TECHNICAL UNIVERSITY OF CLUJ-NAPOCA

ACTA TECHNICA NAPOCENSIS

Series: Applied Mathematics, Mechanics, and Engineering
Vol. 67, Issue Special I, February, 2024

CMM TERTIAL DATUM EVALUATION TO IMPROVE CNC PARAMETER SETUP

Petru Emanoil SERBAN, Lucian GRAMA

Abstract: *The functionality of parts used in different stages of production evolved and improved permanently, due to these modifications it's required that processes to have less and less time for setups. All this led us to low scrape rate acceptance and management of time during reference changes for dynamic production cells. The processes with multiple operations, different clamping phases and assembling operation give us the information that measurement of this references characteristics can create a looping error due to different alignment system interpretation and all these led to increase setup time of CNC machines. To solve this error, we need to investigate the setup step by step until all the dimensions are conform to the requirements. This article will analyze the different methods used to measure a dimension based on tertial datum represented by a slot and propose a solution to have a simple and better interpretation of alignment system of tertial datum. The importance of the new method developed consist in creation of hi setup speed time and adjustments with focus on all measurement results.*

Key words: *SMED, CMM measurement strategy, Industry 4.0, CMM and CNC setup.*

1. INTRODUCTION

Concept development of a product comes with the challenge of ensuring the changes of part assembles fast, easy and the most important aspect by respecting all imposed functionality of assemble after the change. Automotive concepts use for these types of assembling two types of parts: mother and father, in which one part has fixed assemble elements and the other one creates the possibility of assembling the parts without any problems. These types of parts use for father side fixed pins as references and for the mother part a cylinder and a slot or notch shape. The slot shapes guaranty the full variation of opposite part and at the same time ensure the positioning of the rest of parts in the assemble.

The development of product is reflected in the drawing requirements and standards. As a process to run accordingly we have to setup and confirm the part is conform by measurement reports, using measurement equipment, or by using control devices which will guarantee the functionality of product. Customers need is to guarantee 0 defect, and to do this we can used a 100% control of production or a statistical process capability (SPC) analysis to identify the variation of process. The 100% control is very expensive and require unique investment for each reference, costs that well be included in the price of final product. To decrease these costs, coordinate measurement machine (CMM) can measure a variety of products and maintain the level of quality at the same time.[1][2]

In this article it will be presented the concepts of measuring the parts that use slot references and the effect that involve the alignment system in the measurement results.[9] We also present a new concept of measurement focused to give improved and faster results especially for CNC setup, validation of product to start a new production order or periodical verification of product during serial production.

2. MATERIAL AND METHODS

For this article we'll use a single coordinate system type formed by a primary datum plane combined with a secondary datum point formed by intersecting a cylinder with the primary plane datum and as a tertial datum a slot. The primary datum plane constrains three degrees of freedom, the secondary datum constrains two more degrees of freedom (translation in the plane), and the tertiary datum constrains the remaining translation degree of freedom.[3][4]

According to the actual level of knowledge, in the measurement process the focus will be on the tertiary datum, the slot will be evaluated according to different standards and measurement methods.[5]

The actual research has a single configuration of the CMM machine so that the results of the measurement to be evaluated only from measurement strategy point of view. The tests were made on the same reference type and was focused on the results given by the alignment system related to a true position dimension from the drawing. Our goal is to increase the measurement precision with a combination of parameters that are already available on the software but didn't communicate as a single element.[6][7]

The tests are divided in three categories, two of them are traditional measurement methods and the last one is a combination of parameters that will form the reference.[8]

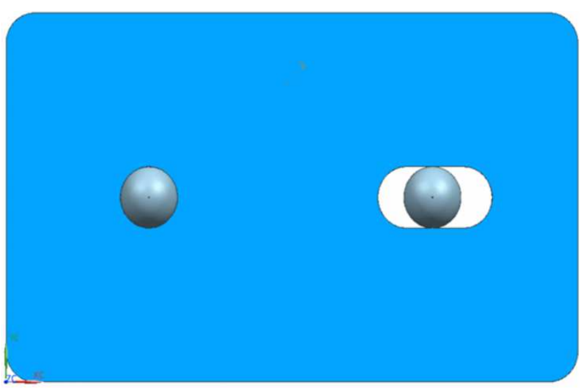

Fig. 1. Coordinate reference system formed by a plane a cylinder and a slot.

