

Water In A Cylinder Of Height 10 Ft And Radius 2 Ft Is To Be Pumped Out. The Density Of Water Is 62.4

Water In A Cylinder Of Height 10 Ft And Radius 2 Ft Is To Be Pumped Out. The Density Of Water Is 62.4 pounds per cubic foot (lb/ft³). Understanding how to calculate the volume of water in the cylinder, the amount of water to be pumped out, and related parameters is essential in various engineering and practical contexts, such as designing pumping systems, estimating energy requirements, or managing water resources. This article provides a comprehensive guide to analyzing the problem step-by-step, including volume calculations, weight estimations, and considerations for efficient water removal.

Understanding the Geometry of the Cylinder

Before delving into calculations, it is important to understand the geometric properties of the cylinder, which will form the basis for volume and weight computations.

Dimensions of the Cylinder

- Height (h): 10 feet
- Radius (r): 2 feet

This straightforward shape allows us to use standard formulas for volume and related parameters.

Calculating the Volume of Water in the Cylinder

The primary step involves determining how much water is contained within the cylinder before pumping out.

Formula for Volume of a Cylinder

The volume (V) of a cylinder is given by:

$$V = \pi r^2 h$$

where:

- r = radius of the cylinder
- h = height of the water column

Given the dimensions:

- $r = 2 \text{ ft}$
- $h = 10 \text{ ft}$

Plugging in the values:

$$V = \pi \times (2)^2 \times 10 = \pi \times 4 \times 10 = 40\pi \text{ cubic feet}$$

Calculating numerical value:

$$V \approx 40 \times 3.1416 = 125.664 \text{ ft}^3$$

Therefore, the volume of water in the cylinder is approximately 125.66 cubic feet.

Estimating the Weight of Water in the Cylinder

Knowing the volume, we can estimate the weight or mass of the water, which is crucial for understanding the load and energy requirements involved in pumping.

Using the Density of Water

Given:

- Density of water (ρ) = 62.4 lb/ft^3

The total weight (W) of water is:

$$W = V \times \rho$$

Substituting the known values:

$$W = 125.66 \times 62.4 \approx 7851.84 \text{ pounds}$$

Hence, the water in the cylinder weighs approximately 7,852 pounds.

Determining the Volume and Weight of Water to Be Pumped Out

The problem initially states that water is to be pumped out, implying the entire volume will be removed unless specified otherwise.

Scenarios to consider:

- Complete removal: Pumping out all 125.66 ft³ of water.
- Partial removal: Pumping out a specified height or volume (not detailed here but useful in practical applications).

Assuming total removal:

- Total volume to be pumped out: 125.66 ft³
- Total weight of water to be pumped out: ~7,852 pounds

Practical Aspects of Pumping Water from a Cylinder

Understanding the calculations is essential, but practical considerations include the type of pump required, energy consumption, and flow rate.

Choosing the Right Pump

- Pump Capacity: Must handle at least 125.66 ft³ of water.
- Flow Rate: Depends on how quickly the water needs to be removed.
- Power Requirements: Based on the height the water must be lifted and the volume flow rate.

Energy Considerations

The work done in pumping water involves overcoming gravitational potential

energy:

$$\text{Work} = W \times g \times h_{\text{lift}}$$

where:

- W = weight of water (pounds)
- g = acceleration due to gravity ($\sim 32.2 \text{ ft/s}^2$)
- h_{lift} = height the water is lifted during pumping (for simplicity, assuming from the bottom to the top, i.e., 10 ft)

However, in practical systems, efficiencies and other factors influence the actual energy consumption.

Additional Calculations and Considerations

Beyond basic volume and weight, other important factors include:

Pressure at the Bottom of the Cylinder

The pressure exerted by the water at the bottom:

$$P = \rho \times g \times h$$

Using:

- $\rho = 62.4 \text{ lb/ft}^3$
- $g = 32.2 \text{ ft/s}^2$
- $h = 10 \text{ ft}$

First, convert density to slug/ft³ for SI compatibility or keep consistent units:

Since the density is given in lb/ft³, and pounds are a force unit, the pressure in pounds per square foot:

$$P = \text{Density} \times g \times h$$

But since the density is in lb/ft³, and gravity is accounted for, the pressure at the bottom (in psf):

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$$P = 62.4 \text{ lb/ft}^3 \times 10 \text{ ft} = 624 \text{ lb/ft}^2$$

Converting to psi:

$$\text{Pressure in psi} = \frac{624}{144} \approx 4.33 \text{ psi}$$

This indicates the pressure at the bottom is approximately 4.33 psi.

Implications for Pump Selection

The pump must be capable of overcoming this pressure, among other factors.

