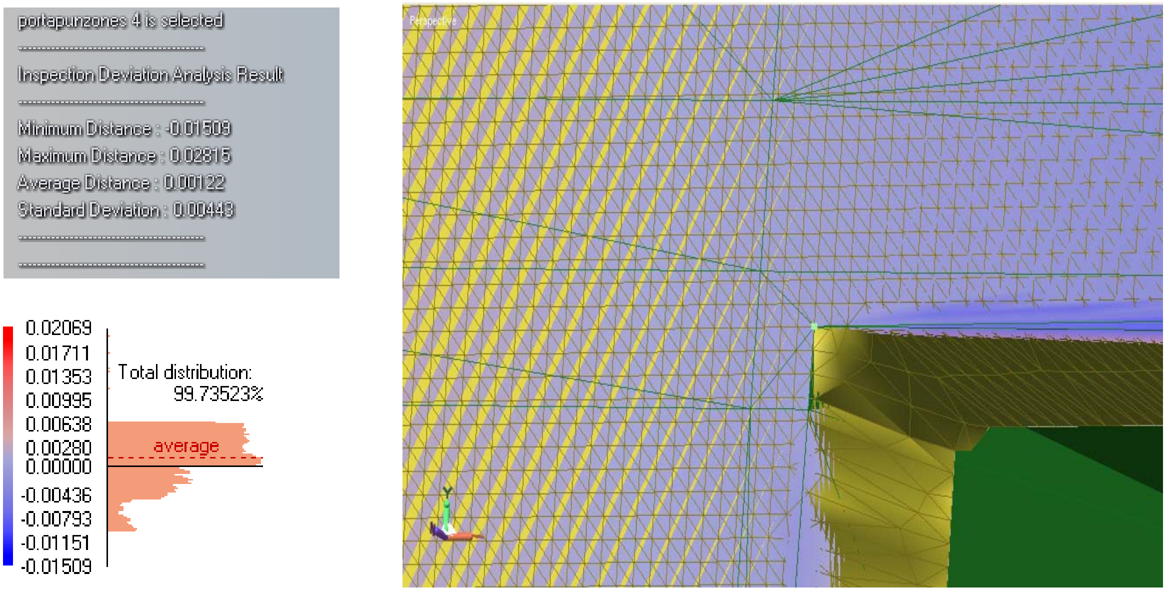

Figure 8. Statistical results of continuous analysis.

RESULTS AND DISCUSSION. STATISTICAL ANALYSIS.

The results offered are: The target value is provided by the CAD model. The statistical variable is the measurable characteristic in this analysis [6,7]. This feature is measurable dimensional deviation between the mesh from the scanning process and the CAD model mesh, is called X. When performing an analysis of deviation between the two models are obtained deviation values that are analyzed.

X → Variable measurable: dimensional deviation between scanning mesh and CAD mesh

The premise of the statistical analysis performed in this paper is to consider that the result of the adjustment is optimal if these values of deviation are under statistical control, i.e. maintaining the target value μ (CAD value) and its dispersion is constant δ = const. (variance or standard deviation).

μ → Target value: CAD mesh reference

δ → Deviation Typical: dispersion measure

The variability interval or tolerance L is the set of admissible values associated with the target. In this case the target is the central value μ, the value 0, and tolerance to be dialed in the first instance is the default resolution of the scanning process, so μ ± L could be the tolerance interval. The quality characteristic of this study is the dimensional deviation X

L → Tolerance: range of variability of the variable X

The hypothesis of the statistical analysis used is: *The result of adjustment of the two meshes is optimal if X deviation values are under statistical control.*

The variable X is distributed as a Standard or Normal distribution (Figure 9)

With parameters (μ δ)

$X \sim N(\mu\ \delta)$

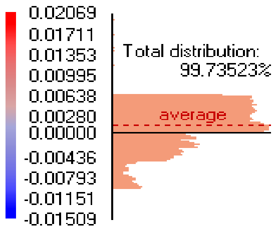

Figure 9. Variable distribution

Thus, we say that a process is in statistical control when it holds that the process capability is six times the standard deviation.

The capability of a process determines the % of points analyzed in control conditions. Outside the interval 6 δ is very unlikely to find observations. The indicator of the capacity or capability index (CI) of the process is the ratio of the range of valid values and process capability.

If IC < 1 the number of points out of control is > 0.3%

If IC > 1 the number of points that are not under control is < 0.3%

For the parameters of this work [8,9], the proposed target is the Six Sigma methodology, that is, reach a maximum of 3.4 defects per million events or opportunities (DPMO). So the Six Sigma quality processing recommended capacity index IC > 2.With this index are generated processes whose quality level is acceptable, and always for processes that are controlled statistically controlled processes.