ISO 1101 general tolerance was applied to evaluate all measurement systems. [3]To present all methods we'll present the theoretic and the practice effect by presenting next figures. The Figure 2 and Figure 3 represent the alignment system that will be used in this article, we all know that theoretic value is not the same as real measurement results and for this we'll present the effect of measurement depending on each method used.

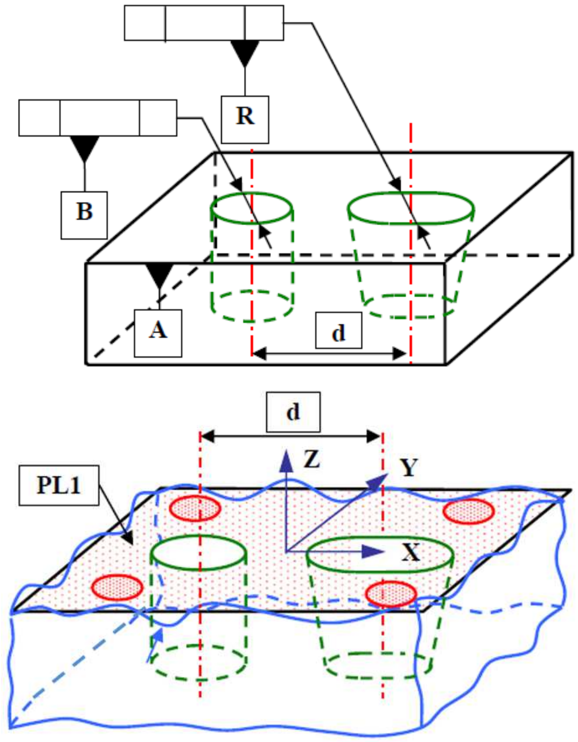

Fig. 2. Real coordinate reference system.

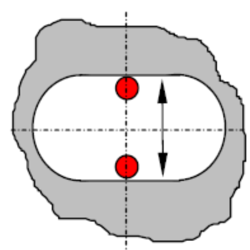

Fig. 3. Drawing slot reference indication to be measured.

In Figure 4 and Figure 5 we are presenting as an example the real form and shape of majority of parts that are machine during serial production processes.

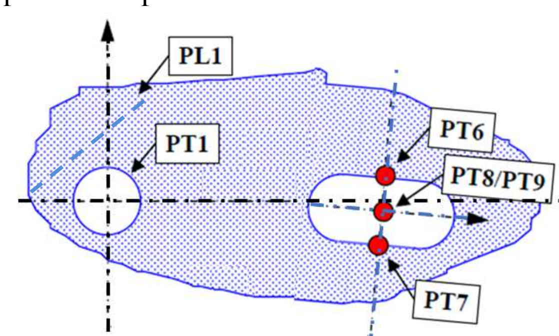

Fig. 4. Real references from a serial process.

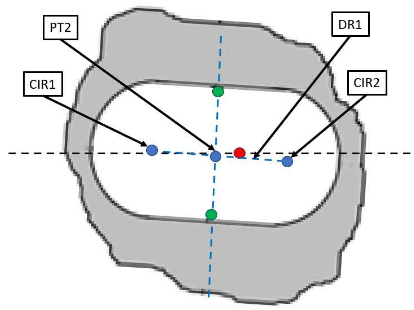

Fig. 5. Slot coordinate vs theoretic value (red point and black line, represent theoretical references from the drawing).

