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Low Cost Solution for Glasses Components Assisted Inspection Optometry Offices Workshops

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***Abstract*—The paper presents a research stage in which a software interface as virtual instrument was envisaged, designed, developed and tested. Interface testing involved two distinct steps, as follows: first stage has meant a thorough, step-by-step verification of the correct operation of the interface, in all aspects, for each distinct stage of its programming. In the second stage, we proceeded to simulate the processing of fictitious values meaning dimensional, shape and optical parameters of some components of glasses. Once the software interface was tested and validated, it was successfully used in a first stage. More specifically, the effective assisted verification of some sets of glasses was carried out, under all the aspects mentioned above. As a final conclusion, it was possible to demonstrate that the proposed solution could be successfully implemented in many of the workshops of medical optics and optometry cabinets.**

Keywords*—*glasses, interface, parameters, inspection, simulation

I. Glasses Inspection and Contact Lens Role

It is proven that, both in the process of education and training, and in jobs, the use of laptop, tablet, smart phone is indispensable. This, unfortunately, almost inevitably, over time, leads to gradual loss of vision or various eye diseases. If, treated in time, these can be reduced (especially at an early age), unfortunately in many cases they can no longer be corrected, but only stopped as evolution, by wearing glasses and / or contact lenses [1], [2].

To really help the person in question, a thorough and correct previous prescription is absolutely mandatory. Thus, in this sense, especially if it is about wearing glasses for the correction of strabismus, astigmatism or anizoiconia, the role of the optometrist is fundamental. This statement is based on the fact that any prescription of glasses or contact lenses must necessarily be preceded by a fair and thorough determination of the correction parameters of the lenses [3]. Or this aspect is mainly dealt with by the optometrist, preferably in collaboration with the ophthalmologist. For this, the strict observance of the evaluation stages for the prescription is absolutely mandatory. autorefractometer and noting the determined correction values. Subsequently, the correction adjustment must be performed, using the test frame for the

Another important aspect regarding the prescription of glasses refers to the physiognomy of the subject's face. From this point of view, the aesthetic aspect is also very important; thus, for example, rectangular frames are fitted to a round face, rectangular shaped frames are fitted to an oval face, as well as classic frames, etc. The client's preferences (regarding the choice of the type of frame that suits him best) must also be taken into account very carefully when prescribing a pair of glasses or contact lenses. It is recommended, however, that the choice of the type of eyeglass frame be made under the guidance of the optometrist (who will take into account the aesthetic aspects of the face physiognomy). Subsequently, aspects such as cutting, processing, grinding, grinding, lenses, and frames are most frequently targeted at the level of the workshops within certain medical optics [4], [5].

II. Solutions Regarding the Inspection of the Glasses in the Manufacturing Stage

A. The importance of simulators

Nowadays, in order to avoid as much as possible waste, loss of materials, time, resources, more and more use is made of simulator software environments, to virtually establish the dioptric powers of the lenses, you have to ensure a fair correction. The simulators allow to go through all the correction steps, as in the real case, being able, at each step, to follow the feedback of the way in which the correction is applied accordingly [5], [6].

B. Processing procedure importance

Generally, the processing of the lenses is done in the workshops of the optometry and ophthalmology offices, by cutting from a raw lens, having the necessary dioptric power of a shape specific to the geometry of the ring of the glasses frame. The adjustment of the processed lenses involves operations of form rectification, their grinding and licking. For a proper and efficient lenses processing, procedures for measuring the geometric dimensions and refractive powers with specific means are recommended. This is preferably ensured even during the processing process, in active and passive control mode [7], [8].

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Unfortunately, however, most of the time this procedure is quite laborious, it involves many additional steps of work, which can lead to a considerable increase in the time required. Worse, due to multiple verification and control operations, subjective errors can occur at some point that can compromise the quality and safety of the delivered product [8], [9].

III. PROPOSED SOLUTION

Based on the above-mentioned considerations, regarding the shortcomings in terms of efficiency and subjective errors in the technology of mounting glasses, in recent years more and more ingenious solutions have been developed for this purpose. One of the most efficient solutions is to equip the cabinets with state-of-the-art equipment and devices in order to process and check the components of the glasses during the manufacturing process. But the big problem is their very high acquisition and maintenance costs, which makes many of the optometry and medical optics offices unable to afford them. For this reason, a solution would be to increase the number of employees in the workshops, but this would also significantly increase production costs [10]. For this, such as the use of dedicated software interfaces for this purpose. However, the disadvantage would be the very high cost of a license, because of this only a small part of the medical offices could afford to purchase such dedicated software licenses. A large percentage of medical opticians, equipped with production workshops could not afford such a solution.

