UDC 681.2-5 DOI 10.31548/ENERGIYA2(66).2023.096

REVIEW OF CALIBRATION METHODS FOR CYLINDRICAL STEEL VERTICAL OIL STORAGE TANKS

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Abstract. *Steel tanks are commonly used in various industries for storing liquids. Accurately sizing the tank is crucial to ensure safe and efficient storage. Tank sizing involves determining the tank's diameter, height, and wall thickness based on several factors. Calibration of tanks is critical to ensure proper inventory management, accurate measurement of tank contents, and compliance with regulatory requirements. There are several methods for tank calibration, including the strapping method, optical reference line method, internal float method, flow meter method, load cell method, ultrasonic method, and laser scanning method. The Laser Scanning Method is a modern and sophisticated technique for tank calibration that uses laser technology to create a 3D tank model. The method is suitable for tanks of any size and shape and provides highly accurate measurements, making it ideal for measuring vertical steel tanks. However, it is more expensive than other methods, but the increased accuracy and efficiency may justify the cost for large or irregularly shaped tanks.*

Key words: ***accuracy, calibration, strapping method, efficiency, flow meter method, internal float method, laser scanning method, load cell method, optical reference line method, steel tanks, store liquids, tank sizing, ultrasonic method***

Introduction. Steel tanks are widely used in various industries to store water, oil, chemicals, and food products [1]. Knowing their exact internal dimensions is essential for the safe storage of substances in the tank. Tank sizing involves determining the tank's diameter, height, and wall thickness based on various factors, such as the liquid's specific gravity, temperature, and pressure, as well as the tank's location and expected lifespan. This article will explore different methods for sizing steel tanks and discuss their advantages and disadvantages. By understanding the various techniques available,

designers and engineers can choose the most appropriate method for their specific project requirements and ensure that the steel tank is safe and effective for its intended use. Accurate calibration of these tanks is critical to ensure proper inventory management, precise tank contents measurement, and compliance with regulatory requirements [2]. Inaccurate calibration can result in significant economic losses and safety risks.

Analysis of recent researches and publications. Tank calibration is the process of determining the accurate volume of a storage tank. The best method for tank calibration will depend on factors such as the tank type, the product stored, the tank size, and the accuracy required.

There are several tank calibration methods, each with advantages and disadvantages.

The strapping method involves measuring the tank's circumference at different heights using a tape measure and then using a mathematical formula to calculate its volume [3]. This method is simple, inexpensive, and suitable for small to medium-sized tanks. This method is cheap and straightforward but requires physical access to the tank and is less accurate than other methods. It does not consider the internal deformations in the tank and the presence of deposits on the walls, leading to the inaccuracy of the calibration process.

The optical Reference Line Method uses laser technology to measure the tank's volume by projecting a laser beam onto the tank's surface and measuring the reflection [3, 4]. This method is fast and accurate, but it requires a clean and smooth tank surface, making it unsuitable for dirty or corroded tanks.

Overall, the studies above highlight the importance of accurate calibration of vertical steel tanks and propose new and innovative calibration methods to improve the accuracy and reliability of tank measurements.

The purpose of the research is to develop innovative calibration methods to increase the accuracy and reliability of tank measurements.

Methods. The research object is the automated system for calibrating stationary measuring vertical tanks using the geometric method.

Calibrating a tank involves determining its volume by measuring its physical dimensions and comparing it to a known reference volume. In the case of the geometric

method, the tank's volume is calculated using its height and diameter. Therefore, the parameters required for calibration include the following (figure):

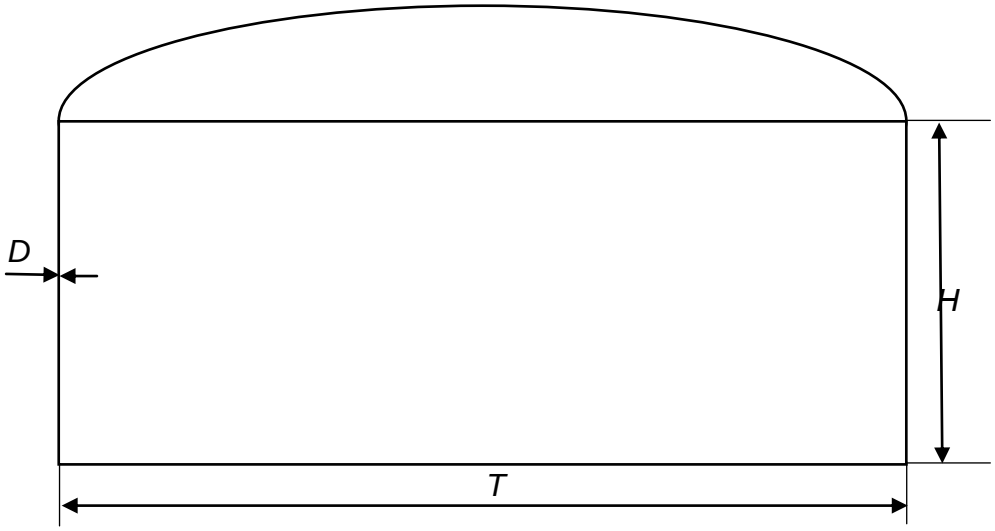
1. Height (H) – the vertical distance between the bottom and the top of the tank;

