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Calculating The Volume Of Liquid In Cylinder Vessels Which Have Curved Borders Level 2 Geometric Surface.

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ABSTRACT

The article discusses the calculation of the volume of liquid in a cylindrical vessel with convex edges in the form of a cone or ellipsoid segment.

KEYWORDS

Volume, Cylindrical, Convex, Flat, Surface, Vessel.

INTRODUCTION

The rapid development of our time is associated with the emergence of innovations in these areas and at the same time their implementation in practice. At the same time, it is expedient for junior engineers working in the field of technology to master professional knowledge as well as mathematical knowledge. Because the problems encountered in the work process can be solved by mathematical calculations. When finding the volume of a large body in the form of a single "copsula" (cylinder), that is, when given the distance from the bottom of the vessel to the surface of the liquid, the convex edges are in the form of an elliptical cone or If we consider the introduction of advanced information technology in the calculation of the volume of liquids in large-capacity cylindrical vessels in the form of ellipsoid (especially spherical) segments with high accuracy, this issue is one of the most pressing issues today.

In this article, in order to create convenience for professionals in the field, professors, students and the general public, it is possible to build a computational model of these issues, to perform computational work on computers, mobile phones in any conditions. software development will be discussed. If today the calculation of the volume of liquids in such containers is based on the use of guidelines set by the manufacturer or the state standard, it is possible to predict that the use of "online calculators" recommended in the article will be highly effective in all respects.

It is known that the solution of the problem cannot be found using elementary mathematical methods, it can be found only on the basis of cubic integrals and theories of analytic geometry. Furthermore, when the convex part of the vessel is generally in the form of an ellipsoidal segment, it is important to select the correct initial data required to calculate the liquid volume based on the practical aspects of the matter.

Given the following:

h - the distance from the bottom of the vessel to the liquid level;

L - the length of the cylindrical part of the vessel;

r_1, r_2, - the lengths of the horizontal and vertical axes of the cross section of the cylinder (if the cross section is a circle $r_1 = r_2 = r$):

l - the distance from the end of the convex part of the vessel to the cylindrical part of the vessel, the height of the convexity (Fig. 1).

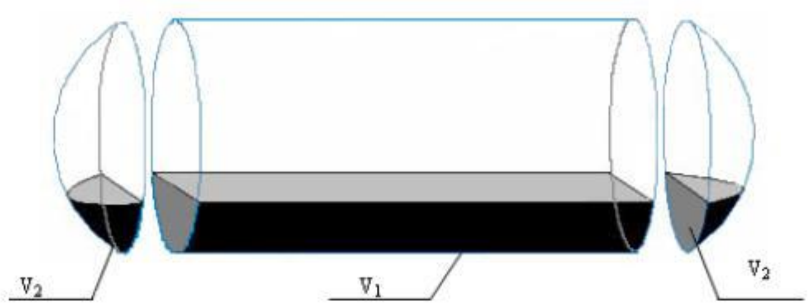

Figure 1

Without going into proof below, the formulas for calculating the volume of liquids in a container based on the initial data are given. The following definitions were used. [2]

$$R = \frac{r^2 + l^2}{2l}$$

$$b_1 = \frac{c}{a}(a-l) = \left(\frac{r_2}{r_1}\right)\frac{r_1^2 - l^2}{2l}, \quad h_0 = 1 - \frac{h}{r_2}, \quad m = \frac{a^2}{\sqrt{b^2 - a^2}} = \frac{a\sqrt{2al - l^2}}{\sqrt{r_1^2 - 2al + l^2}},$$

1. **Formulas for calculating the volume of a liquid in an ellipse-based cylinder with non-convex edges.**

1.1. When the container is in a horizontal position:

$$V_1\left(r_1, r_2, h_0\right) = r_1 r_2\left(\arccos\left(h_0\right) + h_0\sqrt{1-\left(h_0\right)^2}\right)L$$

1.2. When the container is in a vertical position:

2. **Formulas for calculating the volume of liquid in a cylindrical vessel with convex edges in the form of a spherical segment:**

2.1. When the container is in a horizontal position:

$$V = 2V_2 + V_1\left(r, r, h_0\right), \qquad V_2 = -2\left(c^2 h - \frac{h^3}{3}\right) arccos\left(\frac{c-l}{\sqrt{c^2-h^2}}\right) -$$
$$-\frac{4c^2+2r^2}{3}\left(c-l\right) arccos\frac{h}{r} + \frac{4c^3}{3} arccos\frac{\left(c-l\right)h}{r\sqrt{c^2-h^2}} + \frac{2\left(c-l\right)h}{3}\sqrt{r^2-h^2}$$

2.2. The size of the spherical segment considered above is as follows

$$v_1\left(h\right) = \pi h^2\left(R - \frac{h}{3}\right)$$

the volume of liquid in a vertically positioned vessel , taking into account that it is calculated by the formula

$$V = \begin{cases} v_1\left(h\right), & \text{агар } 0 < h \le l \text{ бўлса,} \\ v_1\left(l\right) + \pi r^2\left(h-l\right), & \text{агар } l < h \le L + l \text{ бўлса,} \\ 2v_1\left(l\right) + \pi r^2 L - v_1\left(2l + L - h\right), & \text{агар } L + l < h \le L + 2l \text{ бўлса} \end{cases}$$

can be found using the formula. [1]

3. **Formulas for calculating the volume of liquid in a cylindrical vessel with convex edges in the form of an ellipse-based cone:**