Summary of Key Results

- Volume of water in the cylinder: approximately 125.66 ft³
- Weight of water in the cylinder: approximately 7,852 pounds
- Pressure at the bottom of the cylinder: approximately 4.33 psi

Conclusion

Pumping water from a cylinder involves understanding the volume, weight, and pressure related to the water mass. With the given dimensions and water density, calculations reveal that the cylinder contains roughly 125.66 cubic feet of water weighing about 7,852 pounds, exerting a pressure of approximately 4.33 psi at its base. These insights are crucial for selecting appropriate pumps, estimating energy requirements, and designing efficient water removal systems. Whether planning for construction, irrigation, or water management, accurate calculations ensure safety, efficiency, and cost-effectiveness in handling water stored in cylindrical tanks or containers.

Keywords: water volume in cylinder, water weight calculation, pumping water from tank, cylinder volume formula, water density, pump selection, water pressure, engineering calculations

Frequently Asked Questions

What is the volume of water in the cylinder with a height of 10 ft and radius of 2 ft?

The volume $V = \pi r^2 h = \pi \times (2)^2 \times 10 \approx 125.66$ cubic feet.

How much mass of water is present in the cylinder?

Using density 62.4 lb/ft^3 , mass = volume $\times$ density $\approx 125.66 \times 62.4 \approx 7843.94$ pounds.

What is the total weight of the water in the cylinder?

The total weight is approximately 7843.94 pounds, given the density and volume.

How much work is required to pump all the water out of the cylinder?

Work calculation depends on the height the water needs to be lifted; assuming pumping to the top, it involves integrating the weight over the height, approximately 39,220 ft-lb.

What is the average height that the water needs to be lifted to pump it out?

The average height is half the height of the water column, so 5 ft.

How much energy in joules is needed to pump out all the water?

Since $1 \text{ ft-lb} \approx 1.3558 \text{ joules}$, total energy $\approx 39,220 \text{ ft-lb} \times 1.3558 \approx 53,153$ joules.

If the pump has an efficiency of 80%, what is the actual energy consumption?

Actual energy = work / efficiency = $53,153 / 0.8 \approx 66,441$ joules.

How long would it take to pump out the water if the pump's flow rate is 5 cubic feet per minute?

Time = total volume / flow rate = $125.66 / 5 \approx 25.13$ minutes.

What are the key factors affecting the energy required to pump out the water?

Factors include the height the water is lifted, the volume of water, pump efficiency, and flow rate.

Additional Resources

Water In A Cylinder Of Height 10 Ft And Radius 2 Ft Is To Be Pumped Out: An In-Depth Investigation

Understanding the dynamics involved in pumping water from a cylindrical container is a fundamental problem in fluid mechanics, with practical implications ranging from industrial applications to environmental engineering. This article offers an in-depth analysis of the scenario where water in a cylinder of height 10 ft and radius 2 ft is to be pumped out, focusing particularly on the physical parameters, calculations, and considerations that influence the efficiency and methodology of such an operation.

Introduction

Pumping water from a cylindrical tank is a common task encountered in various engineering and environmental contexts. Whether draining a storage tank, managing water in a flood control system, or performing maintenance tasks, precise calculations and understanding of the involved forces are essential. The problem at hand involves a cylinder with specific dimensions and water density, which must be fully or partially drained efficiently.

Overview of the Scenario

- Cylinder Height (H): 10 feet
- Cylinder Radius (r): 2 feet
- Water Density (ρ): 62.4 lb/ft³ (pounds per cubic foot)
- Objective: Determine the quantities involved and analyze the pumping process.

Physical Parameters and Their Significance

Understanding the physical parameters is foundational to any fluid mechanics problem.

Dimensions of the Cylinder

The cylinder's dimensions directly influence the volume of water and the

energy required to pump it out.

- Volume of Water (V): The total volume of water in the cylinder is given by:

$$V = \pi r^2 H$$

Substituting the known values:

$$V = \pi \times (2)^2 \times 10 = \pi \times 4 \times 10 = 40\pi \text{ ft}^3$$

Numerically:

$$V \approx 40 \times 3.1416 \approx 125.66 \text{ ft}^3$$

Mass and Weight of Water

Using the density:

- Mass (m):

$$m = \rho \times V = 62.4 \times 125.66 \approx 7850 \text{ lb}$$

- Total Weight (W):

Since weight is mass times acceleration due to gravity (g), but here, the density is given in lb/ft³, which already accounts for gravity, the total weight of the water is approximately 7850 pounds.

Pumping Dynamics and Energy Considerations

Efficiently removing water from the cylinder involves understanding the energy requirements, the type of pump needed, and the hydraulic considerations.

Types of Pumps Suitable

Depending on the application, different types of pumps might be employed:

- Centrifugal Pumps: Common for large volumes at moderate head.
- Submersible Pumps: Suitable for submerged operation.
- Piston or Diaphragm Pumps: For high-pressure or precise control.

The choice depends on factors like flow rate, head height, and efficiency.

Hydraulic Head and Pumping Height

The head refers to the height the pump can lift water, which in this case is critical given the cylinder's height.

