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RESEARCH ARTICLE

Measurement, Metering and Calibration of 10000 Barrels and 20000 Barrels of Crude Oil Tank for Flow Station "Using Corresponding Tilt Angle and Displacement Method"

[1]James Agajo, [2]Musa Nicholas Akhaze and [3]Chukwuemeke Henry I. [4]Ojemu Ambrose Bade

[1]Federal University of Technology Department of Computer Engineering, P.M.B 65 Minna Nigeria
[2]Federal University of Technology Department of Mechanical Engineering, P.M.B 65 Minna Nigeria
[3]Federal Polytechnic Auchi Department of Electrical/Electronic Engineering P.M.B 13 Edo Nigeria[3] Federal Polytechnic
[4]Auchi Polytechnic Dept. of Mineral and Petroleum Resources Engineering Technology

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***Corresponding Address:**
James Agajo
james.agajo@futminna.edu.ng

ABSTRACT

This paper presents a method of accurately estimating, measuring and calibrating Crude oil tank by adopting the "Corresponding Tilt Angle and Displacement Method". Test for level of tilt was conducted by carrying out a bottom survey for the tank, the level of tilt was determined with the aid of surveying instrument , which was used in determining the easting and northing position of the tank . A deformation analysis shows that a great degree of linearity exist when Displacement was plotted against corresponding angle with r^2 value ranging from 0.995067, 0.99189, 0.859067 and 0.975067 for tank B,C,D and E respectively. The result shows that tank D is the most degraded with r^2 value of 0.8590 within a stable air temperature of ±3°C, The final calibration result shows that 10000 barrels has reduce to 9750.67, while the 20000 barrels has reduced to 19901.34 barrels, thereby suggesting that a recalibration of the crude oil tank should be carried out every 24 months since the last calibration was done 48 months ago.

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INTRODUCTION

Calibration is the process of accurately determining the capacity or partial capacities of a tank and expressing this capacity as a volume for a given linear increment or height of liquid.

Above ground cylindrical storage tanks are usually calibrated by placing a measuring tape around the tank shell. This procedure, known as the Manual Tank Strapping Method is the original tank calibration technique. (Michael Yeandle, 2014).

Some present day tank calibration techniques have taken the tank strapping method and refined it into two optical methods of measurement. These are known as:

1. Optical Reference Line Method (ORLM).
2. Optical Triangulation Method (OTM).

The "Optical Reference Line Method" can be found in the API Manual of Petroleum Measurement Standards. (Tim Lemmon, (2014)).

The "Optical Triangulation Method" can be found as a standard method in the API Manual of Petroleum Measurement Standards.

Most existing calibration process have been saddle with problems of not been able to factor in the fact that after some time, due to weight and asymmetric nature of the base of the tank, a tilt is usually experienced, deploying conventional methods of calibration like ORLM and OTM might lead to error reading therefore the need for a more optimized method of calibration is necessary. The manual method of calibration is by far more prone to error as parallax and uneven level of measuring point will occur.

The objective of this paper is to come up with an optimized calibration technique that can capture the following:

i. Calibration of tank for a conventional symmetric base
ii. To promote precision and accuracy in the event of hydrostatic expansion of the tank during filling and thermal expansion of the tank shell in service.
iii. To accurately determining the capacity or partial capacities of a tank and expressing this capacity as a volume for a given linear increment or height of liquid.

Oredo flow station Ologbo in Edo state Nigeria was used as the test bed for this work, At Oredo flow station

Ologbo, we deployed the use of both Ultrasonic and 3D laser technologies, the 3D laser scanning technologies can captured a vast array of three-dimensional positions (X, Y, and Z coordinates or points) that provided factual information about assets (GPB Area, 2015).

MATERIALS AND METHODS

Circumference Measurement

Before taking any measurements, it was ascertained that the tank has been filled at least once with a liquid of a density equal to or greater than the normal service liquid. Generally, the static water test carried out on the completion of construction satisfies this condition. (OIML R 120 (2010))

Gathering Centers, Flow Stations

This flow station facility is used to transport crude oil extracted from the oilrig facilities The purpose of separation facilities (known as "gathering centers") is to separate raw crude oil, water and gas produced from the wells into the three main components (] Tomojit Ghosh 2015), figure 12,13 and 14 are devices used in measuring different parameters at the flow station.

