# ON MOLD VOLUME MEASURING – A QUICK APPROACH

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**Abstract:** *Quality and specifications are directly connected, as many times assumed as "conformance to requirements." Frequently quality inspection is implemented statistically by the manufacturer. However, it could be required on every item to guarantee the requirements. It is the case of molds, as, any inconformity will reflect in the production ahead and is usually required by the customer. In this paper we present preliminary results for inspection and measurement of metallic complex shapes.*

**Keywords:** *Volume, Molds, 3D Scanner, Metrology, Inspection, Quality*

## 1. General Introduction

Virtually all manufacturing based definitions identify quality as "conformance to requirements."(Garvin, 1984). Frequently quality inspection is implemented statistically by the manufacturer. However, it could be required on every item to guarantee the requirements. It is the case of molds, as, any inconformity will reflect in the production ahead and is usually required by the customer. The manual inspection of every mold is often impossible due to the time taken to inspect each mold one by one.

In this paper we present preliminary results for inspection and measurement of metallic complex shapes. Specimens are glass molds.

The scope here is the volume rather than a specific dimension or shape. A quick and effective method for measuring the enclosed volume is required that could be cost and time effective. Primarily objectives are to detect the existence of a volume non-compliance with the tolerance.

Quality inspection will be performed mainly to fulfill costumers' requirements. Subsequently, to ensure quality to new possible clients and a feedback to the operators of the line. It will allow an understanding of the errors being generated and where in the production line they are occurring, allowing improvement.

The scope is glass molds and their inner cavity (Figure 1). That is a complex surface, curved, defining the shape of the bottle with the particularity of being made of polished metal, making the surface extremely shinny and reflective.

Thus, it is challenging to fit a geometric shape to the mold outline. Also shinny surfaces are very difficult to scan.

Dimensions of molds can vary depending on the bottle to produce. Even for the same mold dimensions, there are slight variations leading to different volumes.

A mold consists of three parts: two cavities and the bottom part as shown in Figure 1.1. The material is either cast iron or bronze.

## 2. State of the Art

The techniques and technologies already in place and approaches related to volume

**Figure 1 -** *Mold*

measuring allowed to acquire experience and learn advantages and disadvantages of each approach and where difficulties can arise from. Although virtually no references are found in the subject it is not possible to determine a priori which will be the most effective approach towards the desired goal. Despite that, all of the mentioned before need to be taken into account developing a new concept or solution. Effectively the time constraints (more than costs) could be conflicting with the solution performance, as the surface complexity and the nature of the material are not controlled.

One operator can actually perform this task: the mold is joined, closing the gaps with an appropriate isolating material. Having the mold closed it is filled with water. From water weight and temperature, easily the volume is obtained.

Another approach to measure molds inside volume is proposed is Sonicam (Sonicam, n.d.). It consists of a system designed to fill a balloon, (“bladder”), as it can be seen in Figure 2.4b. Bladders are produced in several sizes specific to each type of mold and range of volumes to measure or with the desired dimensions in case of a special order if it fits the minimum and maximum dimensions described in the technical specifications.

## 3.Researched approach

A 3D scanner is a device capable of capturing digital three-dimensional information about the shape of an object. It can capture shapes from a small gear tooth to a real size aircraft. Some can also acquire appearance data such as color and depth.

Commercial cameras and scanners in general were developed to measure distances in larger scenes than the one used for this purpose. These devices have applications such as detection of body parts or obstacle detection.

Early approaches make use of RGB commercial cameras and structured lighting. The latter was obtained from pattern projection or structured light (usually laser or infrared) and slice projections using a planer laser beam. However, they were limited by the computational effort required, thus making their use limited for quality in-line surface inspections.

RGBD cameras simplify the effort. In this specific case there are many expected advantages. Since the current manual procedure is time consuming, it is expected to optimize inspection throughput. Additionally, the surfaces can be matched to projections detecting small variations and/or surface defects. Several technological solutions were considered to determine the best solution regardless of its cost, therefore it is important to understand the principles behind of each method. In order to scan the molds Red, Green, Blue and Depth (RGBD) cameras was used. These are a specific type of depth sensing devices that work in association with a RGB camera, that are able to augment the conventional image with depth in a per-pixel basis.