The elements that are forming the coordinate system references are machined surfaces, all these elements must be maintained in the tolerances that were imposed. These tolerances show us that dimension will not be perfect and here we need to focus our attention.[11]

The primary datum plan PL1 will block three degree of freedom (level and origin one axis) and will be evaluated the same for all tests that will be performed, the cylinder that is intersected to PL1 and give the point P1 will remain also the same for all tests and will block 2 degree of freedom (origin on two axis). The single reference that will change is the tertial datum, this datum will block one degree of freedom, and this is represented by the rotation of the coordinate system.

2.1 Method of points measurement

For this method we'll measure all references as declared above, for tertial reference we'll measure as is presented in Figure 6, at theoretic distance market with x mm two points in the slot and create from them a middle point "PT8".

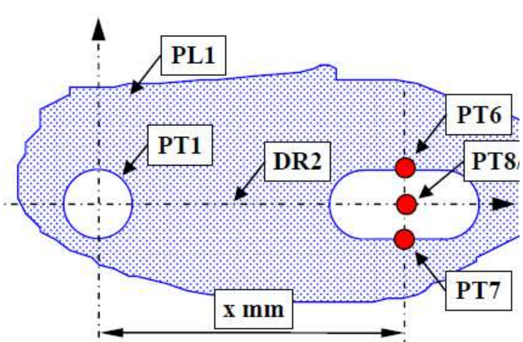

Fig. 6. Coordinate system, with points method.

The ax created by "PT1" and "PT8/PT9" represent the tertial datum and block the rotation of the alignment system.

2.2 Method of lines measurement

For this method we'll measure all references as it was before and for the tertial reference we'll measure as it's presented in Figure 7, at theoretic distance market with x mm two lines from which we create a middle point. This middle point is projected to primary plane PL1.

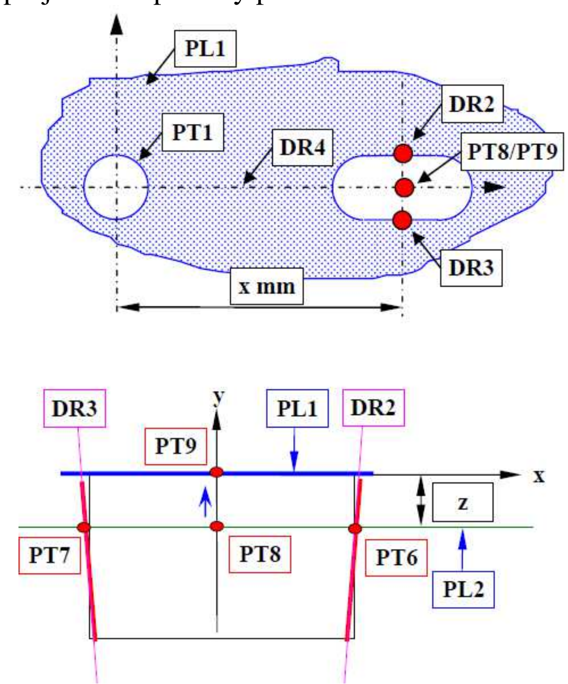

Fig. 7. Coordinate system, with lines method.

The ax created by "PT1" and "PT9" represent the tertial datum and block the rotation of the alignment system.

2.3 Method of points measurement with middle slot real centered

For this method as well as for the other two, first steps remain the same. More in detail we need to establish new rules to can measure alignment point "PT9" as in Figure 8:

- We measure at first the two circles of the slot CIR1 and CIR2;
- We create an axis between these two DR1;
- We creat the middle point PT2;
- We create the alignment formed by DR1 as rotation axis and PT2 as origin;
- In this alignment we measure 2 lignes (green point marked)

- We create the middle point of each line, as we can se in Fig. 8 measured surface can have defects and for a proper measuremnt we'll use the medium point. Result point P6 and P7
- We create the middle point P8 and project it to PL1 in PT9.