Boundary values: in the 6δ range, 99.7% probabilities of finding the variable X. These values are obtained from the analysis of the assembly of both models (Fig. 10)

μ Expected value: 0 mm

δ Standard Deviation: 0.00443 mm

L Tolerance: 0.029 mm

Applying the analysis of processes under control:
The data acquisition process is a process under control

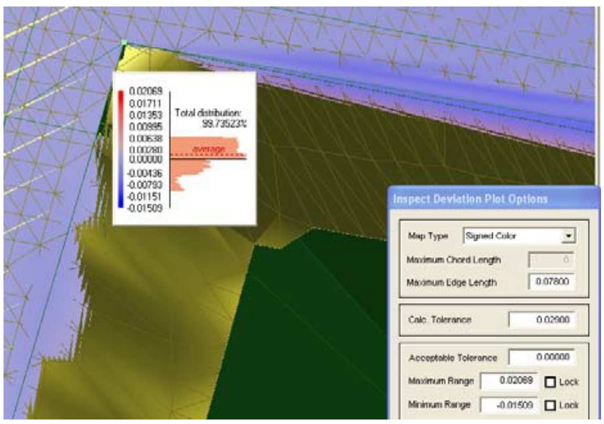

Figure 10. Tolerance 0.029 mm

With these starting values, then an analysis (Figure 11) with tolerance of 0.05 mm which is the maximum resolution of the scanning process.

µ Expected value: 0 mm.

δ Standard deviation: 0.00479 mm.

L Tolerance: 0.05mm.

CI = 3.47> 2

% of out of control points is <0.3%

Six Sigma level of quality guaranteed

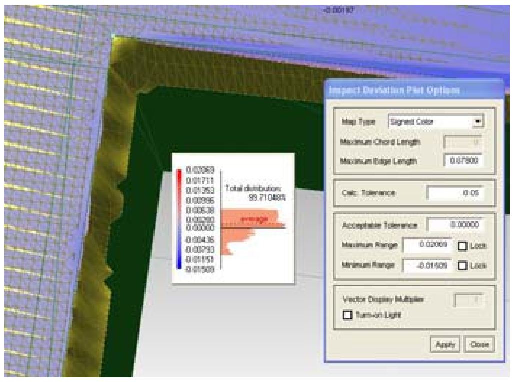

Figure 11. Tolerance 0.05 mm

CONCLUSIONS

It is very difficult to measure a type of key entities in manufacturing. This method allows measuring the vertex that is responsible for the generation of planes and surfaces.

Systems can be established for comparing the manufactured part and the CAD model. This method is away from the traditional direct measurement with classical metrological equipment as coordinate measuring machines CMM or profile projectors.

The results of the analysis and comparison of assembly meshes, concludes that the comparison is reliable with Six Sigma quality levels. Thus the control dimension (distance between the reference points defined) is correct, regardless of value, which is implied in the CAD model.

It can analyze various critical points of each cell punching. Element Just scan these reference points to control the manufacture and apply the method of assembly. If there is an error the deviations in statistical analysis exceed the design value.

ACKNOWLEDGEMENTS.

The authors wish to thank the Government of Extremadura - Ministry of Economy, Commerce and Innovation - European Social Fund (ERDF) and the Ministry of Education, Culture and Sport, the support in conducting this research work.

REFERENCES

[1] S. El-Omari and O. Moselhi. Integrating 3D laser scanning and photogrammetry for progress measurement of construction work. Automation in Construction 18 (2008), pp.

1–9. View Record in Scopus | Cited By in Scopus (13).

[2] Pingbo Tang, Burcu Akinci, Daniel Huber Quantification of edge loss of laser scanned data at spatial discontinuities. Automation in Construction, Volume 18, Issue 8, December 2009, Pages 1070-1083.

[3] W.X. Li and L.D. Mitchell. Laser scanning system testing—errors and improvements.

Measurement 16 (1995) (2), pp. 91–101.

[4] Comité Técnico ISO/TC176 de ISO. Norma ISO 9001. Organización Internacional para la Estandarización. 2008

[5] Traian Onaciu. Alineación Acertada. Inspección geométrica de piezas industriales.

Departamento Metrología de la Fundación ASCAMM.

[6] Anderson, D. R., Sweeny, D. J. y Williams, T. A. Estadística para administración y economía. Thomson Editores. 7ª edición.1999.

[7] Ardanuy, R. Y Q. Martín. Estadística Industrial. Hespérides. 994.

[8] Douglas Montgomery. *Introduction to Statistical Quality Control*. John Wiley & Sons, Inc. New York (USA), 2004

[9] Booker, J. M. and Raines, M. and Swift, K. G. “Designing capable and reliable products”, Butterworth Heinm., Oxford (England), 2001