Industrial Mechanical 3D Model. Study of the remaining deformation due to thermal expansion in industrial hopper.

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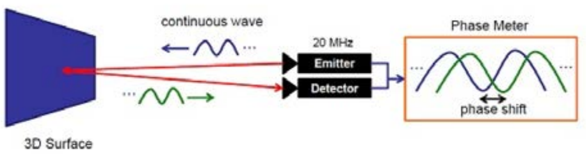
Abstract: - The objective of this work is the study of the remaining deformation of a hopper industrial using synoptic measurement technology, fast, accurate and, as important, that allows us to model the element in question at a certain moment of its useful life. To assess what is the current situation of this industrial hopper, what deformations it presents and what useful life that element can have with the situation it presents and its deterioration throughout this time. The advantage of using imaging techniques as 3D laser scanning over other methods allow us to take a large number of points with high accuracy in a period of relatively short time, which reduces the cost in working hours and allows to offer a high demand service.

Key-Words: - Industrial hopper, remaining deformation, imaging techniques, synoptic data, 3D laser scanning.

1 Introduction

Dimensional optical metrology is the science that one entrusts of the measure of lengths and of angles, assigning to each of the realized measures a certain mistake related to the instrument of measure and to the process.

Laser-based measuring system is an imaging technique, an optical measurement method, which offers real advantages in three-dimensional measurement of the surface of an object. The analysis of the reflected light from a laser beam (X,Y,Z, Intensity) is recorded in a matrix in order to model the object. Laser-scanning system along with photogrammetry are the fast-three-dimensional measurement.



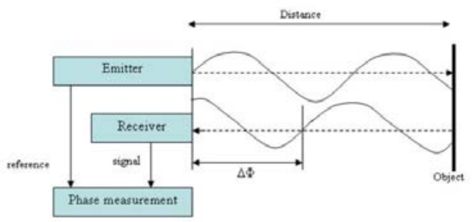


Fig. 1. Outline of operations of a laser phase difference scanner [12].

As-built documentation encompasses the measurement of an existing machinery o industrial structure with facility. The object of this study is the provision of precise geometric data (millimeter accuracy or better) of an industrial tune with corrosion problems.

The classical methods (curb, optical line of reference, optical triangulation ...) have several disadvantages, among them are the lack of precision. The measurements are very discretized by what was worked in concrete areas of the hopper where it is assumed that there are major deformations. They are very slow, slower methods the greater the precision required. This translates into the cost of the project, not only because of the number of hours used by the technicians, but also by detecting the production of the hopper for a long period of time, causing great losses to the production company.

2 Problem Formulation

The objective of this work is the study of the remaining deformation of a hopper industrial technology using synoptic measurement technology, fast, accurate and, as important, that allows us to model the element in question at a certain moment of its useful life.

Traditional methods such as curb measure the circumference of the hopper by a mechanical or optical method at a given height (reference level) and the remaining circumferences at the higher levels are determined by measuring radial horizontal displacements from vertical reference lines in several points of the circumference (ISO 7507-1).

The reference optical line method is used also in order to determine the perimeter of the different element heights using a graduated rule guided by a magnetic carriage. Therefore, the walls of the hopper are traversed and using a theodolite, located at a certain distance, different points of the element are measured (ISO 7507-2).

Another method used is optical triangulation in which the volume of the hopper is measured using two theodolites. The angle measurement and the trigonometric calculations used allow to estimate the volume of the element (ISO 7507-3).

All the methods described above are methods based on point measurements (discrete number of points or linear measurements).

This hopper in its work cycle suffers from mechanical and thermal stresses that, with the passage of time, generates certain deformations. The objective of our work is the continuous measurement of the element to be studied. To quantify them we have used a laser scanner (phase difference), considering that it is the type of technology which can best solve the problem raised taking into account the precisions, distances and synoptic capture that is intended to be made.

Therefore, the main objective of this study is to assess what is the current situation of this industrial hopper, what deformations it presents and what useful life that element can have with the situation it presents and its deterioration throughout this time.