In Figure 10 we can observe that alignment of new PT1 and PT9 will be diferent than the aligment created in first two methods.[3][4][5]

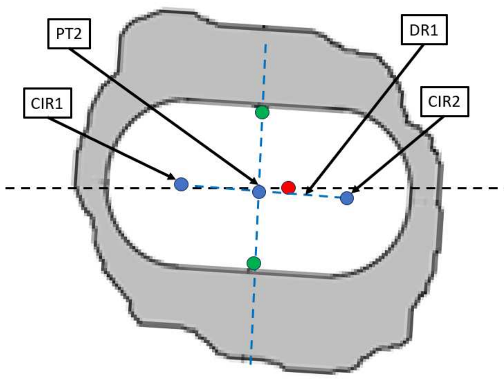

Fig. 8. Coordinate system, with lines method.

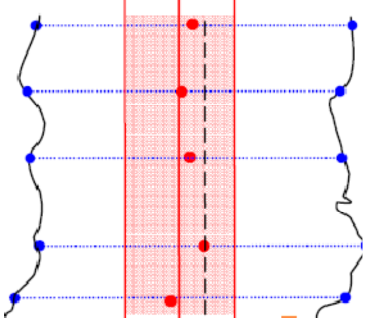

Fig. 9. Coordinate system, with lines method.

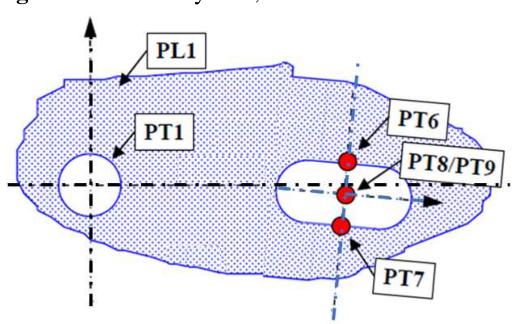

Fig. 10. Coordinate system, with lines method.

The result of these three methods will be presented in chapter 3, were we'll be added a true position of an element that we'll be used as comparison bethel our methods used.

3. PRACTICAL EXAMPLES OF EACH METHOD

We'll start from alignment system defined by coordinate ABC, where A represent the plane, B represent the intersection of cylinder with reference A and reference C well be evaluated based on the methods described in chapter 2. The evaluation will be made for another reference from our part that need to be measure. In Figure 11 we have the dimensions that are evaluated.

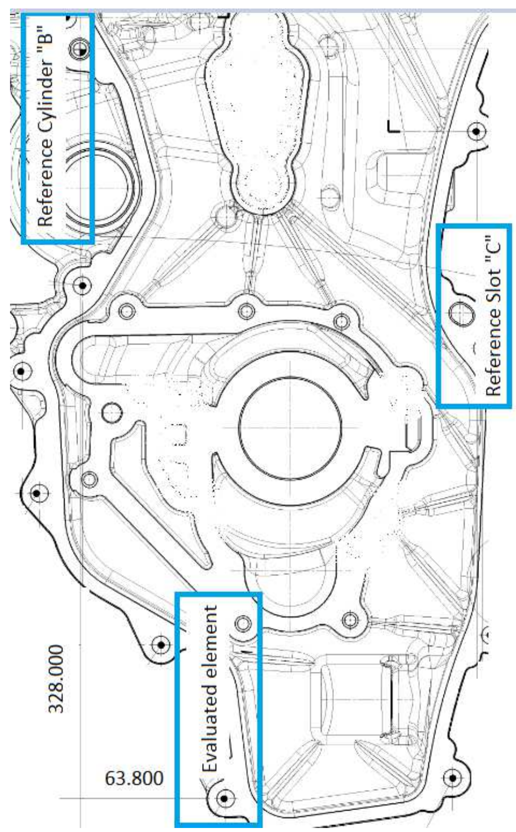

Fig. 11. Evaluated element and references B and C.

The measurement deviations are represented graphical in Figure 12, here we can identify with different colors the result from all tree methods. The differences between method 1 and 2 are very small because the evaluated surface tolerance is thigh and machined by CNC tools, we have a dimension of 8.05±0.02 for slot reference "C".

The ISO standard is used both for casting and machining surfaces and in this case, we can only see that the difference is very little between measured values.

