Virtual instrument for technical and economic standpoint
evaluation of dimensional measurement methods and devices
for the machined components finished products

B C Braun

1 Product Design, Mechatronics and Environment Department, Transilvania University, Brasov, Romania
E-mail: braun@unitbv.ro

Abstract. The paper presents a research stage, within PhD Thesis, focused on critical analysis of the solutions for quality insurance in the production activity, standpoint dimensional inspection. The key was the programming of a flexible and efficient software environment, which will help the operator to make the proper decision on the best method and optimal means of dimensional measurement of various categories of fabricated components. It is practical one and it could be very important for productivity increasing, for low costs and also for finite products high quality. To accomplish this software application it were defined as inputs several criteria, like: inspection process timing, measuring precision, devices costs, process costs and energetic consumption. The most part of these criteria (process duration, measuring precision, devices costs) was possible to be established very properly, due to some previous analytical and empiric results, associated to several tested measuring devices

1. Introduction
In the last decades, the exigencies on product quality have experienced a continued increasing. Engineering standpoint, for a product to be reliable and safe, it must respect serious of strict functional requirements (e.g. automotive, aeronautics, robotics, biomechanics (prosthetic and orthotic), medical equipments etc.) [1], [2], [3]. For this reason, the dimensional and form inspection and surface quality for some functional key parts in the structure of the final products play a crucial key [4], [5], [6].

Surface quality inspection standpoint, for some parts there it can be successfully used, specific measuring devices (roughness apparatus, distance or displacement transducers). However, actually, in a large range of applications, especially in case of deformable, tactile sensible parts or micro-probes, it was proved to be very useful and efficient to use digital high magnitude microscopes or image based dimensional equipments [7], [8], [9].

On the dimensional and form inspection, especially for functional role, a growing scale has the use of CMM and 3D portable scanners, for digitization and even for form modelling (if necessary).

Of the series of functional probes is the category of those who perform translational and especially rotational movements. In their case, in many situations, for dimensional inspection, especially for functional parameters control (e.g. axial or radial beating, misalignments etc.) as measuring devices are recommended the displacement or distance transducers, coupled to a PC, laptop, smart phone or I-phone. These have the main advantage of a low cost comparing with CMMs or 3D portable scanners, however there are a lot of situations in which, despite the high cost, it is recommended to use the latter [10], [11].
2. Principle of measuring devices choice for dimensional and functional inspection

Regarding the used devices and methods for quality inspection, it is absolutely necessary to consider a range of essential aspects, like productivity, measuring accuracy, measuring range but also the costs concerning the acquisition and exploitation of the measuring device or equipment [12]. As a result, taking into account the productivity ask, the primordial criteria obviously is the productivity, meaning the efficiency standpoint measuring and inspection process. Besides this aspect, always must to consider the quality of the products, invoking certainly the measuring precision criteria. The measuring range could also become extremely important when relating to the nature and geometry of the parts composing the final products. Unfortunately, too high costs due to the acquisition, maintaining and exploitation of the measuring devices can often hinder obstacles in desired results obtaining standpoint quality insurance, especially via dimensional inspection [13], [14].

3. Software interface for optimal choice of measurement device

In the researches accomplished during the elaboration of the Doctoral Thesis, it has addressed, among others, the issue of critical analysis concerning the proper measuring device, starting from a concrete case, with the possibility to extrapolate for general cases. Starting from this idea, it was proposed a new solution for critical analysis to find the optimal device for dimensional inspection in case of revolution and translation parts [15].

To make it as flexible and efficient as possible, this critical analysis invoked the programming and developing of a software interface in Lab VIEW, that can be successfully used in a very large range of applications [15], [16].