- To pump water from the bottom to the top of the cylinder, the pump must generate a head slightly exceeding 10 ft to overcome gravitational potential energy.

Calculating the Work Required to Pump Out Water

Basic Assumptions

- The water is drained from the bottom upward.
- The pump operates uniformly, and losses are neglected for initial calculations.
- The process is quasi-static, with no additional energy losses.

Derivation of the Work Done

The work done in lifting water from a certain height involves integrating the weight of differential slices of water over the height of the tank.

Step 1: Consider a differential slice

- Slice thickness: (dy)
- Height of slice: (y) (measured from the bottom)
- Volume of slice: $(dV = \pi r^2 dy = 4\pi dy)$ (since $(r=2)$)
- Mass of slice: $(dm = \rho dV = 62.4 \times 4\pi dy = 249.6 \pi dy)$
- Weight of slice: $(dW = dm \times g)$ but since density is in lb/ft^3 , the weight per unit volume is directly given.

Step 2: Calculate the work

The work to lift each slice from height (y) to the top (height (H)) is:

$$\begin{aligned} & \text{Work} = dW \times (H - y) \end{aligned}$$

Total work:

$$W_{\text{total}} = \int_0^H (\text{weight of slice}) \times (H - y) dy$$

Substituting:

$$W_{\text{total}} = \int_0^{10} 62.4 \times 4\pi \times (10 - y) dy$$

$$W_{\text{total}} = 249.6 \pi \int_0^{10} (10 - y) dy$$

Calculate the integral:

$$\int_0^{10} (10 - y) dy = \left[10y - \frac{1}{2} y^2 \right]_0^{10} = (10 \times 10 - \frac{1}{2} \times 100) - 0 = 100 - 50 = 50$$

Now, compute total work:

$$W_{\text{total}} = 249.6 \pi \times 50 \approx 249.6 \times 3.1416 \times 50$$

$$W_{\text{total}} \approx 249.6 \times 3.1416 \times 50 \approx (249.6 \times 3.1416) \times 50$$

Calculate:

$$249.6 \times 3.1416 \approx 785.4$$

Then:

$$W_{\text{total}} \approx 785.4 \times 50 = 39,270 \text{ ft-lb}$$

Result: The approximate work required to pump out all the water is 39,270 foot-pounds.

Practical Considerations in Pumping Operations

While the theoretical calculations provide a baseline, real-world operations involve additional factors.

Friction and Pump Efficiency

- Frictional losses in pipes and fittings can significantly increase energy

requirements.

- Pump efficiency (η) typically ranges from 70% to 90%. Accounting for efficiency:

$$\text{Actual energy input} = \frac{W_{\text{total}}}{\eta}$$

For an 80% efficient pump:

$$\text{Energy input} \approx \frac{39,270}{0.8} \approx 49,088 \text{ ft-lb}$$

Pump Selection and Flow Rate

Determining the flow rate involves balancing the pump's capacity and the desired time to drain the tank.

- For example, to drain the entire volume in 2 hours:

$$\text{Flow rate} = \frac{125.66 \text{ ft}^3}{2 \text{ hours}} \approx 62.83 \text{ ft}^3/\text{hr}$$

This rate influences the pump size and power.

Safety and Maintenance

- Ensuring the pump can handle the maximum head.
- Regular inspection for wear and corrosion.
- Managing residual water and preventing overflow or structural damage.

Additional Factors Affecting Pumping Efficiency

Variations in Water Level

- If the water level drops unevenly, the pressure at the inlet varies, affecting flow rate.
- For partial draining, the calculations must be adjusted accordingly.

Temperature and Water Properties

- Variations in temperature can slightly change water density.
- The presence of impurities or sediments can clog pumps and pipelines.

Environmental and Safety Regulations

- Proper disposal or treatment of pumped water.
- Compliance with safety standards for high-head pumping.

Summary of Key Findings

- The total volume of water in the cylinder is approximately 125.66 ft^3 .
- The total weight of water is approximately 7,850 pounds.
- The theoretical work required to pump out all water is about 39,270 ft-lb, which increases to approximately 49,088 ft-lb when considering an 80% pump efficiency.
- Pump selection must consider head height, flow rate, efficiency, and operational safety.
- Practical operations involve additional considerations such as frictional losses, water properties, and environmental factors.

Conclusion

Pumping water out of a cylindrical tank of height 10 ft and radius 2 ft involves careful analysis of physical parameters, energy calculations, and practical engineering considerations. While the fundamental physics provides a solid baseline, real-world applications demand attention to efficiency, safety, and environmental impacts. By understanding the detailed dynamics and calculations involved, engineers and operators can optimize their pumping strategies, minimize energy costs, and ensure safe and efficient operation.

References

- Fox, R. W., McDonald, A. T., & Pritchard, T. J. (2011). Introduction to Fluid Mechanics. John Wiley & Sons.
- Munson, B. R., Young, D. F., & Okiishi, T.

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