For a casted surface the Figure 8 presents the influence of measured points during measurement process.

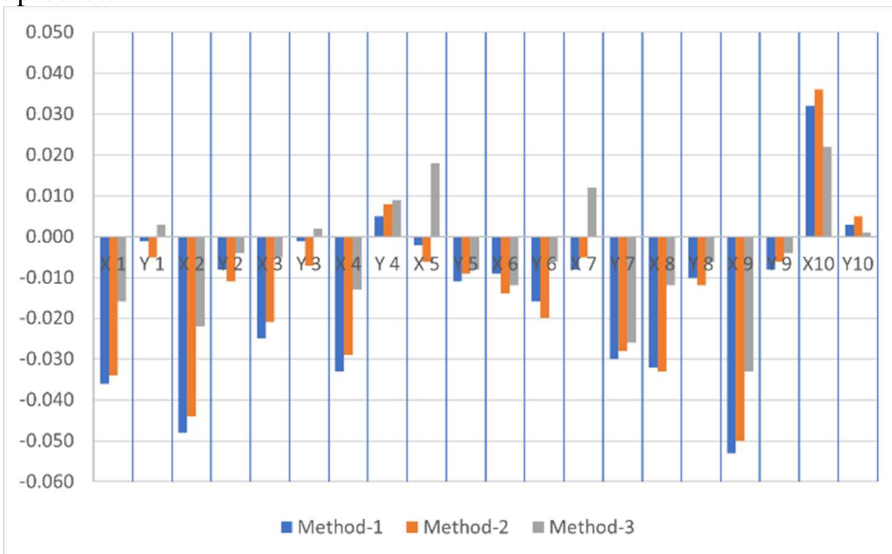

Fig. 12. Evaluated deviation for X and Y axis.

The evaluated surface must be maintained in ⌖ ⌀0.03 A B C tolerance condition. A mistake into reference system can cause the true position to be evaluated wrong and setup of CNC machine to be very difficult to be set.

The test focus is to maintain the measurement error as small as possible to ensure a fast setup of CNC and process control to be done without the risk to measure good parts and to have bad results.[10] For the test were used conform and not conform parts to understand the influence of slot reference movement. Figure 13 present result measurement using the tree method defined in Chapter 2.

