Study on the Use of 3D Scanning as a Verification Method in Technical Quality Control

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***Abstract*—As defined in ISO 9000, quality control is a part of quality management focused on fulfilling quality requirements. The main objective of the quality control is to determinate any unacceptable product defects such as cracks or surface irregularities. The main method used in quality control is the visual inspection, but with the continuous evolution of technology, new methods of verification have emerged. One such method is represented by the use of 3D scanning. This method consists in scanning the physical part, the dimensional evaluation being made on the CAD model obtained after the scan. In this paper, a case on the use of a the 3D portable scanner Go!Scan Spark as a method of technical quality control is performed, the results being compared with the CAD model, as well as with the values in the technical drawings.**

***Index Terms*—3D scanning, projectile, quality control, CAD model, dimensional accuracy.**

I. Introduction

A very important aspect when questioning whether a product is safe to be put in use is that its dimensions falls in the tolerance required by the technical documentation.

Before a product is put into use, it is necessary that it be subjected to certain tests to confirm its usefulness, as well as the necessary dimensional accuracy. The control quality is reception procedure done on fabrication flux or when purchasing a product, and that it implies a surface treatment, a dimensional check up and so on. These checks are made in the technical quality control section where the product is passed through several dimensional checks. If the product deviates from the nominal dimensions, it or even the whole lot from which it comes is rejected.

Inspection is the principal component of quality control, this consisting in the visual examination of the physical product, made by product inspectors. There are different methods of applying quality control, each company having its own method of verification.

With the evolution of technology, a new method of quality verification has been used, quality control using 3D scanners. These 3D scanners are used to scan 3D objects using point cloud plotting and re-model the main object and even modify it to the user's will [1]. By using 3D scanning and reverse engineering technology in conjunction with rapid prototyping technology, the geometric data of components can be easily and rapidly measured and analyzed. The detailed report can be printed out directly to fulfill the requirement of total quality control for quick response products [2].

One of the advantages 3D scanning techniques is that it can provide an accurate surface of the tested elements consisting of point clouds, which can reflect the actual dimensions of the element. In addition, point clouds can be transformed into actual models and compared with design models through reverse modeling [3]. Another advantage of 3D scanning is that this method can determine certain dimensional values that would normally be difficult to measure.

II. 3D Scanning as a Method of Technical Quality Control

One relevant application of 3D scanning is the method of the technical quality control, which is of particular importance in ensuring a good concordance between the technical drawigs of the product's dimensions and surface characteristcs. Scanning can be done both on an assembly level and at the level of subassemblies and parts.

The technical quality control process through 3D scanning is built from 3 stages: (1) scanning, (2) point processing, and (3) modeling the scanned mesh in specialized programs such as SolidWorks. This process is represented in Fig. 1.

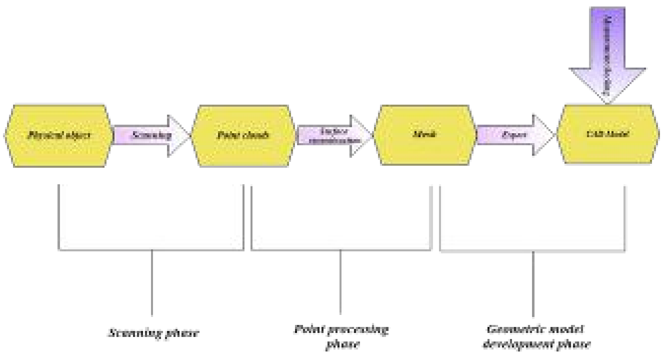

Figure 1. The technical quality control process by 3D scanning

The first stage with which the technical control is carried out is the 3D scanning of the product. This is done with the help of the Go!Scan Spark scanner, a optical device that

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projects light stripes on the object, and then records the distortion of the lines via 3 the cameras over the entire light pattern, thus creating a surface.

The scanning phase consist of choosing scanning techniques, preparing the part, and performing the actual scanning, all which restults in a output materialized a point cloud file [4].

The point pocessing stage consists in importing the raw point cloud data, reducing the noise, and reducing the number of points using filter algorithms that can merge differrent assemblies and subassemblies where the product is captured in multiple 3D scans [4].

This phase is performed using the VXmodels extentention of the scan package, being followed by the next step, to create a 3D model of the product, using a CAD program.