This model uses a stereo infrared technology, meaning the device has two infrared cameras resulting in better depth accuracy compared to older models

## 4. Acquisition System

One advantage of these depth cameras is they are not sensitive to illumination, and the distance measured should be stable. On the other hand, they are sensitive to the surface characteristics giving variable results. Thus, preliminary tests where done through a 3D printed model, for which characteristics where known.

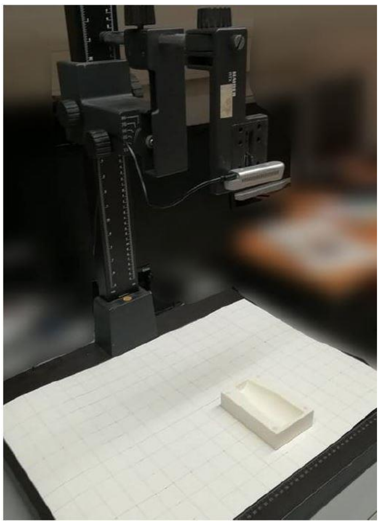


**Figure 2** *Data acquisition*

These can be seen in Figure 2. It is quite remarkable the size of the sensor, allowing it to easily be included in inspection apparatus.

## 5. Analysis

The focus was on testing the implementation performance rather than to quantify the quality of the plastic mold used. Once a final solution is tested and considered functional the implementation will be focusing on the quality control of the mold produced, by returning a mold volume, an error and an uncertainty of the measure calculated during the testing.

The idea showed to be promising for simple geometric shapes which is not the case of typical molds for the glass industry.

The current approach was the use of RGBD cameras, as the Intel RealSense D400 series cameras for all the acquisitions. RealSense D400 or Kinect series cameras have its main purpose for larger size scenes, where they are supposed to be used. The acquisition speed is being expected to overlay precision issues, required to achieve the desired goals for these approaches. However, the fact that a fast system could be achieved makes it still to follow.

Data is primarily grabbed through accompanying software, and processed in sequence through MatLab®.

As it is possible to observe in Figure 3, the use of the digitization table will simplify the processing. Although, some small amount of correctness should be performed in order to eliminate misalignment on the bottom surface. Distances are measured to the camera plane. Points are presented viewed from behind in to enhance the curvature obtained.