3.1 When the container is in a horizontal position:

$$V = \frac{r_1 r_2}{3} l\left(\arccos h_0 - 2h_0\sqrt{1-h_0^2} - h_0^3 \ln\frac{1+\sqrt{1-h_0^2}}{h_0}\right) + V_1\left(r_1, r_2, h_0\right)$$

3.2. When the container is in a vertical position:

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$$V = \begin{cases} \dfrac{\pi r_1 r_2}{3l^2} h^3 & агар\, 0 < h \le l \;\; бўлса, \\ \pi r_1 r_2 (h - \dfrac{2l}{3}) & агар\, l < h \le L + l \;\; бўлса, \\ \dfrac{\pi r_1 r_2}{3l^2}\left[3Ll^2 + 2l^3 + (2l + L - h)^3\right] & агар\, L + l < h \le L + 2l \;\; бўлса \end{cases}$$

4. Find the formula for calculating the volume of liquid in a cylindrical vessel with edges in the form of an ellipsoidal segment.

4.1. When the container is in a horizontal position:

$$V_2 = \frac{\sqrt{2al - l^2}}{2r_2^{\,2}}\left[-2\left(c^2 h - \frac{h^3}{3}\right)arccos\left(\frac{b_1}{\sqrt{c^2 - h^2}}\right) - \frac{4c^2 + 2r_2^{\,2}}{3} b_1 arccos\frac{h}{r_2} + \right.$$
$$\left. + \frac{4c^3}{3} arccos\frac{b_1 h}{r_2\sqrt{c^2 - h^2}} + \frac{2b_1 h}{3}\sqrt{r_2^{\,2} - h^2}\right], \quad V = 2V_2 + V_1(r_1, r_2, h_0)$$

4.2. When the container is in a vertical position:

The following for the size of an ellipsoid segments

$$v_2(h) = \pi h \frac{\sqrt{2al - l^2}}{2r_2^{\,2}}\left(c^2 - r_2^2 + r_2 h - h^2/3\right), \; v_3(h) = \pi h \frac{\sqrt{2al - l^2}}{2r_2^{\,2}}\left(c^2 - h^2/3\right)$$

Given that the formulas are appropriate, using the appropriate combinations of them follows the volume of liquid in a vertically positioned container

$$v_2(h) = \pi h \frac{\sqrt{2al - l^2}}{2r_2^{\,2}}\left(c^2 - r_2^2 + r_2 h - h^2/3\right), \; v_3(h) = \pi h \frac{\sqrt{2al - l^2}}{2r_2^{\,2}}\left(c^2 - h^2/3\right)$$

can be calculated using the formula. [1]

The variables *a, c* involved in the resulting formulas are actually the lengths of the horizontal and vertical axes of the ellipsoid, which are currently unknown variables. To find these unknowns, proceed as follows.

An ellipsoid under consideration

$$\left(\frac{x}{a}\right)^2+\left(\frac{y}{b}\right)^2+\left(\frac{z}{c}\right)^2=1 \qquad (1)$$

According to the equation, a condition blister segment basis ellipsoids, where *x* = *x* axle compared to the possibility of cross-cutting, the arrows r_1, r_2, which is equal to the following

$$\left(\frac{y}{r_1}\right)^2+\left(\frac{z}{r_2}\right)^2=1 \qquad (2)$$

is equal to the ellipse. In turn, *by* substituting the value *x = al* instead of *x in* equation (1) , the following occurs when some elementary substitutions are performed

$$\frac{y^2}{(2al-l^2)\left(\frac{b}{a}\right)^2}+\frac{z^2}{(2al-l^2)\left(\frac{c}{a}\right)^2}=1 \qquad (3)$$

equality can be obtained. The resulting equations (2), (3) represent a single ellipse equation. Hence, the following between the lengths *b, c* and *a* by equating the corresponding denominators

$$b^2=\frac{r_1^{\,2}a^2}{2al-l^2},\qquad c^2=\frac{r_2^{\,2}a^2}{2al-l^2},\qquad b^2=\frac{r_1^{\,2}}{r_2^{\,2}}c^2 \qquad (4)$$

attitude arises.

It follows from the last equations that another additional condition is required to determine the value of the lengths *a, b, c* . Depending on the practical aspects of the issue, one of the following cases can be selected as an additional condition . For example,

1) The vertical axis of the convex surface *c* , and the horizontal axis *is a* ellipse equal to *the z* axis formed into spheroids segment assume, then (4) equal *a, b, c,* s the following arises.

$$a=b=\frac{r_1^{\,2}+l^2}{2l},\quad c=\left(\frac{r_2}{r_1}\right)\frac{r_1^{\,2}+l^2}{2l}$$

2) if the full volume of the vessel V_0 is known in advance

using the formula of *a* length equal to and, in turn, (4) *b,* c lengths can be found. If one side of the vessel is not convex, 2 coefficients in the denominator of the last formula are not involved.

3) Given the length of the arc lying in the *xy* plane, the *x* = *a* end of the convex segment and the points *y* = r_1, *y* = -r_1. In that case, slash formula to calculate the length of *a* following due to the integral equations.

This integral is an integral of the elliptic type and is not represented by elementary functions [1]. It can only be calculated in approximate ways. To get rid of the denominator that turns to 0 under the integral

can be seen. This allows the use of approximate methods in the calculation of integrals.

If we take into account that the value of *a* is bounded from below and above, it is possible to calculate the value of *a from* equation (5) and the value of *b, c,* respectively , after the finite step by means of direct substitutions .

The following integral formulas for finding the volume were used to obtain all the results.

Based on these found formulas, a compact program in the C ++ programming language was developed and tested in specific examples. You can install the program on the Internet and use it as an "online calculator".

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