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VIRTUAL INSTRUMENT FOR COMPONENTS SCANNING AND DIMENSIONAL INSPECTION, WITH APPLICATION IN INDUSTRY AND OPTICS

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Abstract: *The paper presents a low cost and efficient solution based on a high flexible and user friendly software interface for the assisted dimensional scanning and inspection. The main advantage of the software using is that it can offer very quickly all the necessary information on the results, giving also conclusive information on the manufacturing process. The method can be successfully applied for components or probe inspection with application in industry, optics and medicine. The software interface can be used both in case of direct scanning (even manufacturing or turning process) and also in case of indirect inspection (post-process), depending especially by the dimensional measuring devices of the workshops equipments. The application was successfully tested on different types of probes with application in industry and optics, using classic and modern measuring devices. It was found that some components correspond, while other components were rejected or should be rectified.*
Keywords: *software, programming, probe, deviation, dimension*

1. IMPORTANCE OF SCANNING AND DIMENSIONAL INSPECTION

Always, the quality of the production process played an important role for the product quality and also in reliability and operational safety ensuring. For this reason, surveillance and production quality monitoring throughout the process is an absolutely necessary condition. One of the most important aspects refers to the form and dimensional inspection, without which there are major risks that products or components with an important functional role to break much faster than normal [1]. More seriously, these, during their operation could affect the operation or even working safety.
Some representative examples could refer to components inspection having application in industry, medicine optics. For instance, the automotive, robotics or renewable energy systems may be about, first of all, about components with role of rotation movement (pulleys, wheels, bearings, gears, flywheels etc.). In terms of inspection, it could be radial or axial beating measuring, diameter deviations and so on [1], [2], [3].
In Optics or Medicine for ensuring high quality of different type of apparatus (microscopes, telescopes, refract meters, polar scopes, diffract meters, tomography etc., a very great importance is given to the main optical components who equip this kind of apparatus. For this reason, form deviation testing or dimensional inspection for the main optical elements, like: prisms, parallel planes, lens, mirrors, is crucial to reduce drastic the optic and geometric aberrations, the most important condition to obtain clear and quality images using such of apparatus. The inspection, in this case could refer to sphericity, cylindricity, flatness or thickness deviations reported to an etalon, especially in case of lens or parallel planes [4], [5], [6].
Last years, different scanning and dimensional inspection coordinate machines or automatic plants were developed and continuously improved. Thus means that one might say that the equipment issue for efficient inspection is fully resolved. However, the fact that their use involves very high costs and also requires dedicated software with expensive licenses, this makes their use possible only within the big production companies [7], [8], [9], [10].
For this reason, the research described in this paper resumes to propose alternative solution for scanning or dimensional inspection with lower costs. For this it was proposed and developed a method using classic and modern measuring apparatus, associated to a high flexible and user friendly software interface. The classic dimensional measuring apparatus (used mainly in the workshops), refers first of all to mechanical comparators, while the modern measuring systems could refer to digital comparators and distance or displacement transducers [11]. These can function maintaining the contact with the scanned probe or not, having different principles

(magnetic, inductive, ultrasonic and optic principle). In the last years, a strong development was on the displacement and distance transducer, optical principle, especially in case of without contact transducers, based on LASER radiation emission [4], [5].

2. DIMENSIONAL INSPECTION. THEORETICAL BASES

Theoretical consideration meaning the basis to establish the conditions for ensuring the dimensional inspection for components with industrial, medical or optical applications, first of all refer to metrological standards.
In this regard, due to experimental and theoretical studies in terms of metrological considerations, there were established calculus formulas for tolerance dimension field, depending by the inspected probe's dimensions. This kind of formulas can be successfully applied for large range of used components in industry or optics. For instance, in case of industrial components, functional role (bearings, pulleys, flywheels, gears etc.), the formulas for dimensional tolerance field refer first of all to the diameter (d), as it could be seen in equation 1:

$$T_d = C \cdot \sqrt[3]{d} + C_1 \cdot d \tag{1}$$

where *d* means the diameter, *C* represent the processing technology coefficient and C_1 is the measuring errors coefficient [12], [13].
In case of components with application in optics or medical devices (prisms, lens, mirrors, parallel planes etc.), the metrological formulas refer to the thickness deviation, as main measuring parameter (equation 2):

$$T_g = C \cdot \sqrt[3]{g} + C_1 \cdot g \tag{2}$$

In this case, *g* represents the thickness of the inspected probe.