3.1. Software interface description

The interface (O.E.M.A.vi), addresses, first of all, the above specified criteria. Thus means that, to have a conclusive information standpoint each criteria, when its running, the user has to complete, one by one several groups of text boxes, including all necessary technical details meaning using each one of the considered measuring device. Thus means that for all existing measuring systems, the input data can be easily and quickly be introduced by the user, similar to completing an on-line form. The groups to be completed all contain queries meaning technical and managerial data, which the operator can easily complete them. The first group of queries (figure 1) contain exclusive technical aspects on the inspection process:

![Figure 1](image)

**Figure 1.** First group of queries as input information to be completed

Each query, as text-box, meaning input information was defined in the interface to be related to boolean operators, which role is to process the information to obtain, finally the verdict. An example in this regard can be observed in figure 2, one of the input query (as text-box input string) being related to some Boolean operators. In this case, the necessary productivity (known by the operator to be ensured) must to be compared with the automatic determined productivity (as output information), the last information being automatically generation also due to the interface running. In this way, the interface, after its running, can provide conclusive and very useful information regarding the used
device. In this case it is about the productivity standpoint (figure 2). The programming algorithm for the other input – output relationships is similar.

**Figure 2.** Necessary productivity, meaning an example of an input query, to be related in Boolean programming algorithm

The second group of queries, meaning the second step to be accomplished by the operator (figure 3) refers exclusively to the measuring technical conditions. All asked aspects are known by the operator, he knowing all process details, so that it will be easy to be completed. In this group, the main aspect is that each input means that the operator has to choose an option from a predefined list. For instance, referring the query on the displacement transducer to be used, it is possible to choose one from an existing list, mentioning 4 types of transducers (e.g inductive, incremental, pneumatic or with LASER transducer). The input information on geometric parameters of the probes to be inspected mean the third group of queries to be completed before interface running (figure 3).

**Figure 3.** The 2nd and 3rd steps when input data introducing, meaning the second group of technical queries

The second group of queries, meaning the second step to be accomplished by the operator (figure 3) refers exclusively to the measuring technical conditions. All asked aspects are known by the operator, he knowing all process details, so that it will be easy to be completed. In this group, the main aspect is that each input means that the operator has to choose an option from a predefined list. For instance, referring the query on the displacement transducer to be used, it is possible to choose one from an existing list, mentioning 4 types of transducers (e.g inductive, incremental, pneumatic or with LASER transducer). The input information on geometric parameters of the probes to be inspected mean the third group of queries to be completed before interface running (figure 3).

**Figure 4.** Specifying the process’s dynamic parameters in terms of productivity
Also this category of information is very well known by the operator. After that, establishing the dynamic parameters for the inspection process is also very important, to have the information on productivity ensuring if using the selected measuring displacement transducer (figure 4). The cost criteria, one of the most important, must to be addressed as input queries in the 5th step, meaning costs information for each one of the existing measuring devices and also for the entraining system during inspection process is presented in figures 5 and 6.

![Figure 5. The costs queries on the first 3 types of displacement transducers](image)

![Figure 6. The costs queries on the last type of displacement transducers and entraining system](image)

Once all group of input queries were completed, the next step is the interface running, a group of outputs (marked in blues) providing all useful and conclusive information for a verdict regarding the type of measuring device, in the previously specified technical and economical conditions (figure 7). The illustrated example presents a case in which the selected device (inductive displacement transducer) would satisfy 3 from 4 criteria (productivity, measuring range and costs, but not the measuring accuracy). Thus means that the in discussion transducer would not be the optimal one for the necessary inspection process. The rectangular state LED displays the final verdict on the analyzed measuring device to be used. In the presented case, the LED is turned off, meaning a negative verdict for the in case chosen transducer.
Figure 7. Example results on all criteria for one of the chosen measuring device to be used for a dimensional inspection process, due to the interface running

In terms of programming, in figure 10 there is presented an example of a sequence referring to the algorithm which uses Boolean algebra for data processing to obtain the final complete information. The most important used function is a multiplexor AND type, having 4 Boolean inputs, being related to the 4 criteria specified in figures 8 and 9. Each one is shown as a Boolean output item (in green) (e.g. “The chosen transducer corresponds, costs standpoint”). The rectangular LED (as final verdict) shown in figure 9 corresponds to a Boolean item (framed in red in figure 8).

Figure 8. Sequence of algorithm programming to ensure the displaying the verdict and necessary information for the in case measuring device

4. Conclusions

In the Doctoral researches, all types of measuring devices were used, being known all technical and economic specifications. In these conditions, the presented software interface was programmed also as an important research activity. It was successfully tested for all used measuring devices. Finally, due to the use of the interface it was found that, for rotational and in translation functional probes (with application in aeronautics and automotive) the incremental proved to be the optimal one standpoint all criteria.