Through VXmodels' features, the raw surfaces resulted through scanning are cleaned of the noise and the additional objects captured in the scanning process, aligned with the additional parts that were separately scanned (where is the case), improved by checking and editing the surfaces created by the program after the first stage

The VXmodel interface provides a navigation tree that will show what you have worked on in (modules, meshes, alignments and entities), allows to hide or show items and allows to view details on meshes, alignments and entities.

In the last stage a 3D reproduction is created based on the mesh resulted by the processing of the 3D point cloud data. With this phase completed, tehnical quality control can begin, so the 3D model obtained provides the geometric dimensions of the scanned product , and these will then be compared with those provided by the technical drawings.

The most common import and export items that VXmodels provides are VXelements sessions, Modified Meshes and CAD Models, that come with the specific file extensions.

Therefore, summarizing the the quality control process through the 3D scanning, based on the surface reconstruction (mesh) a 3D model of the product is creted in a CAD program. This model will provide the geometric dimensions of the product, that will be later compared to the dimensional references provided by the technical drawings.

III. Experimental Study of 3D Scanning as Quality Control Method

To test how 3D scanning can be used as a method of technical quality control, an experimental study was performed, presented in this chapter. The following subchapters present the testing methodology, the processing of the obtained data, as well as the results of the study.

A. Experimental setup and procedures

The experimental setup is illustrated in Fig. 2 and represents the main items needed in order to perform the process of scanning:

a) The GO!Scan Spark scanner is a professional, portable 3D scanner designed to scan any object without need for a set-up, also offering details of the object such as texture and geometry acquisition.

b) The 30×165 mm AP-T projectile, an armor-piercing projectile that is generally cast from a special mixture of chrome steel melted and forged into its shape. Projectile's nose geometry and shape is an important factor in order for it to pierce an armor of a certain hardness, this affecting the mechanism of deformation of the target plates [6].

c) Positioning targets, that hold an important role in the scanning process, due to the fact that they create a mark and aid with the right positioning of the scanner.

d) The surface on which the scan is performed must be matte, to ensure a functioning of the scanner in the nominal parameters. The positioning target placement is recommended to be as random as possible, so that the scanner would pick up more marks such that even when the scanning process is stopped it can be picked back up from the point it was left.

Figure 2. a) Go! Scan Spark 3D Scanner, b) 30×165 mm AP-T projectile, c) Position Targets, d) Surface on which the scan was performed

The purpose of this experiment is to determine whether 3D scanning is an effective method of technical quality control. In this project, a projectile was designed using SolidWorks CAD software, as we can see in Fig. 3.

After obtaining the CAD model, the projectiles were manufactured using CNC machines, using the values from the technical drawings. For this experiment, a number of 10 random projectiles were chosen.

The 10 projectiles were scanned under the same lighting conditions, using the same 3D scanning method and following the same data processing steps. The scanner was calibrated before each scan began.

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Figure 3. Reference CAD model

In order to start scanning the 10 projectiles, a matte surface was chosen, which would reflect as little light as possible, the position targets being placed on this surface as reference elements. For the scan processing part, the VXmodel and VXinspect software were used.

Using the scanner Go! SCAN SPARK and VXscan software, each projectile was scanned. In addition to geometries, the Go! SCAN SPARK scanner is also able to pick up the texture of the projectile. Thus, in the VXmodel program, using the "Texture" command, the scanned texture can be added. This is shown in Fig. 4.

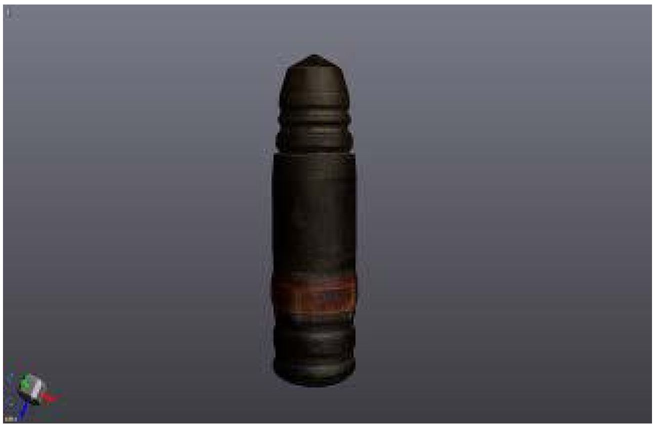
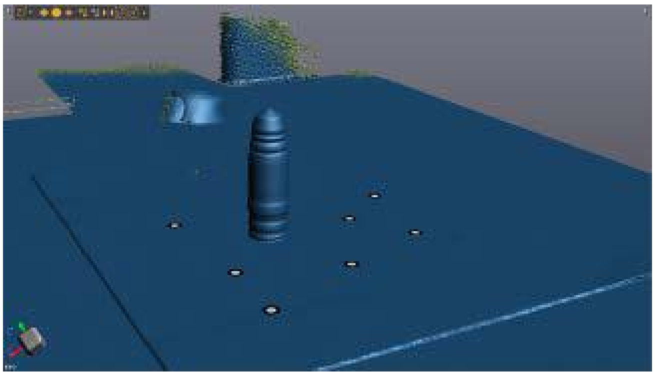