This work will also serve as the basis for using this type of technology for the geometric characterization of elements that suffer deformations or pathologies throughout of its useful life and learn how to use cloud point management programs such as SCENE of FARO and modeling programs such as the Geomagic of 3D Systems.

The importance of knowing the deformations suffered by the industrial hopper is no other than to be able to determine an approximation of the useful life based on the remaining deformations. Being able to also know the most affected areas is very useful as it will help us to apply preventive actions before the deterioration leaves out of service to the hopper.

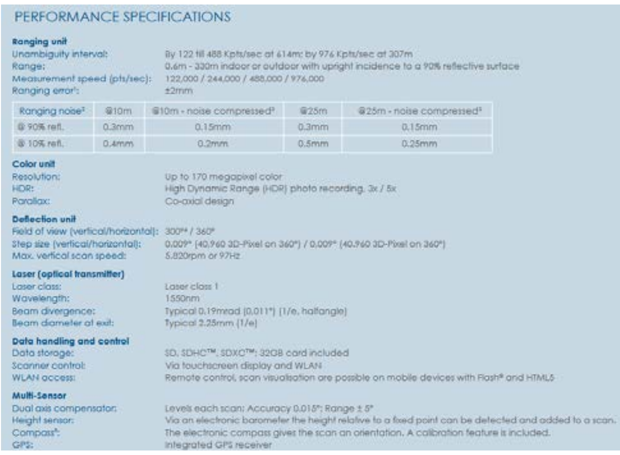
On the other hand, the advantage of using 3D laser scanning over other methods is its ability to take a large number of points with high accuracy in a period of relatively short time, which reduces the cost in working hours and allows to offer a high demand service. As line-of-sight instruments are scanners, it is necessary make multiple captures from different points to ensure complete coverage of an object.

2.1 Imaging Technique: 3D Laser Scanner.

The 3D scanner is any device that collects 3D coordinates from a given region of an object surface automatically and systematically, at a high rate (hundreds or thousands of points per second), and obtaining the results (i.e., 3D coordinates) in real time. The scanner may or may not provide reflectivity values for scanned surface elements in addition to the 3D coordinates.

Fig. 2. Escáner 3D FARO X130 utilizado para el proyecto. [13].

From the point of view of the users, the method is not very different from the flight time method. Due to the more complicated signal analysis, the results can be more precise (at the expense of the measurement rate).



PERFORMANCE SPECIFICATIONS

Ranging unit
Unambiguity interval: By 122 till 488 Kpts/sec at 614m; by 976 Kpts/sec at 307m
Range: 0.6m - 330m indoor or outdoor with upright incidence to a 90% reflective surface
Measurement speed (pts/sec): 122,000 / 244,000 / 488,000 / 976,000
Ranging error¹: ±2mm

Ranging noise²	@10m	@10m - noise compressed³	@25m	@25m - noise compressed³
@ 90% refl.	0.3mm	0.15mm	0.3mm	0.15mm
@ 10% refl.	0.4mm	0.2mm	0.5mm	0.25mm

Color unit
Resolution: Up to 170 megapixel color
HDR: High Dynamic Range (HDR) photo recording, 3x / 5x
Parallax: Co-axial design

Deflection unit
Field of view (vertical/horizontal): 300°⁴ / 360°
Step size (vertical/horizontal): 0.009° (40,960 3D-Pixel on 360°) / 0.009° (40,960 3D-Pixel on 360°)
Max. vertical scan speed: 5,820rpm or 97Hz

Laser (optical transmitter)
Laser class: Laser class 1
Wavelength: 1550nm
Beam divergence: Typical 0.19mrad (0.011°) (1/e, halfangle)
Beam diameter at exit: Typical 2.25mm (1/e)

Data handling and control
Data storage: SD, SDHC™, SDXC™; 32GB card included
Scanner control: Via touchscreen display and WLAN
WLAN access: Remote control, scan visualisation are possible on mobile devices with Flash® and HTML5

Multi-Sensor
Dual axis compensator: Levels each scan: Accuracy 0.015°; Range ± 5°
Height sensor: Via an electronic barometer the height relative to a fixed point can be detected and added to a scan.
Compass⁵: The electronic compass gives the scan an orientation. A calibration feature is included.
GPS: Integrated GPS receiver

Fig. 3. Performance Specifications 3D FARO X130 [13].