3. PROPOSED SOLUTION FOR LOW COST DIMENSIONAL INSPECTION OR SCANNING

3.1. General considerations

Starting from endowment in metrology laboratories, it has been proposed to carry out research on developing a low cost method for scanning and dimensional inspection for components with application in industry, optics and medicine, using existing measuring devices (classis apparatus and modern distance or distance transducers). The most important aspect of the research refers to the developed associated software interface as described below.

3.2. Software interface developing by graphical programming

The most important issue of the research referred to develop a software interface for assisted scanning or dimensional inspection for different types of probes with application in industry, optics and medicine, as it can be seen in table 1:

Table 1: Types of probes to be inspected, via developed software interface

With application in industry	With application in optics and medical devices
pulleys	parallel planes
bearings	prisms
flywheels	lens
gears	mirrors

The role of the software interface is to improve the inspection process, first of all standpoint of efficiency and also a very important aspect refers to the accessibility by the operator, meaning to be user friendly one. Another issue is to be flexible and to give all necessary information on the subject, in a short time.
As software programming interface, there was chosen the Lab VIEW environment, due to the fact that it enables the creation of virtual instruments for inspection, measurement, etc. Also it allows a good interface for the users, allows connection of data acquisition systems, specific measurement operations, assisted inspection, allows for the subsequent effective improvement of a VI already created [14], [15], [16].

The created software interface has a friendly graphical interface, in which the operator can introduce all the necessary input date and, after its running can obtain in a very short time all the necessary results and information on the scanned or inspected probe. To be easier to access dialog and text box on the panel interface, these were defined in two different colors, as it can be seen in figure 1: In red (on the left side) there are the dialog and text box, in which the user or operator will choose the input data (method of assisted inspection, scanning or inspection conditions, type of evaluated probe, standpoint its application, dimensional range, dimension of the monitored parameter etc. In blue (on the right side), the interface displays all the results and information about the assisted testing standpoint scanning or probe's dimensional inspection. Due to this, the operator will know exactly and immediately what have to do with the tested component.

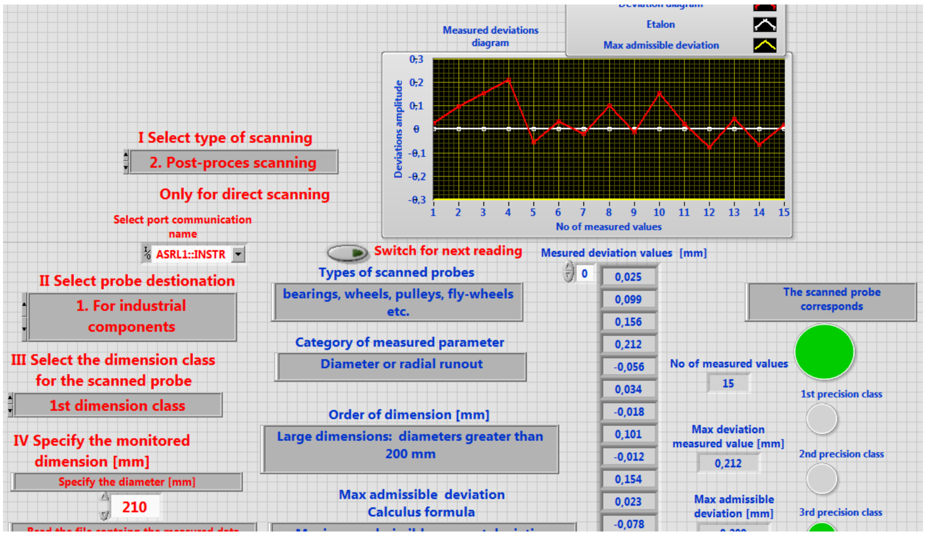

Figure 1: The created software interface for assisted scanning and dimensional inspection

In the following there it will be presented, at a time, each window, text box, text dialog for interfacing with the user: The first dialog box ("I Select type of scanning", figure 2) refers to a selection that the operator must to made, in the first step. It refers to the method of evaluation, meaning during the process (direct data acquisition) or post process.