Figure 4. Scanned projectile with added texture

As you can see in Fig. 5, in addition to the 3D model of the projectile, there are other entities, such as the surface on which it was scanned or other objects in the background. These items were removed using VXscan software.

First, with the "Remove background" command, the area on which the scan was performed was removed. The next step was to select the surface of the projectile and with the help of the "Keep only"| command, all other entities not related to the element of interest were removed. Using the "Finalize" command, the scan was completed, and the resulting model was sent to the VXmodel software for post-scan processing.



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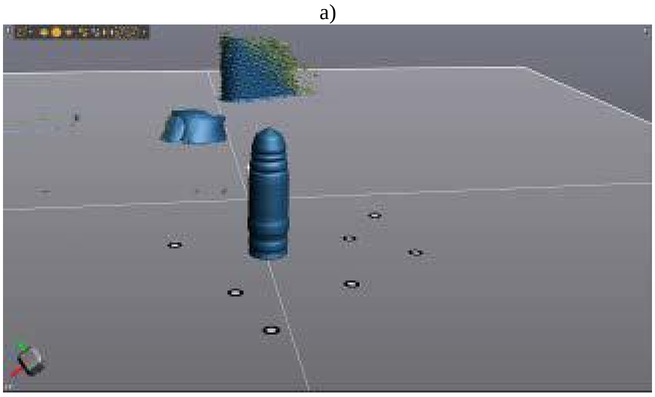

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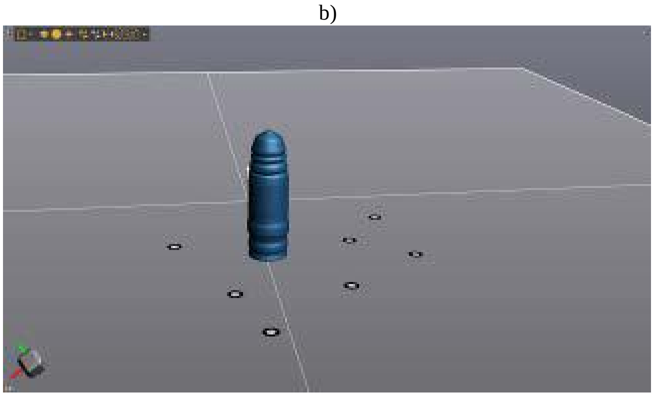
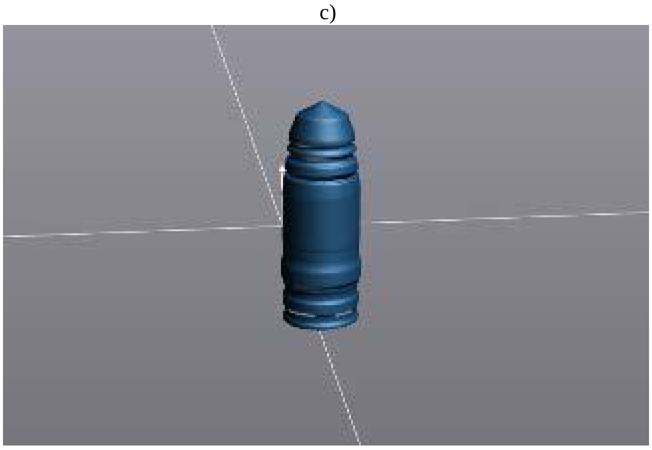


c)



d)

Figure 5. The scanned model after: a) The end of the scanning process, b) "Remove background" command, c) "Keep only" command, d) "Finalize" command

As can be seen in Fig. 6, the model obtained in VXmodel has several defects, such as holes in the surface or surface irregularities. To correct these defects, using the "Clean mesh" command we eliminated the irregularities on the scanned surface, and with the help of the "Fill holes" command we managed to have a uniform pattern, without surface defects. In order to complete the obtained model and to send it later in the VXinspect software, we use the "Clean mesh" command again to eliminate the possible spikes that appeared as a result of filling the gaps.