Since a well-defined return signal is needed, scanners using the phase comparison method can also have a narrow range and tend to produce more erroneous or dropped points [3].

The equipment with which the scans have been performed is the Focus X 130 model from the manufacturer FARO. It is a phase difference scanner in which the transmitted beam is modulated by a harmonic wave and the distance is calculated using the phase difference between transmitted and received wave.

2.2 Registration and preprocessing data

Starting from the point scans obtained with the 3D laser scanner we started to work importing data into SCENE program (FARO processing software). Since the hopper cannot be entirely scanned at one time, it was necessary several scans. It was changing the position scanner along the hopper until which was covered in seven scans.

Therefore, we will have seven point clouds without join, each with a different origin of coordinates. To refer all coordinates of scans from the same origin of coordinates, are placed before performing the scans some references that can be flat or spherical that have a characteristic have a high reflectivity being easily detected by the scanner.

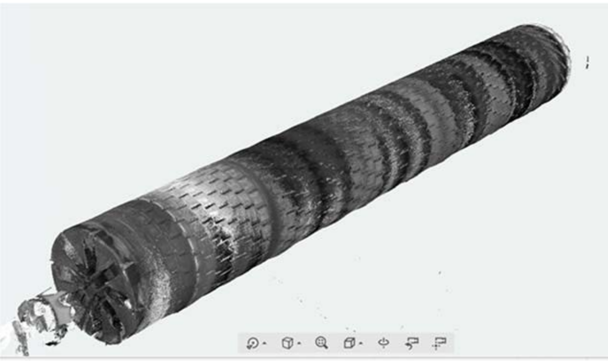


Fig. 4. Point cloud filtered and registered (more than 4 million points).

Once the data has been pre-processed and filtered (scattered point filter, distance based filter, filter for dark scanning points ...) it is necessary to proceed to the modelling of the point cloud in GEOMAGIC.

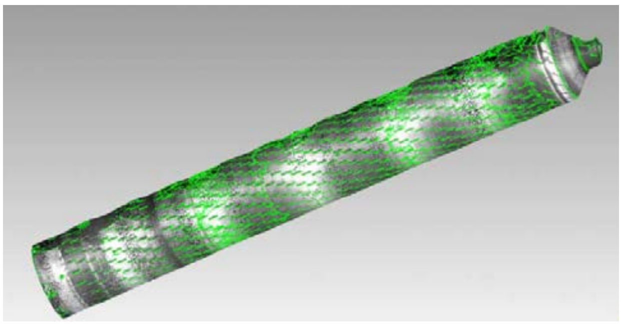


Fig. 5. Modelling the hopper with more than 8 million triangles.

3 Problem Solution

The theoretical model has been made using Autodesk Inventor.

Once all the field work has been done and its subsequent analysis, in effect, the hopper presents deformations at the time of its geometric characterization (Fig. 7), that is, there are areas where three-dimensional modelling generated exceeds the theoretical model and areas where it is below.

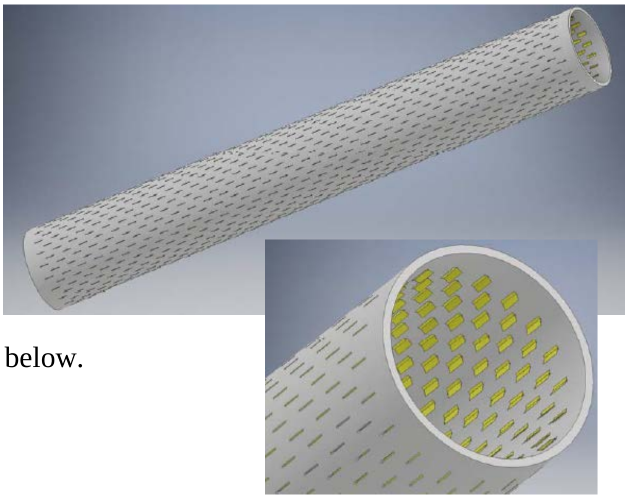


Fig. 6. 3D Real Model of the industrial hopper.