Separation facilities (also called Gathering centers/flow stations) separate natural gas and water from crude oil extracted from production wells.

Reason for calibration of storage tanks

Imperceptible to the human eye a tank may change its calibration whenever the operating conditions are changed. This could be for a variety of reasons. For example:

- Expansion or contraction of tank shells due to hydrostatic liquid head pressure or changes in operating temperature.
- Any modifications to the tank or the dip plate - i.e., new pipe inverts, floor repairs, floating roof modifications, changes in deadwood, etc.(Srini Sivaraman , Sk Japan (2012)).
- Each gathering center processes an average of 10000 barrels of oil, and 20,000 barrels of produced Crude oil each day quantities vary from facility to facility.

Instruments used are as follows

A list of some of the instrument used in conducting the calibration work are as follows:

i. High precision Telescope
ii. Calibration Software Estimator
iii. 3D Laser beam
iv. Equipment
v. Ultra Sonic transducers

Heights and other measurements

All height measurements were recorded to the nearest 0.01' from the laser equipment. The total shell height was measured together with the heights of the plates in each ring. The total gauge height along with the height of the liquid level in the tank is required, also recorded should be the maximum fill height.

Tilt

Test measurements of the tank should be made to find out whether the tank is tilted out of the vertical. The manual and some existing method could be carried out by hanging a plumb line from the top of the shell to the ground, from various positions around the top of the tank. If tilt is present, it should be related back to the datum plate. Tanks tilted less than one part in seventy parts can be disregarded, as the correction is negligible. (ISO 8222 (2002)).

This work presents a method of deploying a laser beam equipment and total station, a tilt test was carried out on all the four tanks with the instrument by checking the angle against distance with the aid of the instrument and the level of variance was used to check for tank tilt level and deformation EURAMET/cg-19/v.2.1 (2012)

Test for tilt

Bottom survey was determined by means of a surveyor's level or transit measuring the height differences between the datum plate and various selected points on the tank bottom. Starting at the datum plate a survey is taken to the center. Then, from the datum plate, take survey levels around the circumference, and at each 45-degree position again take another survey into the center of the tank. It follows that the more level readings that are taken, the more accurate the bottom calculations. Another method of determining the bottom volume of the tank is by metering quantities of Crude in the tank and recording the relative heights above and below the datum plate.(Handbook of Chemistry and Physics)

Flow Station Tank Calibration method

With the aid of the theodolite and the work station and reflectors we were able to carry out various measurements to ascertain the dimension of the tank. The easting and northing were measured, the terms easting and northing are geographic Cartesian coordinates for a point. Easting refers to the eastward-measured distance (or the x-coordinate), while northing refers to the northward-measured distance (or the y-coordinate).(API Manual2010)

Easting and northing coordinates are commonly measured in metres from a horizontal datum. However, imperial units (e.g., survey feet) are also used.

Below is some of the various measurements carried out.

Conversion scale

The diagram in figures 1, 2, 3, 4, 5, 6 are sketches of tank whose calibration where carried out.

In assigning values to the scale one took into cognisance the following conversion formular:

0.3040 feet = 1 metre

159 liters = 35 gallons = 1 barrel of oil

Since 1 barrel = exactly 42 American gallons, and

3.785431178 liters = 1 gallon, then

42 x 3.78 = 158.987 liters = 1 barrel

1000 cubic centimeter = 1 litre

1 Barrel = 158.987295 litres

1000 x 158.987295 = 158987.295 cm^3

158987.295 cm^3 = 1 Barrel of crude oil

The results obtained from the instrument were tested with the mathematical formular

Volume of Cylindrical tank A = r – r' ……… (1)

Internal radius of cylinder = r' …………….. (2)

Thickness of material = r – r' ……...………. (3)

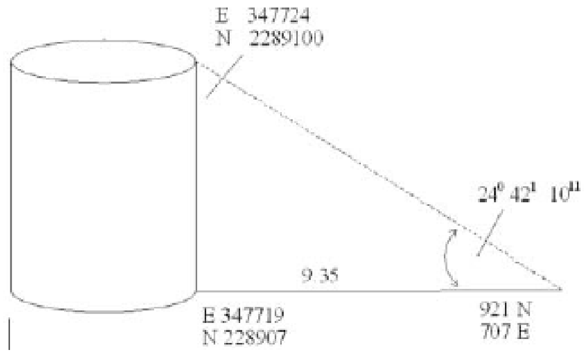


Fig. 1: Height of Tank E being measured with dimension on easting and Northing as taking with the theodolite and work station.