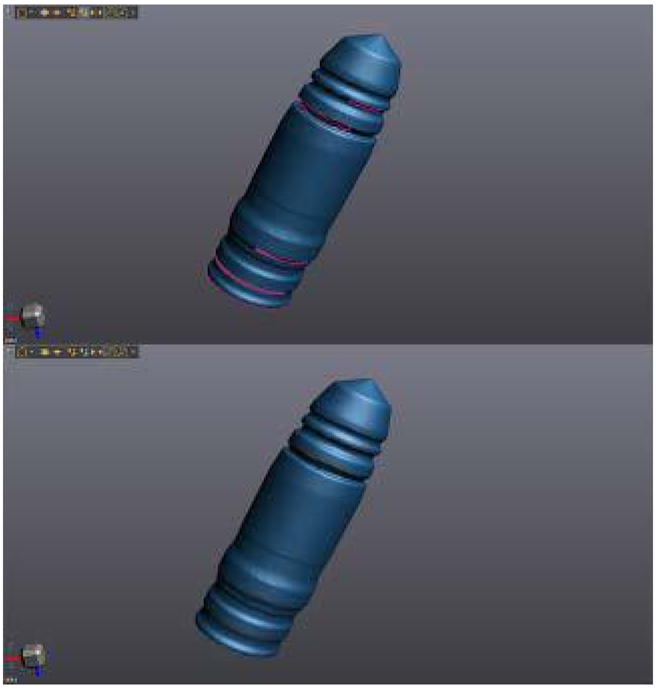


Figure 6. The scanned model before and after the processing

B. Scan results and comparisons

To determine if 3D scanning is an appropriate method of technical quality control, the scanned model obtained was compared with the original CAD model.

As comparison elements, several dimensions of interest of the projectile were chosen, such as the total length or the diameter of the forcing arm. These values are shown in Fig. 7.

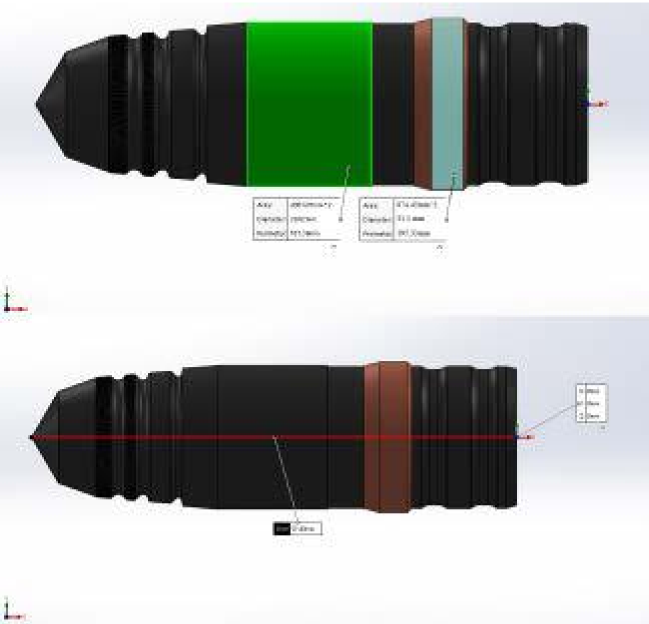


Figure 7. The values of interest for the comparison of the two models

In order to highlight the dimensional differences between the two models, with the help of VXinspect software we can overlap the two entities. The two overlapping models are presented in Fig. 8.