For this reason, this paper presents a practical solution, synthesizing aspects of theoretical and experimental research. It consists in the design and development of a low cost software interface for assisted inspection during the production of glasses in the workshops of medical optics offices. The interface is intended to ensure efficiently all aspects of the correct completion of all stages of production; besides, the interface aims to help qualified personnel on the production side, in the workshops, significantly simplifying the procedure and, as a consequence, considerably increasing efficiency and productivity. The use of the interface in terms of ensuring the assisted post-process inspection, during the production process aims at two main aspects: the first refers to the geometric and shape parameters of the processed frame; the second aspect refers to the geometric, shape and optical parameters of the processed lenses; here, first of all, it is about their dimensions (width, height, thickness at the center, thickness at the edge) but also about their dioptric powers [8]. The possibility of fast data processing is a particularly important aspect in the development of the interface. Moreover, the possibility of saving data into EXCEL files is meant to provide a particularly useful feedback both in the production process but, especially related to the remedy of some aspects that might otherwise lead to repeated errors. When designing and developing the software interface, a very important aspect was taken into account, namely the flexibility of its use, for different categories of glasses, both in terms of frame shapes depending on the physiognomy of the face and in terms of optical parameters of processed lenses. Besides, it can be used for absolutely any type of glasses, for subjects of both sexes and for all age categories. The presented interface development supposed first of all its design, starting from the needs of an assisted and efficient inspection of the production operations. Subsequently the step-by-step programming of the interface was carried out, using a graphical programming interface. Simultaneously with the programming stage, but especially at the end of it, the interface was tested to see if it meets all the aspects covered during the design stage, as well as to verify the extent to which data processing and processing numerical is done correctly. The most efficient method of testing the interface was the one through which various simulations were performed regarding the assisted inspection of some spectacle components, the procedure for performing the simulations being described in more detail in paragraph 4.1. The programming of the interface was done in a graphical window associated with the *LabVIEW* environment. In this context, a multi-case programming structure was used, associated with an input variable, specific to the choice of the category of glasses components subject to inspection (frame or lenses). For each case, we proceeded to program its specific algorithm. For example, for the specific case of frame inspection, a main aspect referred to the definition of a *Boolean* structure regarding the choice or not of the frame-specific data processing option. For the affirmative situation, another multi-case structure was defined, regarding the specification of some standard values, imposed regarding the parameters of the frames. Two other *Case Switch* structures were also used for random programming of all computational algorithms for processing numerical data measured during the processing and assembly process. Specifically, it is a structure specific to the shape parameters of the frame and another structure specific to the geometric and optical parameters of the lenses. For a correct and efficient interpretation of the processed data, an algorithm for calculating the reference values of the parameters of the spectacle components was necessary. It was designed in two stages, exactly in two sequential structures for the necessary calculation algorithms. Also, for processing and saving data in EXCEL files, sequential structures were programmed, including several *Boolean* structures for accessing the option of selective data saving. Regarding both the first category of components (frames) and the second category (lenses), the problem of a strict calculation algorithm was posed, through which, from a metrological point of view, the values of the parameters measured during the process can be correctly determined. More specifically, these are programming subroutines for processing 3 measured values, specific to each parameter of interest, both for frames and lenses. The using of the interface while its running has proven to be particularly efficient, providing the full range of necessary information specific to some fundamental aspects of assisted inspection of orchestration components during the production process. In support of this statement also comes the aspect related to the very short duration for a running cycle of the interface, specific to a pair of glasses in progress. According to the operator, the procedure for using the interface is simple, with the following steps: step 1. Reset all values, using the commands (*Edit – Reinitialise values to default*); step 2. Choosing the category of testing glasses, which involves choosing the appropriate option from a predefined list of the *Chose the category of tested glasses* dialog box; step 3. Selecting the component for the current testing glasses (first the frame must be selected); 4. Data importing (as previously measured numeric values) for processing for frame; step 4. Data processing for frame; step 5 – Saving results into EXCEL files (while interface running a dialog box will guide the user what to do for data saving); step 6 - Disabling the data processing option; step 7 - Selecting the component for the current testing glasses; step 8 - Data importing (as previously measured numeric values) for processing for lenses; step 9 - Data processing for lenses and finally results saving into EXCEL files for lenses parameters. Figure 1 presents an exemple of the interface for the assisted inspection.