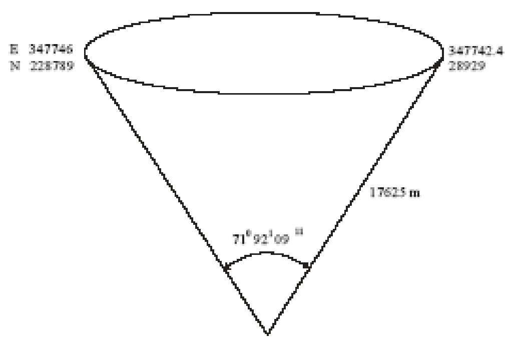


Fig. 2: Angular tilt measurement of Tank E as taking with the theodolite and work station.

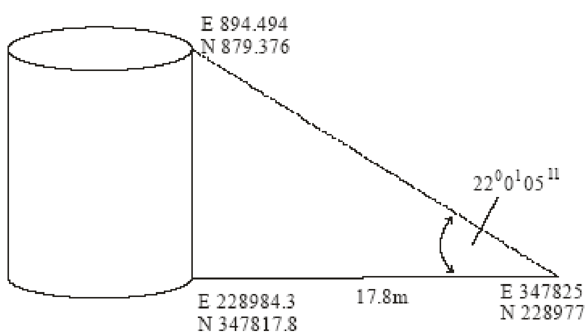


Fig. 3: Height and angle of Tank D being measured with dimension on easting and Northing as taking by the theodolite and work station

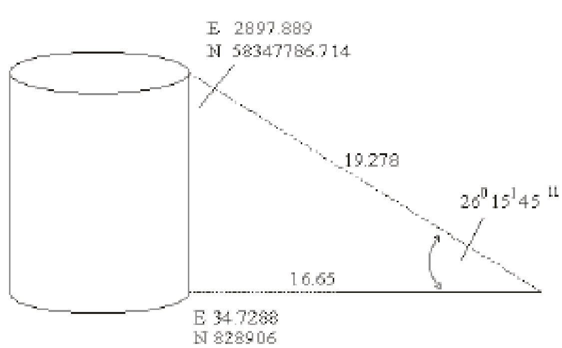


Fig. 4: Height and angle of Tank C being measured with dimension on easting and Northing as taking by the theodolite and work station

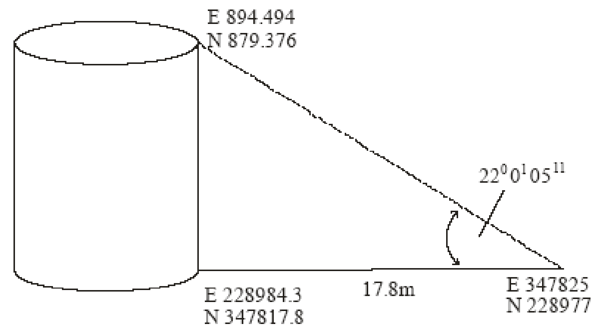


Fig. 5: Height and angle of Tank B being measured with dimension on easting and Northing as taking with the theodolite and work station.

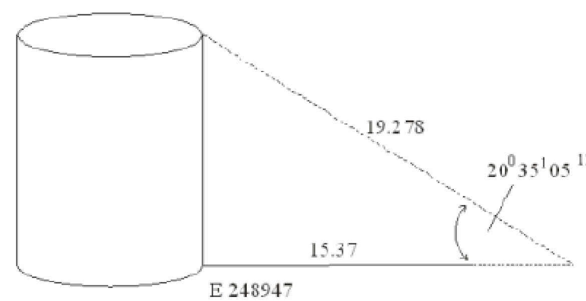


Fig. 6: Volume of Cylindrical tank with the top covered with a hemisphere

Volume of cylindrical tank = $\pi(r - r')h$ ……. (4)
Volume of hemisphere = $2/3\ \pi(r - r')^3$ ……. (5)
Volume of Cylindrical tank with the top covered with a hemisphere = $\pi(r - r')h + 2/3\ \pi(r - r')^3$ .. (6)
At Oredo Flow Station several test were carried out to check for tilt and displacement for Tank E,D,C,B using angle and displacement in table below
Angle refers to angle of elevation
Disp refers to displacement (distance between instrument and tank.