The question is, how reliable is this hopper model when we know that the 3D laser scanner has a certain error when measuring distances, of value according to the manufacturer of ± 2 mm.

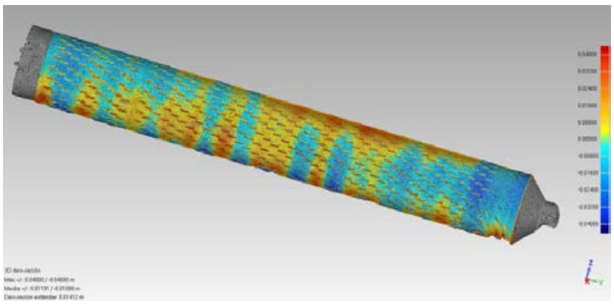


Fig. 7. Deformation Chart between real and theoretical industrial hopper.

It is observed in the map of deviations that the degree of deviation is greater than centimetre (is about 4 centimetres in the most deviated points), so the methodology applied allows us to reliably determine the order of magnitude of the deformations studied.

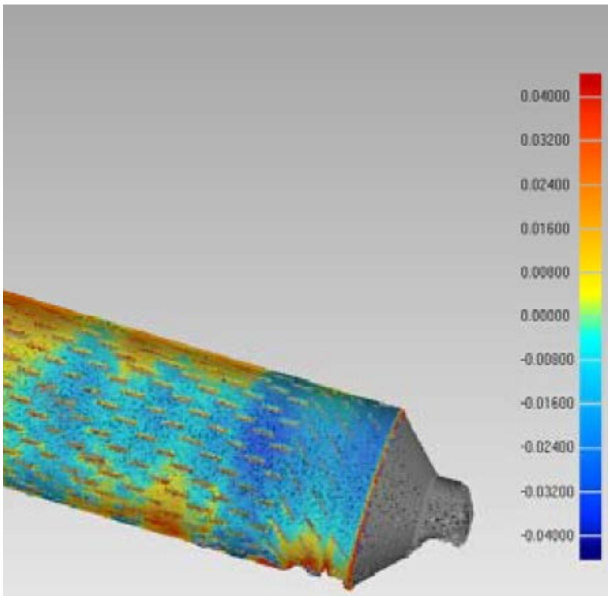


Fig. 8. The deviations observed are in the range of 4 cm

4 Conclusion

There is no regulation that specifies in detail how to measure the remaining deformation due to thermal expansion in industrial hopper. We have considered the regulations applied to the calibration of oil tanks, which due to their dimensions can be extrapolated to the case study.

Do new technologies allow the 3D laser scanner to perform a characterization geometric elements such as the one presented in a reliable way and with the enough precision?

The answer is clearly affirmative. This type of technology is fast, reliable, synoptic and very useful to know exactly the state in which it is the industrial hopper, its possible deformations, the corrective measures that must be applied, the degree of security that it provides and the margins of useful life that it has left.

However it is important to establish hopper must comply with stipulated safety measures, so that the importance of this study is none other than to ensure that it remains within margins of security, at the same time as predicting when it will stop being

Traditional methods such as curb, reference optical line method or the optical triangulation are based on discrete measurements of the object to be analyzed and estimate its parameters based on these measurements. This technology provides continuous information of the element at a specific time, allowing to establish corrective and security measures on it.

It is observed in the map of deviations (Fig.7) that the degree of deviation is greater than centimeter (is about 4 centimeters in the most deviated points), so the methodology applied allows us to reliably determine the order of magnitude of the deformations studied.

The future lines of work are in relation with the close range photogrammetry and 3D Imagining. This kind of industrial problems could have been solved by using cameras with a suitable lens or by combining both methods (photographic cameras with laser scanner as support) and the reliability of the results is our object.

It is demonstrated that near object photogrammetry works well in industrial applications but it is necessary to determine the reliability of the data in the analyzed cases.

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