FLEXIBLE PARTS MEASUREMENT SIMULATION WITH A CAD MODEL OBTAINED BY A REVERSE ENGINEERING METHOD

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Abstract: *In the industry automotive and aerospace, there are a lot of flexible parts. There are two methods usually used to control these parts: the first method with metrology assembly gage and sensors, and the second method using a coordinate measuring machine (CMM) to validate the parts positioned on the control device.*

This article introduces a new method to take into account the real shape of the real parts before the positioning on the control device.

The used method is based on reverse engineering principles to rebuild the model CAD with its defaults. We use a Faro Arm to scan the part and to obtain the cloud of points before rebuilding a CAD model. We apply the finite element method (Abaqus, 3DCS) to calculate the geometry of a flexible part after positioning on the control device. The obtained geometry is controlled with a virtual measurement method (Metrolog).

This new approach use a CAD model linked to the real shape of the part as an alternative to a CAD theoretical model.

Keywords : *Metrology, Measurement, Flexible parts control*

1. Introduction

1.1. Problematic

In the industry of automotive and aerospace, we can find a lot of flexible parts (Figure 1). These parts can be made of plastic or metal sheet. We call flexible part, any part that loses its shape due to the gravity effects. This type of parts needs often to be controlled with a specific metrological device.

Figure 1 : *Flexible part in automobile industry*

The aim of manufacturers is to answer to the customer's request. In addition to the classical dimensional and surface quality measurement, the customer is more sensitive to the perceived quality.

1.2. Context of the study

One of the hypothesis that is often assumed before performing a measurement with a coordinate measuring machine (CMM, Figure 2), is that a part is a solid without any deformation due to its own weight and positioning.

Figure 2 : *CMM Coordinate Measuring Machine*

Before being able to measure a flexible part with a CMM, it will be necessary to define and to manufacture a specific positioning device

(Figure 3). The complexity of this type of device could be very high. The cost of this positioning device is often also very high.

Figure 3 : *Control device*

2. Previous work

2.1. The part design for the study

For the first step of the study, we have chosen to manufacture a very simple part with geometry easy to measure and to manufacture.

Previous experiments [6] have been made with a thin aluminum part. It's a bent rectangular metal sheet (Figure 4) with different holes. The holes were placed in asymmetric position to induce a torsion deformation of the part placed on the control device.

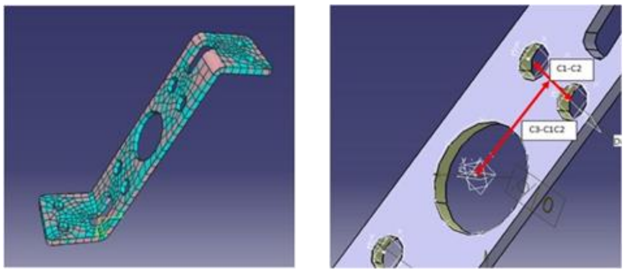

Figure 4 *: Simple part for the study*

2.2. Used methodology

In the case of an industrial part, we could observe and measure a lot of different parts with a form and dimensional dispersion. In the study, we reverse the variable parameter and we can simulate the effect of dispersions of the parts by a variation of the size of the control device.

The control device presents a point that defines the contact between the free side of the part and the control device. This point is able to move along the Z axis (Figure 5) to simulate the positioning of various shapes of parts on a single control device (linked to the CAD nominal model).