A plot showing strong linearity for Tank E,D,C and B indicate that the status of the tanks are healthy and we give it a clean bill of health based on the result obtained and this can be confirmed by the values of r^2 diagram figure 7,8,9 and 10 respectfully.

RESULTS

Present volume can be obtained from the r^2 x Original volume

Parameters for Tank E
The height of the tank E was measured as 7.64 metres/25.05 feet
The internal height of tank E was measured as 7.00 metres
The level of crude in the tank was measured as 4790bbl/1.8m/6ft
The diameter was measured as 25.44m/83.47feet
The internal volume from our calculation is
20000 x 0.99567 = 19901.34 barrels

Parameters for Tank D
The height of the tank E was measured as 7.64 metres/25.05 feet.

Table 1: Angle against Distance in Tank E

	Angle	Disp
1	20	1.9
2	30	2.8
3	40	3.7
4	50	4.8
5	60	6.8
6	70	6.9
7	80	7.9
8	90	8.1
9	110	9.1
10	120	10.2

Table 2: Angle against Distance in Tank D

	Angle	Disp
1	20	1.9
2	30	2.8
3	40	3.7
4	50	4.8
5	60	6.8
6	70	6.9
7	80	7.9
8	90	8.1
9	110	9.1
10	120	10.2

Table 3: Angle against Distance in Tank C

	Angle	Disp
1	20	2.2
2	30	2.8
3	40	3.9
4	50	4.8
5	60	6.1
6	70	6.9
7	80	7.9
8	90	8.9
9	110	9.6
10	120	10.2

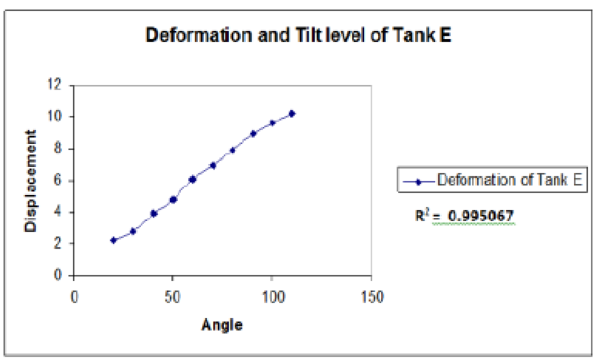
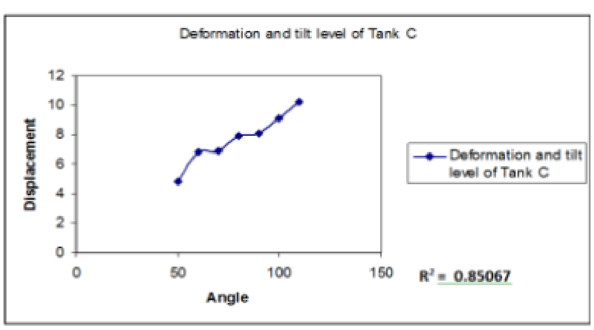


Fig. 7: Graph showing check for tilt and deformation of tank E.



Graph 8: Showing check for tilt and deformation of tank C.

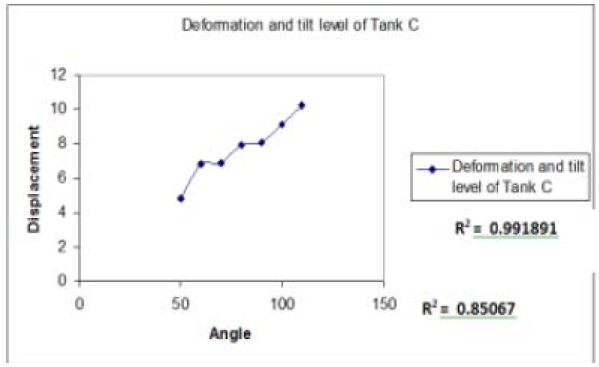


Fig. 10: Graph showing check for tilt and deformation of tank C.