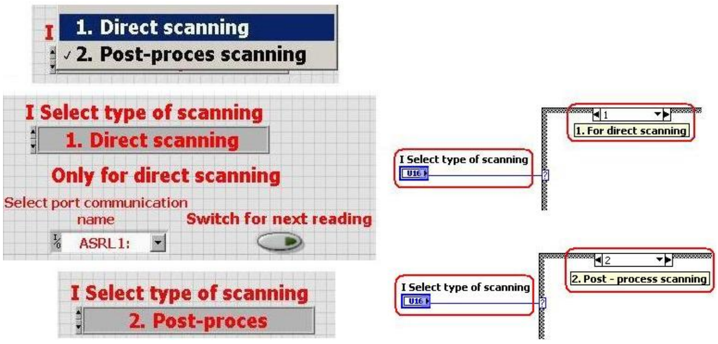

Figure 2: Dialog box for type of inspection choosing

Related to the interface, in terms of programming, in the diagram window, it was defined a switch-case structure, to address the two specific situation (figure 2, right side). The second dialog box allow the operator to select the category of tested components, standpoint their application (figure 3)

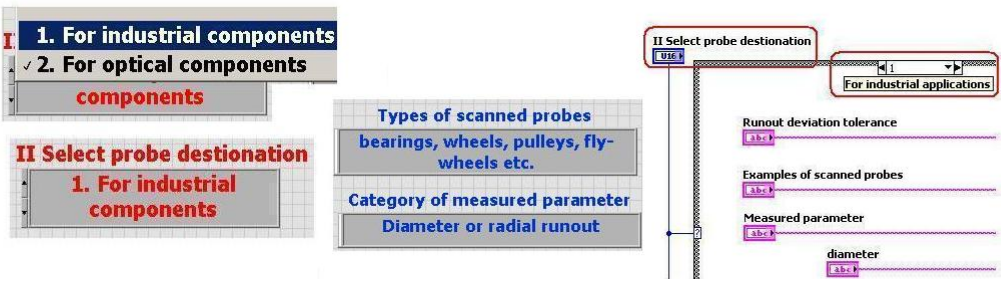

Figure 3: Dialog box for selection of category of probes to be scanned. Example of industrial probes case

Corresponding information related to the selection is displayed in blue into two text box (first for type of scanned probes and the second for the measuring parameter). As programming, another switch-case structure was defined, in which, in function of case, several string items have the role to display to the user all the specific information related to each selected case.
The next step which the operator has to go through is to select the dimensional class of the evaluated component, via another dialog box (figure 4):

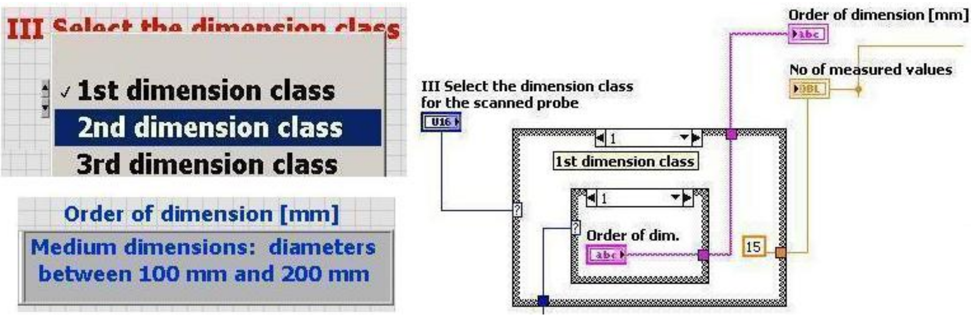

Figure 4: Dimensional class choosing

The corresponding text-box (in blue) informs the user on the dimensional range related to the tested component. The specific programming sub-routine invoked the defining of a switch-case (three iterations, one for each case category of dimension class), containing, in turn, a switch structure containing each one two cases, related to the type of application. In case of industrial application components, the text box shows the order of dimension in diameter, in case of optical application components, it displays the order of dimension in thickness (e.g. lens or parallel plane thickness etc.).
Next step for interface running is to specify the nominal dimension of the evaluated probe, against which the software will determine the measured deviations, as it can be seen in figure 5:

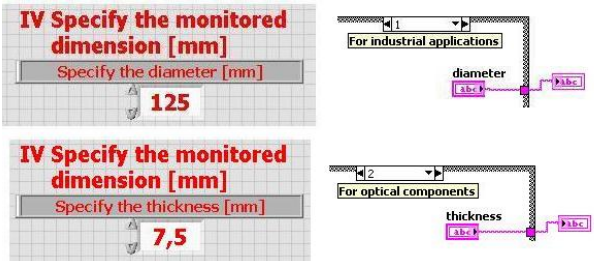

Figure 5: Specifying the nominal dimension of the tested probe

A case structure was programmed, each case containing a string, for displaying the type of dimension, related to each case (diameter in case of industrial components or thickness in case of optical or medical components).
Another text box intends to inform the user what he has to do, in case in which indirect scanning (meaning post-process inspection) is the option.

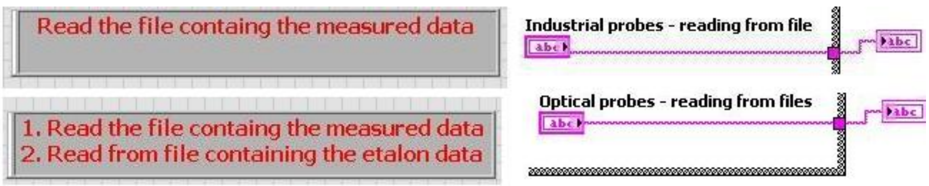

Figure 6: Displaying the message referring to the files reading to provide the data
If the operator has chose the post-process inspection (see figure 2), he must proceed to read from file the data (previously introduced due to measuring, using, for instance classical measuring devices). A message appears in which the user is informed what he has to do (from what kind of file must take the data (figure 6). Two strings were defined for the messages displaying, each one of them referring to each measuring case. The type of data files is predefined in format .XLS or .TXT, to be properly and quickly read. In this case, the software interface has the role to process the data and to establish a very clear and correct conclusion on the measured probe's evaluation results, in a very short time. For data files reading a special function was defined ("Read from Spreadsheet File"), with transposition option, placed into a flat sequence programming structure. Each sequence corresponds to a file reading, for instance, in case of optical probes, it is necessary to read from two file

subsequently, first from the file containing the measured data, and then from the file containing the etalon values.
In both cases (direct or post-process inspection, meaning reading from data files), a programming sub-routine has the role to determine automatically the results in terms of assisted measured dimension deviations for the certain probe. For this, first, a text – box, containing the measured deviations (in which considered equidistant point of the probe) displays the results, as numeric values (in blue), as it can be seen in figure 7. Besides, statistical information regarding the metrological standpoint are given, like: maximum value of deviation, for a measuring or scanning cycle and also maximum admissible deviation, according to the metrological standards, depending by the probe's dimension (using the relations 1 and 2).

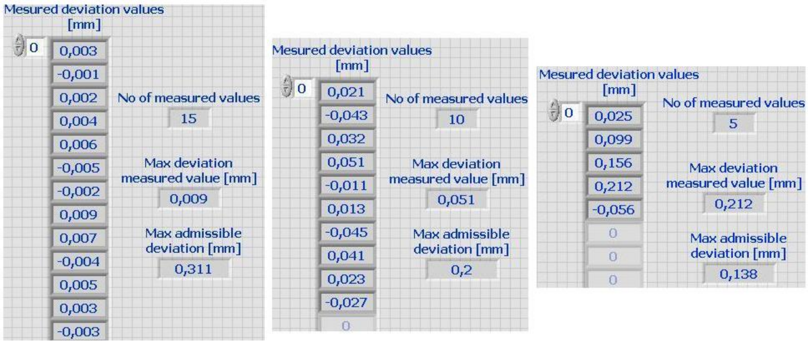

Figure 7: Example of determined dimension deviation values in case of an inspected lens