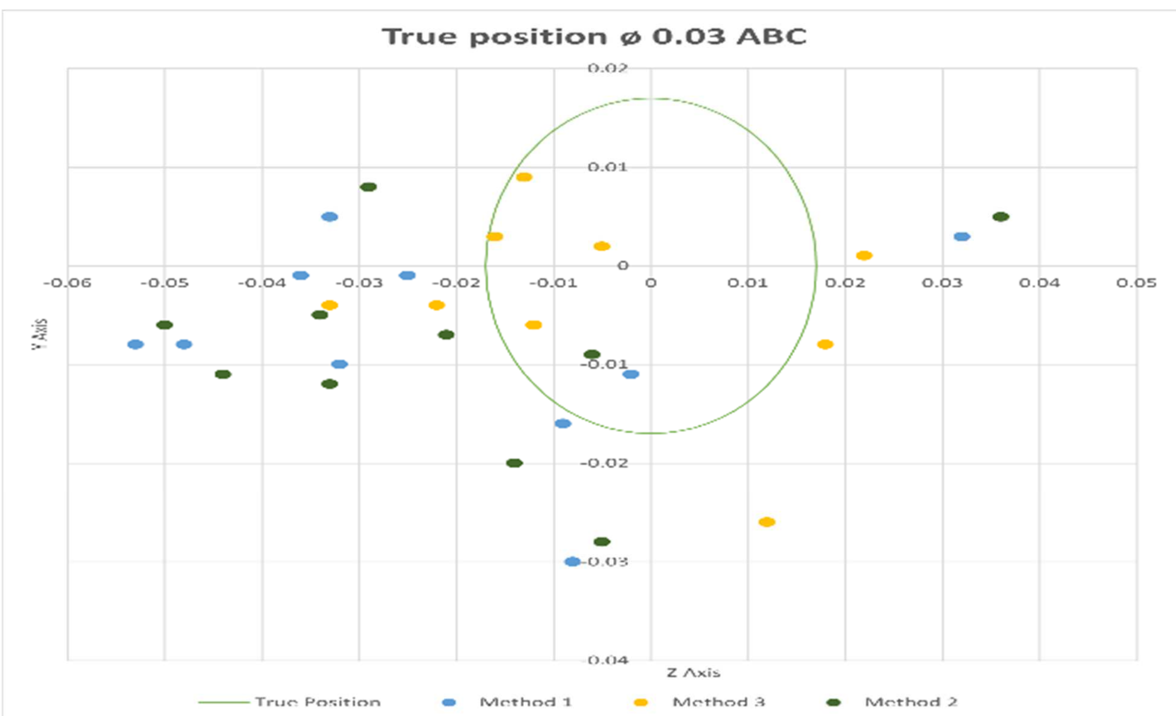

Fig. 13. Evaluated true position for measured parts.

4. CONCLUSION

Comparing values from Figure 12 with positions from Figure 13 give the possibility to observe that method 1 and method 2 results are most similar, method 3 give more positions closer to the nominals and this can be observed better in Figure 14.

Here we can see the influence of centering the alignment system of slot reference "C" by measuring the circles of the slot, creating the ax between them, and measuring the slot position on the middle of it.

The slot position hazes a tolerance that is verified as well in the measuring report, but if this is out of tolerance, we can adjust the setup without to have a big influence on the rest of measurement report.

Figure 14 also represents the connection of same measurement element by evaluating it with the tree methods described.

If we focus for a particular case, all measurement except point 10 are as we can see from Figure 12 deviated in the same part of the coordinate system, point 10, which is in the opposite side influence the method 1 and 2 by having the values different than the rest of measurements reports, while method 3 remain more constant and closer to the nominals.

