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AN ASSESSMENT OF THE INFLUENCE OF ELASTIC, OR PLASTIC, DEFORMATION, ON THE MEASUREMENT ERRORS

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Abstract— The reason for choosing this theme is to emphasize the phenomena that occur in a set (measuring device) due to external environmental factors and forces that errors involved in the measurement process. These factors influence the measurement results and their presence can not be seen with the naked eye. Thanks to the progress of last years and helping on software, advanced design and analysis, the designer have handy ever since the concept of a device able to check the resistance to stresses and deformations that may occur in a structure, model or assembly. Following that verification it is able to more easily decide how to strengthen the structure needed, more robust modeling benchmarks or the use of harder materials. These issues are highlighted in this paper and illustrated by finite element analysis of the structure of a measuring device using Ansys software.

Keywords— measurement errors, plastic deformation, elastic deformation, finite element analysis, robot manipulator

I. INTRODUCTION

BY measurement means determining the value of a physical quantity by reporting to a different size of the same nature, taken as a unit, using an instrument or a gauge. The use of any means of measurement of physical quantities introduces measurement errors. These imperfections are caused by equipment used, environmental conditions, or even by the operator. In practice, the real value (real) of a physical size is impossible to determine, which is why instead accept a value determined with an uncertainty sufficiently low, namely conventional true value. Measurement uncertainty is the range that is expected with a certain probability (confidence level called) that is the true value of the measured quantity. Measurement uncertainty estimates measurement error limits. Specifying the maximum error that can be accepted for a measurement made with certain means and under certain conditions, and the uncertainty of measurement are useful or not, the measurement result.

All measurements even with the most advanced measuring instruments involve measurement errors, which consist of imperfections due methodology that instrument due to the operator. Thus the general form of measurement error include the following components, proposed by Rabinovich, [1]:

$$\zeta = \zeta_m + \zeta_i + \zeta_p \qquad (1)$$

Each of these components can in turn was influenced by other factors. Thus, methodological errors can occur due to inappropriate use of a theory of phenomena underlying relationships and inaccuracy of measurement that are used to find the estimated quantity measurable. A methodological error is a base and misuse of quotation, but also influential status as a basis for measuring surface, studied and developed the theory applied to L. S. Babadzhanov, N. N. Dzhorbenadze, Yu. N. Nikolaishvili [2]. These authors proposed that the basic elements of their theory assumption that surfaces due to unevenness, described by a polynomial curve (in section) of grade II:

$$y_i = ax^2 + bx \qquad (2)$$

the coefficients

$$a = \frac{1}{\Delta}\begin{bmatrix} \frac{\sum_{i=1}^{n} x_i^2 y_i}{n} & \frac{\sum_{i=1}^{n} x_i^3}{n} \\ \frac{\sum_{i=1}^{n} x_i y_i}{n} & \frac{\sum_{i=1}^{n} x_i^2}{n} \end{bmatrix} \qquad (3)$$

$$b = \frac{1}{\Delta}\begin{bmatrix} \frac{\sum_{i=1}^{n} x_i^4}{n} & \frac{\sum_{i=1}^{n} x_i^2 y_i}{n} \\ \frac{\sum_{i=1}^{n} x_i^3}{n} & \frac{\sum_{i=1}^{n} x_i y_i}{n} \end{bmatrix} \qquad (4)$$

$$\Delta = \begin{bmatrix} \frac{\sum_{i=1}^{n} x_i^4}{n} & \frac{\sum_{i=1}^{n} x_i^3}{n} \\ \frac{\sum_{i=1}^{n} x_i^3}{n} & \frac{\sum_{i=1}^{n} x_i^2}{n} \end{bmatrix} \qquad (5)$$

Measured values can be determined using standard deviation formula for calculating the standard deviation unknown.

The same author, Babadzhanov in [3], shows how measurement errors, δ, are influenced by the geometric features (across all measurement R) and mechanical Poisson's ratio respectively modulus E, the contact surfaces, and the dynamic measurements, resulting in a nonlinear dependence of force measurement:

$$\delta = 0.825\sqrt[3]{\frac{P^2}{R}\left(\frac{1-\mu_1^2}{E_1}+\frac{1-\mu_2^2}{E_2}\right)^2} \quad (6)$$

which is evidenced by the relationship $\delta = kP^{\frac{2}{3}}$.