2. Diameter (D) – the horizontal distance across the broadest part of the tank;

3. Thickness (T) – the distance between the outer and inner walls of the tank;

4. Tilt (θ) – the angle of inclination of the tank, which affects the accuracy of the measurements;

5. Temperature (Tm) – the temperature of the measured liquid, which affects its volume.



Figbre. A vertical tank specified parameters

Accurately measuring these parameters is essential for accurately calibrating the tank. The automated system for calibrating stationary measuring vertical tanks using the geometric method aims to provide a reliable and efficient way for measuring these parameters and calculating the tank's volume.

The internal Float Method involves placing a float inside the tank and measuring its position as it is filled or emptied [5]. The float's position corresponds to the liquid level, which can be used to calculate the tank's volume. This method is accurate and suitable for small to medium-sized tanks, but it requires access to the inside of the tank and can be time-consuming.

Comparative analysis of tank calibration methods

Method	Accuracy	Applicability	Advantages	Disadvantages
Strapping	+/- 0.1%	Vertical cylindrical tanks	Low cost, simple	Limited to vertical cylindrical tanks, time-consuming
Optical reference line	+/- 0.1%	Vertical cylindrical tanks	High accuracy, fast, non-contact	Limited to vertical cylindrical tanks, requires special equipment
Laser scanning	+/- 0.2%	Any tank shape	High accuracy, fast, non-contact, 3D data	Expensive equipment, requires special expertise
EODR (Electro-Optical Distance Ranging)	+/- 0.2%	Any tank shape	High accuracy, fast, non-contact	Expensive equipment, requires special expertise
Sonar profiling	+/- 0.25%	Any tank shape	Non-contact, suitable for hazardous materials	Limited accuracy, affected by tank contents and conditions
Water draw method	+/- 0.5%	Vertical cylindrical tanks	Low cost, simple	Limited to vertical cylindrical tanks, time-consuming

Flow Meter Method involves pumping a known volume of liquid into the tank and measuring the volume using a flow meter [6]. This method is accurate and suitable for tanks without physical access, but it requires expensive equipment and is time-consuming.

Load Cell Method: This method involves weighing the tank when it is empty and complete, and the volume is calculated from the weight difference [7]. This method is accurate and suitable for small tanks, but it is not ideal for large tanks, as the tank's weight can affect the measurement's accuracy.

The Ultrasonic Method involves using ultrasonic waves to measure the distance between the tank's liquid level and the top of the tank. The tank's volume can then be calculated based on the distance measurement [8]. This method is accurate and suitable for

large tanks. Still, it can be affected by tank deformation or irregularities and requires a clear line of sight between the ultrasonic transducer and the liquid level.

Laser Scanning Method uses laser technology to create a 3D tank model, and the volume is calculated from the model [8]. This method is accurate and suitable for tanks of any size and shape but expensive and time-consuming.

Results. The Laser Scanning Method is a modern and sophisticated technique for tank calibration that uses laser technology to create a 3D tank model. The method involves scanning the tank's surface with a laser scanner, which generates a point cloud of millions of data points. The point cloud data is then used to create a 3D model of the tank, which is used to calculate the tank's volume. This method is perfect for measuring vertical steel tanks, further modeling, and calculations.

One advantage of the laser scanning method is its high level of accuracy. The laser scanner can capture even the most minor irregularities in the tank's surface, resulting in highly accurate measurements. The method is suitable for tanks of any size and shape, including irregularly shaped tanks, which can be challenging to measure accurately using other methods.

The laser scanning method is also fast and efficient, with data capture taking only a few hours, and 3D modeling can be completed in a few days. This course is ideal for large tanks that must be calibrated quickly and accurately.