To validate the developed interface, a set of 5x3 simulations was performed. More exactly, assisted testing was simulated for the production of 5 categories of pairs of glasses (for children aged between 5 and 10 years, for children aged between 10 and 18 years, for adults with a round facial appearance, for people adults with an oval facial physiognomy, also for adults with a triangular facial physiognomy). For each set of glasses pairs, 3 simulations were made to observe possible errors occurred in the operation of the interface and in the correctness of the data processing.

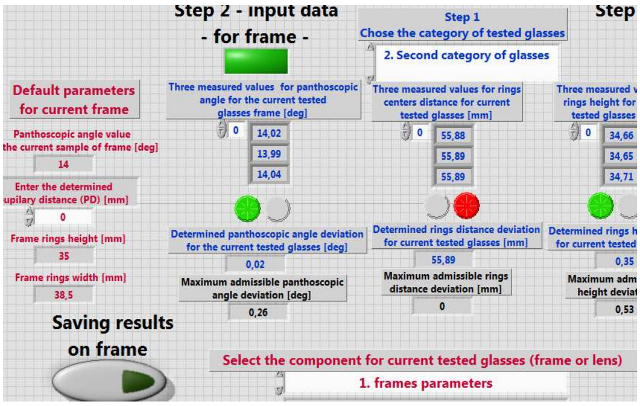

Fig. 1. Example of using the interface in the process of assisted inspection of the processing and assembly process for a pair of glasses - exemplification for frame testing

IV. Results and conclusion.

Following the testing and validation of the interface, as a result of some sets of simulations, it was used concretely for the assisted inspection in the case of 3 sets of pairs of glasses, each set including 5 pairs of the same category [8].

Specifically, a simulation meant an evaluation of a set of 5 pairs of glasses. For each simulation, using the developed software interface it was possible to evaluate, on the one hand, the technical parameters of the rings and the arms of the glasses, respectively the optical and geometric parameters of the lenses. Of interest were the values of the deviations in relation to a prototype of glasses in the respective series, the values being automatically generated within the interface, then saved as EXCEL files.

Subsequently, the data were processed, obtaining 5 diagrams of variation of the deviations, for each pair evaluated, separately. The procedure was applied for each of the 3 simulations, meaning for each set of 5 pairs of glasses (figures 3, 4 and 5). For the first simulation it was observed that, in general, the distribution of deviations was almost reproducible for all 5 pairs of glasses. It was noted that for the geometric parameters of the lenses the deviations were the largest and almost the same for all 5 pairs (figure 3). The simulation for the second set of glasses pairs also involved almost similar values on the parameter deviations, however existing two exceptions: 1. The deviations on the geometric parameters of the frame for the second pair were significantly more large (up to 7-8 times) than in the case of other pairs; 2. The deviations of the lenses optical parameters for the first pair were significantly smaller (up to 18 times) than in the case of the other pairs. At the same time, in this context, for the second simulation it could be found that only the first pair corresponded from all points of view, being able to be considered accepted for assembling (figure 4). For the third simulation, with two exceptions (width deviation for right eye lens and 1st dioptric power deviation for right eye lens), the distribution of deviations for all 5 pairs was almost identical (figure 5). However, due to the fact that some of the geometric and optical parameters invoked notable deviations (up to 5-6 times higher than the specific deviations of the other parameters), no one of this set could be considered accepted for assembling.

The criteria according to which the deviations on technical parameters for frames and lenses could be considered to fit or not within certain limit values were established via metrology, based on calculation relations regarding the determination of some tolerance fields [10], [11]. In this context, for certain frame-specific dimensional parameters (rings width and height, distances between the rings centers), the relation regarding the tolerance field (T_X) was established according to the relation (1) [11]:

$$T_X = C * X^{1/3} + K * X \quad (1)$$

where *C* is a coefficient of the processing technology; it could be *0.45* în case of rings width and height or *0.4* in case of distance between the rings centers; *X* means the concerned dimension (width, height of center's distance) and *K* an error processing technology coefficient, being equal to *0.001* for width and height and *0.002* for distance between the rings centers. In the case of deviations regarding the pantoscopic angle of the frame arms, the relationship is slightly different, in this case a coefficient regarding the degree of adjustment of the arms (χ) for assembly being recommended to be taken into account:

$$T_\theta = (C * \theta^{1/3} + K * \theta)^{1/\chi} \quad (2)$$

where θ is the measured nominal value of the standard panthoscopic angle, specific to a frame prototype and χ can take different values depending on the frame's typology (ie 0.96 for frames with round face adaptation, 0.98 for frames with oval face adaptation or 0.97 frames with rectangular or triangular face adaptation. For lenses geometric parameters it could be used the relation (1) to determine the high-limit deviation while for dioptric lens power limit deviations the relation (3) was recommended to be applied:

$$T_P = T_D + (C * P^{1/3})^{1/\eta} \quad (3)$$

where T_D means the tolerance field for lens diameter's deviation, P – measured lens dioptric power and η is a coefficient considering the lens geometric aberrations (η could be established to be between *0.95* (for high aberrations) and 0.99 for low aberrations).

These considerations were taken into account when programming the algorithm specific to the automatic deviations establishing for geometric and optical parameters evaluated for both frames and lenses (paragraph III).

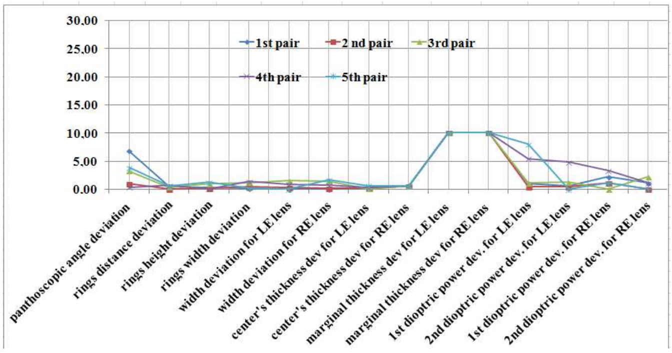

Fig. 3. Determined parameters deviations for the 1st set of tested glasses (in percents)

Based on the methodology of using the interface, as well as the results obtained for testing the 3 sets of pairs of glasses, it was possible to ascertain the efficiency and usefulness of this proposed solution. For this purpose, in the future it could be widely implemented in several workshops of optometry and medical optics offices. In addition, as future research steps, an extension of the interface and for the inspection of contact lenses is envisaged.

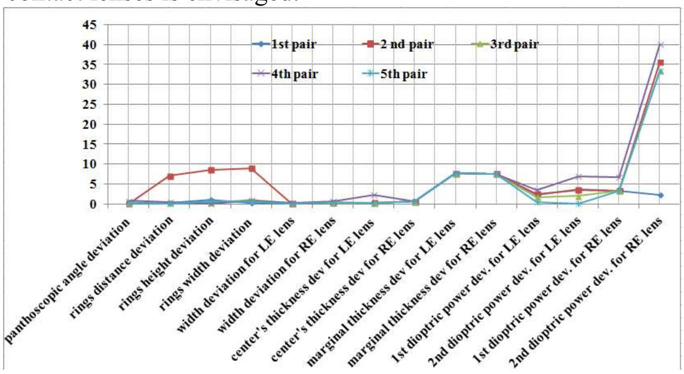

Fig. 4. Determined parameters deviations for the 2nd set of tested glasses (in percents)

For this purpose, in the future it could be widely implemented in several workshops of optometry and medical optics offices. As future research steps, an extension of the interface and for the inspection of contact lenses is envisaged.

Although the proposed solution could involve a disadvantage, such as interfacing with a screen (visual problems may occur over time), it can be successfully compensated.

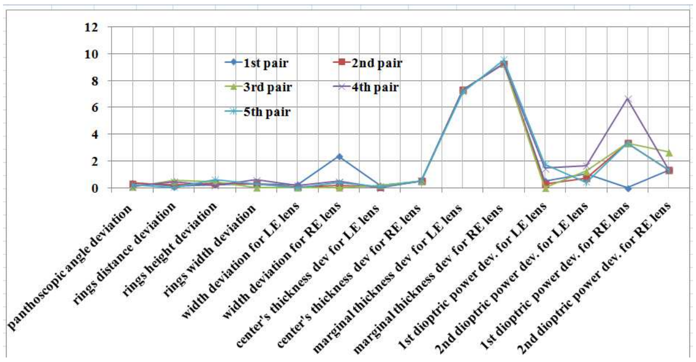

Fig. 5. Determined parameters deviations for the 3rd set of tested glasses (in percents)

This can be ensured, on the one hand by using screens with a high degree of radiation protection and, on the other hand by reducing the time required for meticulous calculations (on paper or on the computer), which would involve a much longer eye strain.

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