Medical applications for offset errors measurement methods developed theories and calculations of authors P. Drouet, S. Dubowsky, C. Mavroidis, [4] are important and deserve to be highlighted by the implications that may occur, especially in the treatment extremely precise patient positioning system, conducted at Massachusetts General Hospital (MGH). A robotic positioning system (PPS) is a proton gun accuracy of ± 0.5 (mm), at a distance of 5000 (mm). The errors of such equipment and the equipment are given, along with the patient, varies between 20 and 200 (kg). These errors are due to system geometry, and its elastic deformations during operation. The method developed by the authors has embodied in a procedure of calculation and determination of the compensation practice geometric errors and elastic deformation. Perfecting this methodology, by C. Mavroidis, S. Dubowsky, P. Drouet, Hintersteiner J., J. Flanz, [5], has resulted in its application to the patient positioning system, to determine the exact error and kinematic geometric due to elastic deformation. Performant studies on measurement errors introduced by elastic deformation in the kinematic chains of the robot, Craig, [6], are detailed and remove any doubt about their importance. Gy. Hermann [7] presents a study of geometric correction of errors due: manufactured goods geometry and configuration, fault orientation but also those due to thermal deformation during operation, or mechanical processing. A large number of errors that can compete in a manufacturing process is given by their sources: measurement errors, errors of production errors calibration bias (defined sometimes generic bias, as being equal to the difference between the measurement errors and random errors), presented in detail Mekid, [8]. Determination of measurement errors, as very advanced methodology using atomic force microscopy (atomic force microscope (AFM)) by H. Xie, S. Kishimoto, A. conceals, Ch. G. Boay, N. Shinya, J . Yu, BKA Ngoi, [9]. They have developed, in fact, a scanning method based on Moiré method, to determine errors and measuring principle using atomic microscopy.

II. PROCEDURE FOR ELASTIC DEFORMATION ASSESSMENT

A. Review Stage

For evidence of deformations elastic total respectively axial, all three areas were carried out three projects finite element analysis to simulate conditions extremely unfavorable to facilitate the formulation of conclusions as relevant, to be useful in industrial practice.

The geometry data are presented in Table I, and a geometry model is shown in Fig. 1:

TABLE I
GEOMETRY DATA

Object Name	*Geometry*
State	Fully Defined
Definition	
Type	DesignModeler
Length Unit	Millimeters
Element Control	Program Controlled
Display Style	Body Color
Bounding Box	
Length X	470, mm
Length Y	566, mm
Length Z	300, mm
Properties	
Volume	8,1494e+006 mm³
Mass	63,973 kg
Scale Factor Value	1,
Statistics	
Bodies	85
Active Bodies	85
Nodes	168157
Elements	88710
Mesh Metric	None
Basic Geometry Options	
Parameters	Yes
Parameter Key	
Attributes	No
Named Selections	No
Material Properties	No
Advanced Geometry Options	
Use Associativity	Yes
Coordinate Systems	No
Reader Mode Saves Updated File	No
Use Instances	Yes
Smart CAD Update	No
Attach File Via Temp File	Yes
Temporary Directory	C:\Users\admin\AppData\Local\Temp
Analysis Type	3-D
Decompose Disjoint Geometry	Yes
Enclosure and Symmetry Processing	Yes