Another advantage of the laser scanning method is that it is non-intrusive. Unlike other methods, such as the internal float method, which requires access to the inside of the tank, the laser scanner can be used from the outside, minimizing the need for tank entry and ensuring that the tank's integrity is not compromised.

One disadvantage of the laser scanning method is that it is more expensive than other methods. The equipment cost, such as the laser scanner and associated software, can be high. However, for large tanks or tanks with irregular shapes, the price may be justified by the increased accuracy and efficiency of the method.

There is also an option to scan the tank from the inside, which involves using laser scanning technology to create a 3D model of the tank's internal surface. Scanning the tank from the inside is a method of tank calibration that involves using laser scanning

technology to create a 3D model of the tank's internal surface. This method is suitable for tanks inaccessible from the outside or with complex internal structures.

One of the advantages of this type of scanning is higher accuracy. Scanning from the inside increases accuracy as the laser scanner can capture more detailed information about the tank's internal surface. Scanning from the inside provides better visualization of the internal structure of the tank, which can help identify any defects or areas that need maintenance.

Scanning from the inside requires access to the tank's internal surface, which can be challenging or impossible for some tanks. This can result in additional time and cost for preparing the tank for scanning and pose safety concerns for personnel who need to enter the tank. Precautions must be taken to protect the personnel from any hazardous substances or environmental conditions inside the tank. It may not capture the entire tank surface if some internal structures or obstructions block the laser scanner's view.

Eventually, scanning the tank from the inside is a highly accurate calibration method, but it may only be suitable for some tanks due to limited access and safety concerns. When considering this method, it is essential to carefully evaluate the tank's internal structure and assess the potential risks and benefits of scanning from the inside.

In general, the laser scanning method is a highly accurate and efficient tank calibration method suitable for tanks of any size and shape. While it may be more expensive than other methods, its accuracy, efficiency, and non-invasiveness make it popular for large tanks or tanks with irregular shapes.

Discussion. In summary, the best method for tank calibration depends on various factors, such as the tank's size, the product stored in the tank, and the accuracy required. Choosing the most suitable method for the specific tank being calibrated is essential to ensure accurate and reliable measurements. In conclusion, precise calibration of steel tanks is crucial to ensure safe and effective storage of liquids and compliance with regulatory requirements. Different tank calibration methods are available, each with its advantages and disadvantages. Recent research and publications have proposed innovative calibration methods to improve the accuracy and reliability of tank measurements. Among the different calibration methods, the laser scanning method is the most accurate and efficient

method for measuring vertical steel tanks for petroleum products. While the method is more expensive than other methods, its benefits justify the cost, especially for large tanks or tanks with irregular shapes. Overall, the laser scanning method can help ensure proper inventory management, accurate measurement of tank contents, and compliance with regulatory requirements, thereby reducing economic losses and safety risks.

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МЕТОДИ КАЛІБРУВАННЯ ЦИЛІНДРИЧНИХ СТАЛЕВИХ ВЕРТИКАЛЬНИХ РЕЗЕРВУАРІВ

О. В. Третяк, Д. М. Проскуренко, М. В. Філіппова, М. О. Безуглий

Анотація. *Сталеві вертикальні резервуари зазвичай використовуються в різних галузях промисловості для зберігання рідин. Точне визначення розміру резервуара має вирішальне значення для забезпечення безпечного та ефективного зберігання. Розмір резервуару передбачає визначення його діаметра, висоти та товщини стінок резервуара на основі кількох факторів. Калібрування резервуарів має вирішальне значення для забезпечення належного управління запасами, точного вимірювання вмісту резервуарів і дотримання нормативних вимог. Існує кілька методів калібрування резервуара, включаючи метод обмірювання, метод оптичної еталонної лінії, метод внутрішнього поплавця, метод витратоміра, метод тензодатчика, ультразвуковий метод і метод лазерного сканування. Метод лазерного сканування – це сучасна та складна техніка калібрування резервуару, яка використовує лазерну технологію для створення 3D-моделі резервуара. Цей метод підходить для резервуарів будь-якого розміру та форми та забезпечує високоточні вимірювання, що робить його ідеальним для вимірювання вертикальних сталевих резервуарів. Однак це дорожче, ніж інші методи, але підвищена точність і ефективність можуть виправдати вартість великих резервуарів або резервуарів неправильної форми.*

Ключові слова: ***визначення розмірів резервуарів, ефективність, калібрування, метод витратоміра, метод внутрішнього поплавка, метод лазерного сканування, метод обмірювання, метод оптичної опорної лінії, метод***

тензодатчика, рідини для зберігання, точність, ультразвуковий метод, сталеві резервуари