The results displaying can be made in different forms (different numbers of considered equidistant measuring points), according to the dimension class of the evaluated component. In the first case it is about of a large dimension probe, the second case corresponds to a middle dimension, and the last case addressed a small dimension class for the tested probe. To determine the numeric results, some arithmetic algorithms were applied for the sub-routine programming, one of them being based on the relations 1 and 2.
Besides, the software interface displays a conclusive diagram of the measured form or dimension deviations chart distribution (figure 8). The most interesting aspect is the distribution diagram (represented in red) reported to the extent limits (represented in yellow), informing the operator not only about the numerical deviation values, but also about the some zones (indicated by points of measuring) where there might be problems. If the distribution diagram is situated entirely inside the yellow limits, the diagram informs that the scanned probe corresponds. Else, the probe has some problems regarding its manufacturing precision.

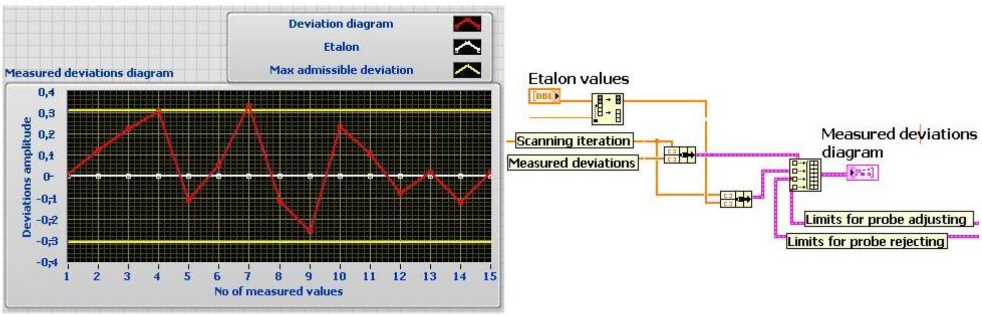

Figure 8: Example of diagram of dimension or form deviation distribution for a scanned probe

Several LEDs of state inform the used about the final conclusion on the tested probe (figure 9). If the big LED turns red, than the tested probe is rejected. If it turns green, than the probe is accepted. The small LEDs inform about the precision class related to the evaluated probe. For each precision class, a programming algorithm was defined, through each precision class corresponds to an equidistant sub-interval, from the interval determined by the tolerance limits.

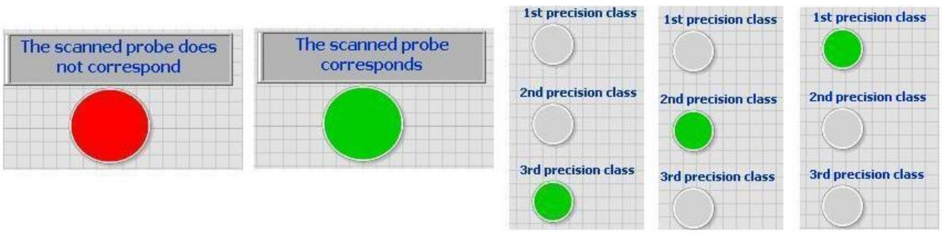

Figure 9: Examples of final conclusion (via LEDs of state) referring to the tested probe

4. RESULTS AND CONCLUSION

The method was successfully applied for two gears, a flywheel, three bearing rings and two lens testing, invoking classic and modern measuring devices, meaning both direct and indirect method of scanning. Due to the tests, some important conclusions could be drown: the flywheel corresponded, from the three inspected bearing rings, only one corresponded and from both gears one corresponded, the other did not corresponded. In terms of lens, also it was proved that one of them corresponded and the other din not correspond.

It was demonstrated that the software interface use could be extended to the workshops and even in the industrial environment, the solution being flexible one. The interface could be used during the production (e.g. during turning, grinding, polishing, gluing etc.) and also post-process, giving important information on the manufactured components sorting.

In the present, the software can be used during the production (direct scanning or inspection method) meaning a data acquisition system using serial communication ports. Unfortunately, this solution is no more useful, because the this type of communication ports are no more compatible with the modern gadgets (e.g. laptops, tablets, I Phones, smart phones). For this reason, an important future direction of research is the acquiring, developing and implementation of modern communication systems (e.g. USB or Bloototh devices, adaptable to the measuring devices and to the modern gadgets).

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