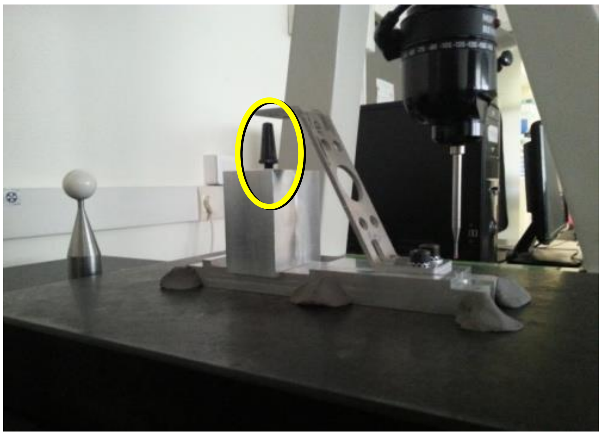

Figure 5 : *Device control with a Z moving point*

We start with a CAD model and we apply a finite element method (FEM) to determine the deformation of the part placed on a variable control device.

We use specific software (3DCS) to simulate the dispersions on the CAD model. 3DCS is able to create variable sizes (Figure 6) of the CAD model. We obtain more than 10 000 virtual parts (Monte-Carlo statistical method).

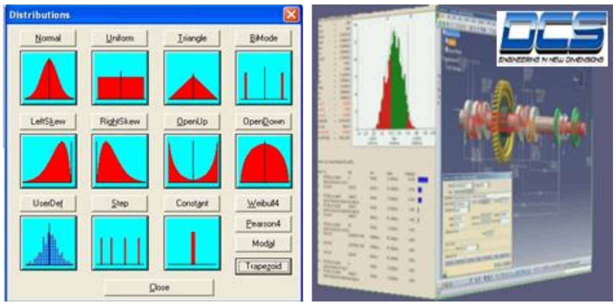

Figure 6 : *3DCS software*

3DCS include also an FEM module that is able to introduce the deformation of the part due to the positioning point variation (0, 1, 2 or 3 mm for the Z displacement of the contact point) into the calculus of the dimensional and geometrical dispersions.

We can then compare the measurement of the position of holes on the part by moving the contact point to the numerical simulation of the assembly and virtual measurement.

2.3. Results

The result of the experiment (Figure 7) shows that it is possible to simulate with a good quality the variations of the measurement.

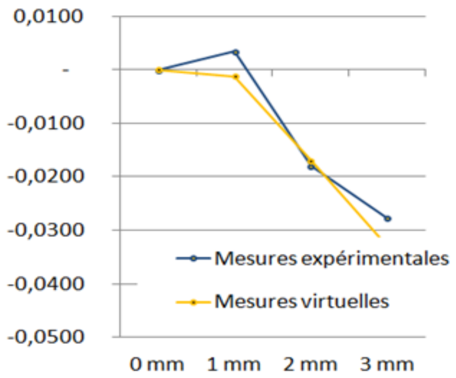

Figure 7 : *results of the previous work*

The numerical simulation indicates that the value of the distance will only decrease when we augment the Z position of the contact point. We can observe on the measurement values that there is first an augmentation of the distance before the decreasing curve.

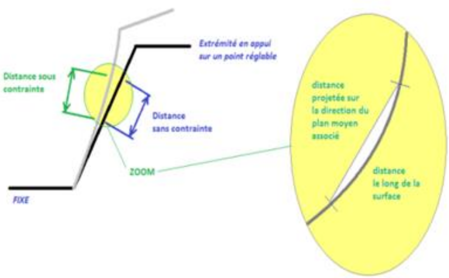

Figure 8 : *Theoretical variation of the dimension*

If we start with a CAD model, the flatness default is zero and the distance will decrease when the part is bending (Figure 8).

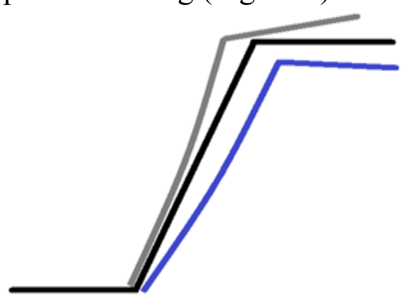

Figure 9 : *Source of the difference*

In the real measurement, the flatness default of the part for the zero position is different to zero (Figure 9). A detailed analysis of the form shows that the theoretical central plane is in fact a curved surface (near to a plane).