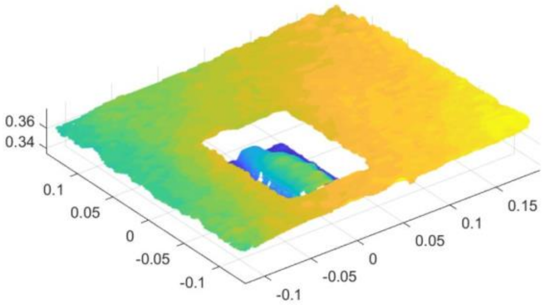



**Figure 3-** *Data acquired – inverted image*

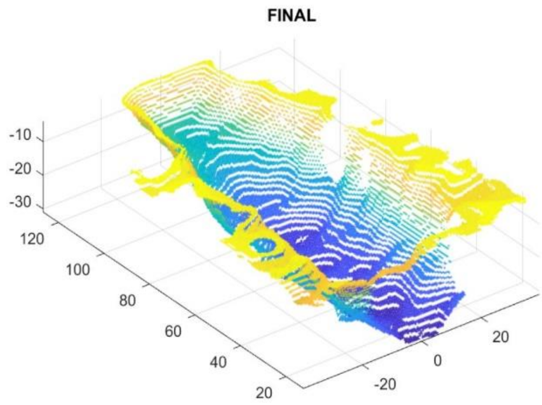
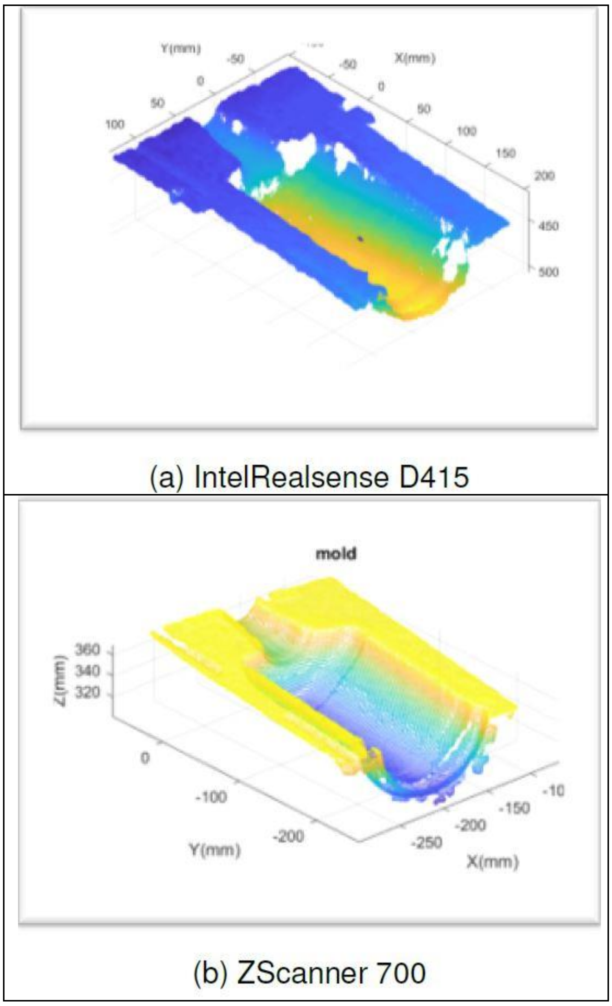



**Figure 4 -** *Data selected for processing*

## 6. Results

Results were obtained for different scanning of molds. Molds were fixed in a bench with artificial room illumination. The first approach was again with Intel RealSense D415 for the 3D printed simulated mold. As it can be observed in Figure 3, the shape and dimensions are present. The mold is abs, non-polished, but with imperfections and an unsmooth surface. However, there are missing data, which are due from curvature and small size of the model. Results where promising, but insufficient for a quantitative comparison. Data obtained from true molds (Figure 4) allow to make quantitative comparisons between values obtained and true values. However, mold shape increases the missing areas. These, although could be required by moving the camera, implies the calculus to be executed by sections. Which is conflicting with time requirements for the in-line system.

For this reason, the use of a hand scanner was researched as a comparison pattern. One example is on Figure 5. Cloud points obtained from Intel RealSense D415 and ZScanner 700 are presented. The ZScanner, although with a more precision is the juxtaposition of multiple passages, without any complementing powder.




(a) IntelRealsense D415

(b) ZScanner 700

**Figure 5-** *Comparison*

## 7. Conclusions

In the previous sections the possibility of implementing a volume measuring solution for the glass mold industry was pursuit. The need behind this research and the methodologies to follow were described. Several approaches were pursued and tested.

The molds are produced in bronze or cast iron, with polished surfaces, with complex features and engravings.

| | D415 | Hand Held |
|---|---|---|
| Volume (cm3) | 1017,5 | 1017,5 |
| Computed (cm3) | 951,2 | 1019,2 |
| Percentage Error | 6,5% | 0.2% |

Main concern was through the use of RBGD cameras and a comparison with hand scans of data acquisition were used. This allowed to understand their advantage for the desired application. One of the main constraints time, allowing it is to be used in production line and cost effectiveness.

Tests were carried out with Intel RealSense D415, D435, Kinect and ZScanner 700, cameras with no reconstruction algorithm relying in one acquisition only, that although showing promising results for applications of standard objects as boxes did not perform with sufficient precision and accuracy that would allow them to be considered for a mold volume measuring solution.

Although more precise, the data from a hand held scanner requires large time to be acquired until all the gaps have been closed. To overcame this situation several hypotheses are being considered, as for instance, to close the cloud point by extrapolation and 'a priory' knowledge (e.g. symmetry, or the blue prints use) or for the use of multiple cameras.

## References

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