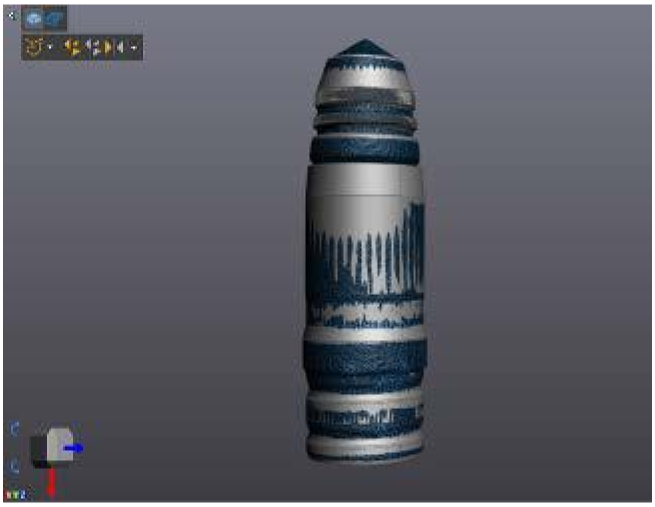


Figure 8. The CAD model and the scanned model overlap

The biggest differences are in the area of the forcing arm, in the threaded areas, as well as in the ogival part. These differences occur as a result of 3 different sources of error: dimensional errors caused by the projectile manufacturing process, errors from scanning devices and dimensional errors that occurred as a result of the reconstruction of projectile surfaces using software.

In order to be able to observe all these differences, a deviation map (Fig. 8) was made with the help of the VXinspect program. This map consists of 30 ranges of values, 15 for positive values and 15 for negative values, as well as a range for nominal values. Nominal range (green color) represents the areas whose minimum or maximum deviation does not exceed the values of –0.015 mm and 0.015 mm. The deviation map was made for each scanned projectile, the maximum and minimum deviation being presented in Table I.

TABLE I. MAXIMUM AND MINIMUM DEVIATION OF THE SCANNED PROJECTILES COMPARED TO THE CAD MODEL

Projectile No.	Minimum deviation	Maximum deviation
1	-1.033 mm	1.315 mm
2	-1.132 mm	0.920 mm
3	-1.005 mm	0.982 mm
4	-1.079 mm	0.916 mm
5	-1.120 mm	0.915 mm
6	-1.012 mm	1.026 mm
7	-1.021 mm	0.965 mm
8	-1.004 mm	0.954 mm
9	-1.028 mm	0.906 mm
10	-1.005 mm	0.946 mm

The maximum deviation is 1.315 mm, for projectile number 1, and the minimum deviation is –1.132, for projectile number 2. Also, studying the 10 deviation maps, we found that for each projectile, the minimum differences are in the ballistic cape crimping grooves area, while the maximum deviations are in the area of the forcing arm. These errors are due to the scanning mode, the 2 areas being areas of high detail.

Another comparison can be made between the dimensional values of interest for the scanned model, the CAD model and the dimensional values according to the technical drawing. This comparison is presented in Table II.

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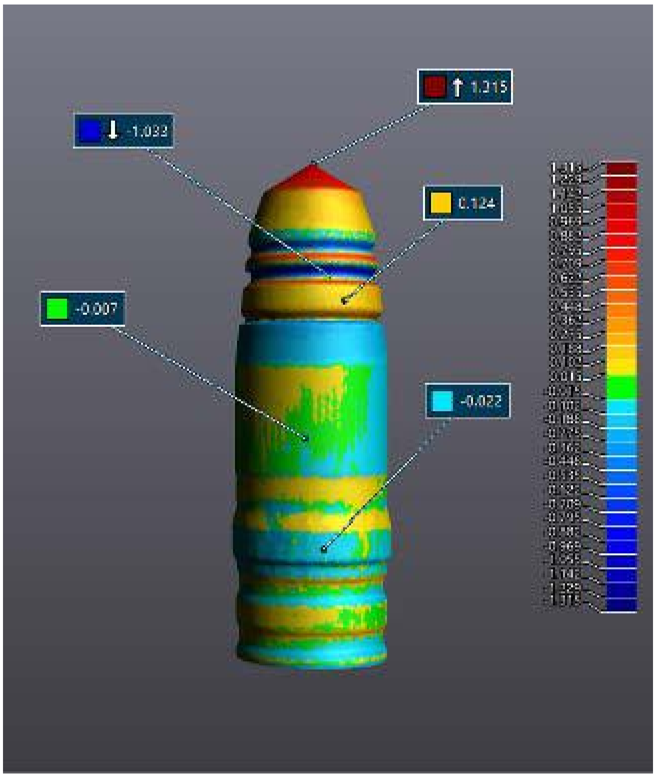
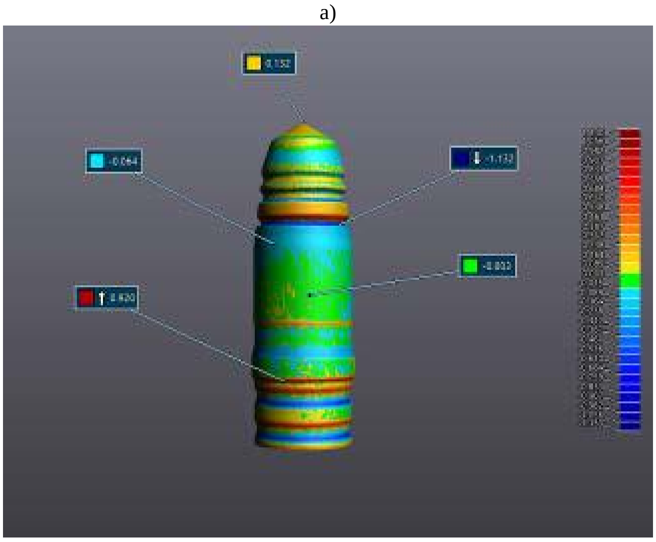
TABLE II. DIMENSIONAL VALUES OF SCANNED MODELS COMPARED TO CAD MODEL