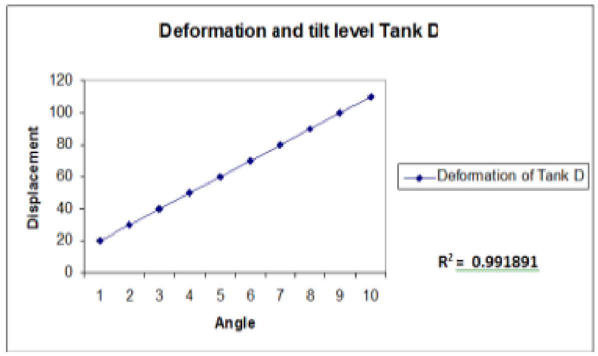


Fig. 11: Graph showing check for tilt and deformation of tank D.

The internal height of tank E was measured as 7.00 metres
The level of crude in the tank was measured as 4790bbl/1.8m/6ft
The diameter was measured as 25.44m/83.47feet
The internal volume from our calculation is
20000 x .991891 = 19837.82 barrels

Parameters for Tank C
The height of the tank E was measured as 9.4 metres/29.8 feet
The internal height of tank E was measured as 9.05 metres
The level of crude in the tank was measured as 4790bbl/1.8m/6ft
The diameter was measured as 15.215 m/50.175 feet
The internal volume from our calculation is
20000 x 0.974907 = 9749.07 Barrels

Parameters for Tank B
The height of the tank E was measured as 9.4 metres/29.8 feet
The internal height of tank E was measured as 9.05 metres
The level of crude in the tank was measured as 4790bbl/1.8m/6ft
The diameter was measured as 15.215 m/50.175 feet
The internal volume from our calculation is 10000 x 0.975067 = 9750.67

DISCUSSION OF RESULT

Different angle of elevation were taken with respect to displaced length from the tank and the graph in figure 6,7,8 and 9 , it shows the linearity in the tank, which tells one the that tank E, C, B are in good condition and well

Fig. 12: Analogue Pressure meter.

Fig. 13: Digital Pressure meter.

Fig. 14: Digital Vibrating meter.

Positioned, while the graph in figure 9 is not as linear, the graph shows the degree of tilt, which shows the tilt intensity.

r^2 shows goodness of fit for the relationship which is somewhat close to 1. This indicates that the test for tilt signifies that the tanks are stable.

The final Calibrated result for is that the minimum 0 feet, 0metre, and the maximum tank level is 24f, 7.3m, 19161bbl.

Plate I: showing site of Tank C.

Plate II: showing site of Tank E.

Plate III: Demonstrating the use of Digital Station.

Plate IV: Demonstrating and surveying the use Reflectors and Digital Total station on site.

Some crude oil pressure and vibration measuring equipment were installed to the pipes delivering crude oil to the tank which reads pressure and vibration of crude oil flow as shown in figure 12 &13.

An estech vibrating metre shown in figure 14 was use to test vibration for the tank and pipes in the flow station. The parameter for the vibrating meter is given below

Features:

• Ranges — Acceleration: 656ft/s2 (200m/s2), Velocity:7.87in/s(200mm/s), Displacement:0.078in(2mm)
• Remote vibration sensor with magnetic adapter on 39"(1m) cable
• Wide frequency range of 10Hz to 1kHz

Comparison with result of existing methods

Most existing method of calibration generate result directly from the instrument thereby not taking into cognizance the base deformation resulting to tilt, but this work factored in the need for both standard plane base and a deformed base., the r^2 parameter was also used to measure linearity.

Conclusion

In conclusion this work checked for tank tilt and deformation of Tank A and Tank B, Tank C and Tank D with the aid of equipment by the Engineering and the surveying team, manual approach would have been an option but with the present day need for precision and accuracy the need for precision equipment has become necessary as Measurement of Parameters of Tank A and B were carried out with the aid of Digital Theodolite(Tank Thickness, height, internal and external diameter e.t.c

Crude oil height measurement with the aid of insertion wires and other photogrammetric equipment were used to validate this work, the deviation was very low.

Recommendation

Air temperature

During the calibration at Oredo Flow Station we were able to work within the stable air temperature of at least ± 3 °C and its value recorded, we therefore recommend that this standards should be maintained to make for metal and instrument expansion drawback.

Note characterizing the make of the metal is very important as different metallic tank materials have different expansion coefficient.

This work strongly recommends that calibration and measurement should be carried out every 24 months interval for Oredo flow station, judging from our result the 10000 barrels has reduce to 9750.67, while the 20000 barels has reduced to 19901.34 barrels.

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