3. New approach proposed

3.1. Reverse engineering of the CAD model

To solve this problem, a new approach of the problem is proposed in this study. We propose to rebuild a CAD model more close to the real shape of the part (Figure 10).

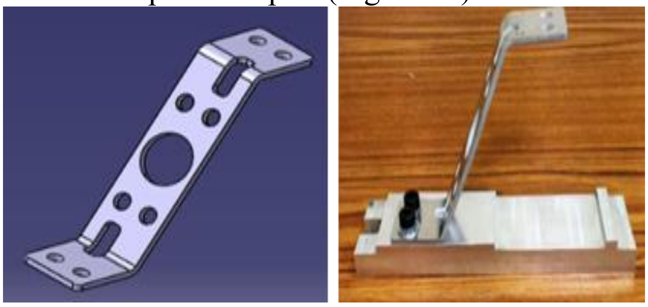

Figure 10 : *CAD model and real shape of a part*

In this approach, the CAD model used for the 3DCS simulation is a CAD obtained by reverse engineering of the real part. We use a FARO Scan arm to obtain a cloud of points representing the real shape of the part (Figure 11).

The cloud of points is the base of the reconstruction of a CAD model representing the real shape of the real part.

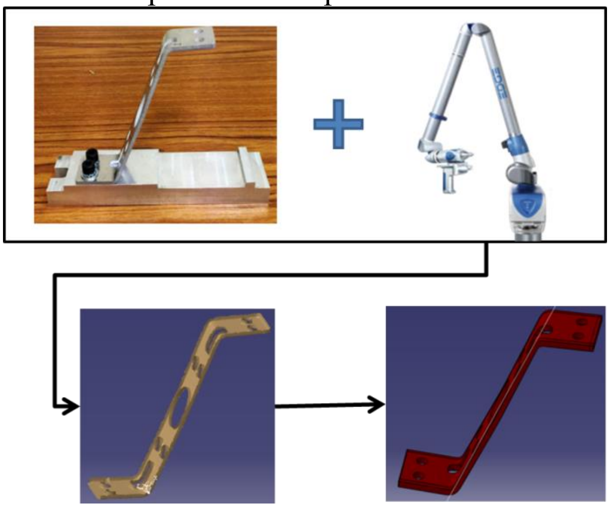

Figure 11 : *CAD model built by reverse engineering*

With the reverse engineered CAD model, we can apply the method we have presented before.

A FEM module associated to the 3DCS software allow simulating the deformation of the real part after its positioning on the control device. We can perform a virtual measurement on the virtual part after deformation.

3.2. Results of the new approach

As shown on the above figure (Figure 12), the values are more similar between the real measurement and the simulation of a virtual metrology process on the virtual part.

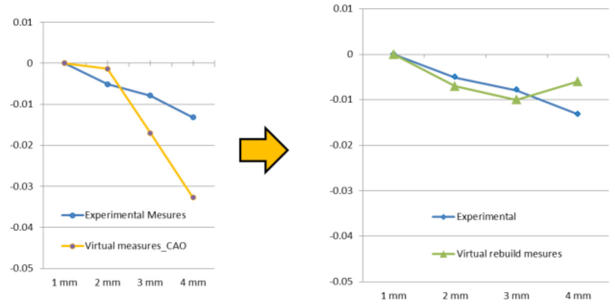

Figure 12 : *New results*

4. Conclusion

This study presents a new approach to be able to use the best CAD model before applying a numerical simulation of the deformation of a part. This work shows that with a reverse engineering approach, the CAD model represents the real shape of the part. The reconstructed CAD model can be used with the 3DCS simulation software to obtain a simulation of the metrology process on a part after deformation on a control device.

This study demonstrates the feasibility of the approach.

One of the limits is the cost (time cost) of the reverse engineering methodology to obtain a CAD model representing the real shape, but with a good stability when used with de FEM and 3DCS simulation tools.

5. References

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