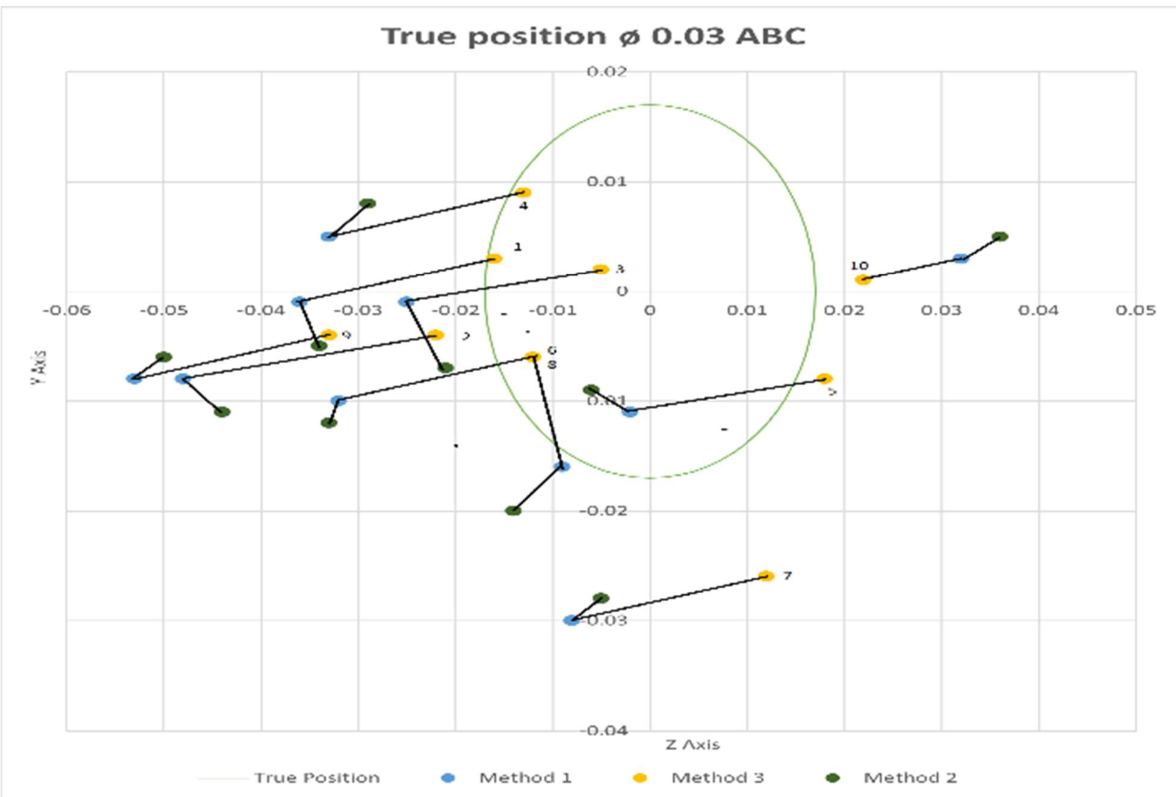

Fig. 14. Evaluated true position for measured parts.

To extend the work on this article we can evaluate more types of alignment systems that in the end should present same results.

The most important evaluation should be conducted for casted parts, where the surface of slot is not machined, and shape form can influence method 2 from method 1 when evaluation is made for another measured element.

Connection of machined coordinate system is always connected to this alignment system and all process of machining the part can present the influence of using these three distinct methods.

Another article that can present these influences can focus on the CNC clamping device, where parts are aligned and clamed on the casted references and measurement of the distance between reference B and C give a particular point of axis rotation that is different from the drawing requirement rotation system.

Method 3 can be applied on that exact point by crating the alignment of the slot to have the origin of clamping device.

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EVALUAREA REFERINȚEI TERȚIALE CU AJUTORUL CMM-ULUI PENTRU ÎMBUNĂTĂȚIREA SETĂRI PROCESULUI PE CNC

Rezumat: Funcționalitatea pieselor folosit în diferite etape in producție evoluează si se îmbunătățește permanent, datorită acestor modificări cerințele procesele trebuie sa furnizeze timpi tot mai scurți pentru reglarea procesului. Toate acestea cresc cerințele pentru nivele tot mai scăzute al pieselor rebutate la reglarea procesului dar si timpi optimizați în alocarea acestei etape a procesului, mai ales pentru celulele de producție dinamice. Procesele cu operații multiple, ce prelucrează piesa pe mai multe faze si operațiile de asamblare indică ca măsurarea acestor referințe pot crea o buclă de erori cauzată de interpretarea diferită a sistemelor de aliniament și acest lucru duce la creșterea timpului de reglaj al mașinii CNC. Pentru a elimina această eroare trebuie sa analizăm procesul pas cu pas pana când toate caracteristicile dimensionale sunt conforme cu cerințele. Acest articol va analiza diferitele metode folosite pentru a măsura o abatere de poziție care v-a fi influențată de baza de cotare responsabilă cu rotirea sistemului de coordonate, care este reprezentata de un slot și propune o soluție pentru a avea un sistem de aliniament mai bun și mai rapid. Importanța noi metode dezvoltate constă în crearea unei viteze mai ridicate în reglarea proceselor de producție și se axează pe toate rezultatele măsurate.

Petru Emanoil SERBAN, PhD Student, Eng., Durkopp Adler, Quality, Serban.Petru@yahoo.com, Office Phone +40727857000, Home Address. Str. Garii, nr 524G1, loc. Cristesti, jud. Mures, Romania, Home Phone +40741202028.

Lucian GRAMA, PhD Profesor, Profesor, University of Medicine, Pharmacy, Sciences and Technology “George Emil Palade”of Targu Mures, Faculty of Engineering and Information Technology University of Medicine, Lucian.Grama@umfst.ro, Office Phone +40265215551, Home Address N. Iorga street, no. 1, Targu Mures, Romania, Home Phone +40745787811.