No.	Scanned model			CAD model		
	Length	Forcing arm diameter	Body diameter	Length	Forcing arm diameter	Body diameter
1	96.88	30.86	29.55	97.49	31.1	29.95
2	97.74	31.11	29.79	97.49	31.1	29.95
3	96.66	31.13	29.84	97.49	31.1	29.95
4	96.88	31.14	29.87	97.49	31.1	29.95
5	96.81	31.10	29.79	97.49	31.1	29.95
6	96.83	31.14	29.86	97.49	31.1	29.95
7	96.80	31.16	29.87	97.49	31.1	29.95
8	96.38	31.15	29.84	97.49	31.1	29.95
9	96.71	31.08	29.17	97.49	31.1	29.95
10	96.95	31.13	29.83	97.49	31.1	29.95



a)



b)

Figure 9. The deviation map of projectile: a) number 1, b) number 2

C. Comparisons results and discussion

As mentioned in the previous subchapter, there are several reasons that lead to differences in dimensional values. The main errors come from the scanning mode and the software processing, which are influenced by a multitude of factors, such as poor lighting, shadows on the scanned body, erroneous approximations of the software for surface gaps or the wrong scanning angle. These errors affect the overall performance of the scanner.

Given the results obtained, for 3D scanning to be an efficient method of quality control, it is necessary to take into account several aspects. First of all, in order to make the control in the most exact parameters possible, the scan must be done in such a way that on the obtained model there is no need to make approximations of the surfaces with the help of the software. Also, if the scanned bodies have reflective surfaces, it is recommended that they be coated with a mattifying substance to eliminate reflection, such as White Powder Spray from Creaform 3D, but not affecting the finish of the part.

Another important aspect to consider is performing multiple scans of the same object for higher dimensional accuracy. Thus, putting together different scans, the resulting mesh will be more accurate, each scan raising the degree of accuracy. The joining of the models can be done with the help of VXmodel software, the main disadvantage of this process being the fact that it is time consuming.

Taking into account these aspects, the results obtained are satisfactory, the average deviations from the original model being below 0.5 mm. It should also be borne in mind that physical products are not completely identical to the CAD model, as they have certain tolerances in which they fall.

IV. CONCLUSION

The technical quality control is an important step in the development of a new product, following this process it can be stated if the obtained product falls within the initial requirements. 3D scanning is a relatively new technology, but it is used in a wide range of fields, such as reverse engineering or quality control.

The purpose of this article was to verify whether 3D scanning technology is a coherent and precise method of technical quality control and whether it can be a substitute for classical control methods. Following the experimental testing of this method, the results obtained were satisfactory.

The experimental study consisted in scanning 10 projectiles using the Go! Scan SPARK scanner. The mesh obtained was subsequently compared with the CAD model of the projectile. Following these comparisons, a number of conclusions can be drawn, such as:

· the scanned model is very close in size to the reference CAD model, the biggest differences being in the detail areas of the parts;

· the gaps that appear due to the inability of the scanner light to penetrate those areas are filled by the corresponding software by approximation, this leading to some dimensional errors;

· areas of great detail, such as striated areas, are not recognized by scanning;

· areas in the scanned model that reflect the scanner light more are slightly larger than the actual size of the product;

· for a better scanning accuracy, in the part of the mesh processing it is recommended that all the commands for correcting the model be done manually, in order to avoid possible errors that appear as a result of the automatic correction;

· 3D scanning is recommended as a method of technical quality control for hard-to-reach dimensions to be measured manually.

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