It was demonstrated that such of software interface could be successfully and easily used by almost any operator, specialized in metrology, on production lines. The most important aspect is that the interface, being user friendly, thus means that the staffs in field do not require any specific IT knowledge or skills.

It’s using could lead to the manufacturing processes improving, especially productivity and costs standpoints, having a positive influence managerial standpoint.
5. References

[1] Kishu, M 2011 Quality assurance: Importance of systems and standard operating procedures, Perspectives in Clinical research, pp 34,35

[2] Cristea, L 2008 Research concerning the improvement of bearings quality and performances, using automatic systems, The 19th INTERNATIONAL DAAAM SYMPOSIUM "Intelligent Manufacturing & Automation: Focus on Next Generation of Intelligent Systems and Solutions", DAAAM International Vienna, 22-25th October 2008, ISSN 1726-9679

[3] Giuseppe Di Leo, Liguori, C., Pietrosanto, A., Sommella, P. 2017 A vision system for the online quality monitoring of industrial manufacturing, Optics and LASERS in Engineering, ELSEVIER, 89, pp. 162 - 168

[4] Micu C., Dodoc, P. 1980 Aparate și sisteme de măsurare în construcția de mașini, Editura Tehnică București

[5] Militaru, C., Moldoveanu, M. 1991 Controlul dimensiunilor mari în construcția de mașini, Editura TEHNICA, București, ISBN 973-31-0305-5

[6] Cristea, L, Baritz, M 2008 Research on the improvement of bearings quality using automatic systems, Proceedings of the 9th International Conference on Mechatronics and Precision Engineering, COMEFIM ’08

[7] Barreiro, J.; Alaiz, R.; Alegre, E. and Ablanedo, D. 2008 Surface finish control in machining processes using textural descriptors based on moments, 6th International DAAAM Baltic Conference "INDUSTRIAL ENGINEERING 24-26 April 2008, Tallinn, Estonia

[8] Baritz M. 2015 Structural analysis by image processing of the multilayer ophthalmic polycarbonate lenses behavior during mechanical factors aggression, Metalurgia International, pp. 121-125

[9] Chenlong, L., Yongbo, Y., Mingyuan, Z. 2016 Uncertainty analysis of displacement measurement with Imetrum Video Gauge, ISA Transactions, ELSEVIER, 65, pp. 547 - 555

[10] Ponsar, M., Chicot, J. et al 2008 Three - dimensional measurement with LASER, The Romanian Review Precision Mechanics, Optics & Mechatronics, 18, pp 91 - 94

[11] COORD 3 Metrology 2015 Benefits of CMM Laser Scanning, Metrology in Focus http://www.coord3-cmm.com/benefits-of-cmm-laser-scanning/

[12] Braun B 2009 Contribuții privind optimizarea echipamentului de măsurare de la automatele de control, Teză de Doctorat, conducător științific: Prof. Dr. ing. Ciprian OLTEANU, pp 86+93

[13] QM for Windows, 2008 Modelarea și simularea proceselor economice. Manualul utilizatorului

[14] Cristea, L, Baritz, M, Roșca, I 2006 Modular reorganisation of the automatic system for the micro-bearings dimensional inspection, International Workshop "Advanced Researches in Computational Mechanics and Virtual Engineering", COMAT, ISBN 973-635-823-2

[15] Braun, B., Drugă, C.; Costăș, C 2008 The experimental determining of the dynamic dimensional control about the measuring precision, 6th International DAAAM Baltic Conference "INDUSTRIAL ENGINEERING 24-26 April 2008, Tallinn, Estonia

[16] Braun, B., Drugă, C., Olteanu, C 2007 The statistical evaluation of the aided by pc measuring results, via Lab VIEW. The 2nd International Conference "Computational Mechanics and Virtual Engineering" COMEC 2007, ISBN 978 -598 –117-4

Acknowledgments
The research presented in the paper was accomplished in the Doctoral stage, due to the CNCSIS national grant, code 293, awarded to young PhD students, in the period of years 2005 and 2006.