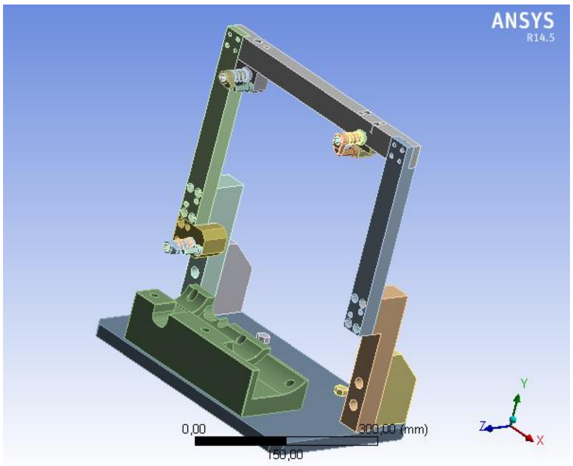

Fig. 1.- The geometry model of the robotic device

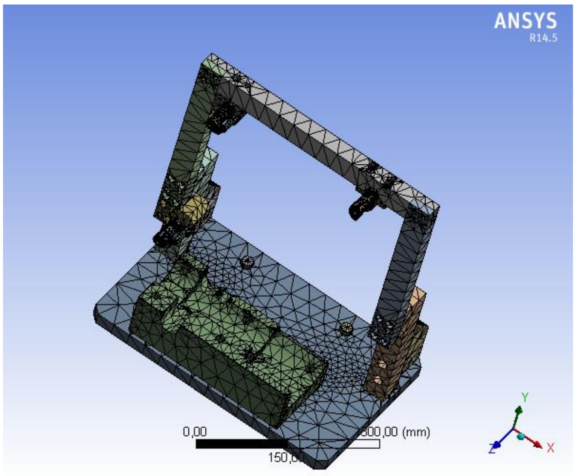

Fig. 2. – Discretization of the geometry model

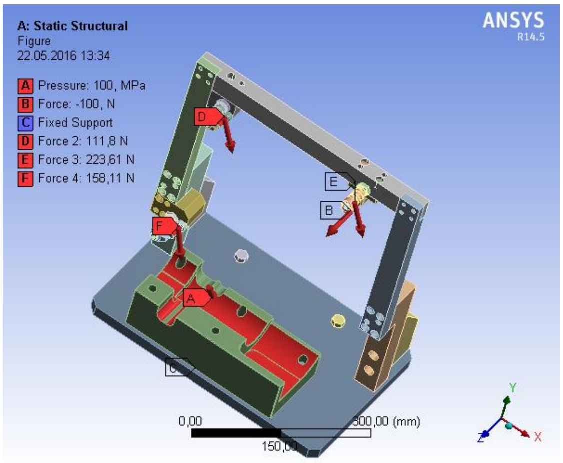

Fig. 3.- Static structural loads, modeling of the load performing

B. Results

The solution of the simulation consists of Total Deformation module, and three Directional Deformation module, corresponding to all axes of the Coordinate System:

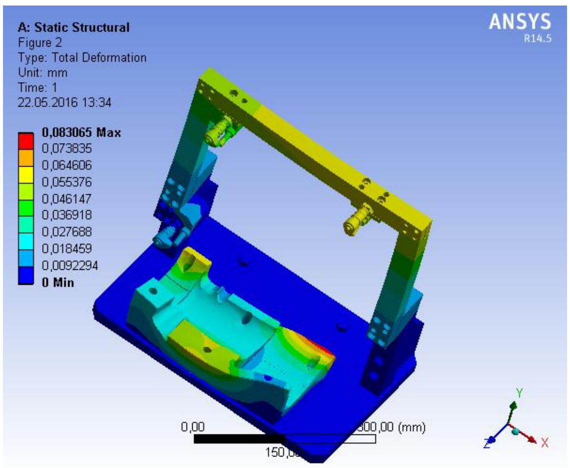

Fig. 4. Total deformation results

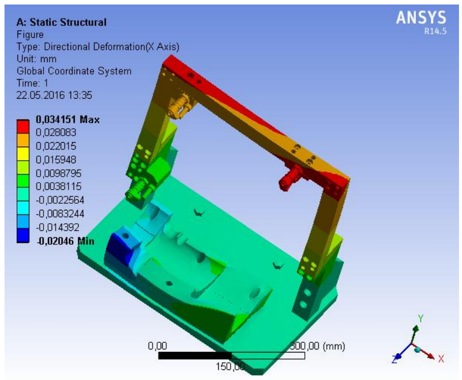

Fig. 5.- Directional Deformation- X axis

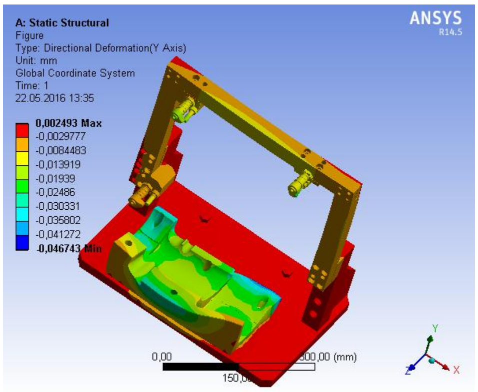

Fig. 6.- Directional Deformation- Y axis

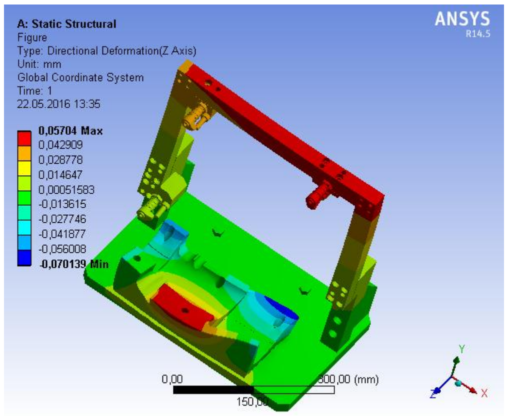

Fig. 7.- Directional Deformation- Z axis

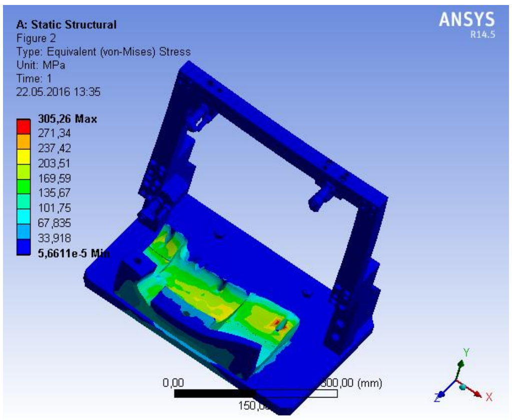

Fig. 8. – Equivalent, von Mises, Stress

III. PARAMETERIZATION

The optimization analysis was adopted in order to found if there are influences of the magnitude of pressure and concentrated forces. Here was chosen to be parameters of the simulation: the pressure (wich simulate the gravitational force, i.e. the device mass), and axial forces (X, and Y).

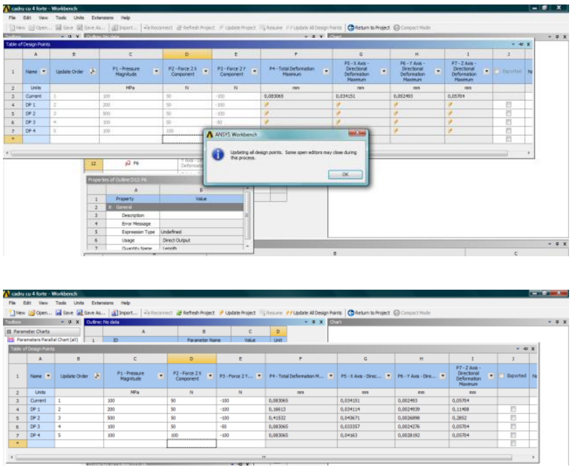

Fig. 9.- The parameterization of the analysis

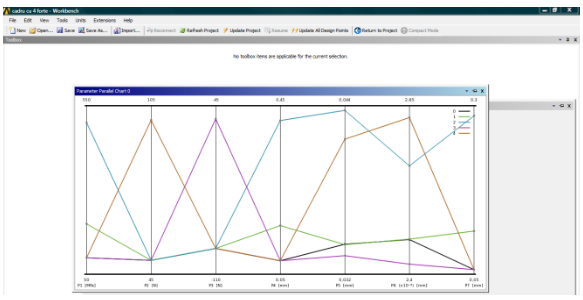

Fig. 10. – The chart of all parameters evolution

IV. CONCLUSION

1) *–The analysis of device behavior, if action weight of the device is modeled using real data, in order to achieve a comparative examination of the behavior of the device;*
2) *-The analysis models presented in the paper can be easily adapted for any type of measuring device;*
3) *-Analysis FEA using ANSYS is very easily achievable, based on geometric patterns in different formats;*
4) *–The analysis settings parameters: load restrictions or kinetic dynamic parameters is performed almost intuitively, ANSYS;*
5) *-The parameterized finite element analysis (setting as a standard of comparison) results in getting some different approaches based on multiple values set for those parameters;*
6) *-The results of the analysis: permanent plastic deformation, deformation equivalent von Mises, residual stress are easily taken in calculations and subsequent verification procedures;*
7) *– The permanent deformation amount may change the "size of the movement" directional be useful in developing conclusions about the influence on measurements and precision machining accordingly;*
8) *-The results of the analysis presented in the three projects provide an opportunity conclusions on the quality of the measurements, but also quantitative conclusions. The two conclusions allow the user to intervene on the project of construction of carriage, especially on the location of the supporting points (restrictions), but also points to "cross" and positioning of these points, depending on the results of spatial deformation total or directional;*
9) *-In practice, the designer of such a highly complex device, has provided this type of analysis using finite elements, as a study to verify their degree of "coverage" of the measurement errors due to deformation (generated by tare weight, or environmental factors, external);*

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