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Experimental Investigation on a Water Pressure Enhancement System

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Abstract

The experimental investigation on a water pressure enhancement system was carried out to study water distribution in a multi-level gravity-fed system. The experimental setup consists of an elevated overhead water tank mounted on a rigid steel frame supplying water through a vertical PVC pipeline. Three outlet points are provided at different heights to simulate water supply conditions in multi-storey buildings. Each outlet is fitted with a control valve and a pressure gauge to measure and regulate pressure and flow. The system operates on gravitational principles, where water pressure varies according to elevation. Lower outlets receive higher pressure while upper outlets experience reduced pressure. By adjusting the control valves, the system enables partial regulation of flow to achieve improved pressure balance among different levels. The experimental results help in understanding the relationship between hydraulic head, pressure distribution, and flow control. This setup serves as a practical and cost-effective model for studying water pressure enhancement techniques and developing efficient water supply solutions for residential and commercial buildings.

Keywords — Small-scale industries, Water pressure enhancement, Gravity-fed system, Multi-storey water supply, Plumbing design, Experimental analysis, PVC piping system.

I. INTRODUCTION

Water distribution in multi-storey buildings often faces the problem of uneven pressure and flow variation between different floors. Due to the effect of gravity and height difference water flow is usually higher at lower floors and lower at upper floors, which leads to inefficient water distribution. To address this issue, an experimental investigation on a water pressure enhancement system is carried out to study how water pressure and flow can be balanced across multiple levels. The system consists of a top storage tank, vertical PVC pipeline, pressure gauges, outlet valves and a supporting frame that represents a three-floor water distribution model including Ground Floor (GF), First Floor (F1), and Second Floor (F2).

In this setup, an impeller mechanism is introduced inside the vertical pipeline to improve the distribution of water flow. The impeller rotates when water passes through it, creating a controlled flow movement that helps regulate pressure variations along the pipeline. This mechanism assists in reducing the difference in flow rate between the floors and promotes a more uniform water supply. By analyzing the pressure readings and flow rates at different levels, the experiment aims to evaluate the effectiveness of the impeller in enhancing water pressure distribution and achieving nearly equal flow across all three floors.

II. LITERATURE REVIEW

Adedeji et. al., (2018) explored pressure management strategies for water loss reduction in large-scale water piping networks. Their research highlighted the importance of optimal pressure control in minimizing water loss and improving system efficiency. By optimizing pressure control, water utilities can reduce leakage and improve the overall performance of their systems.

Mosetlhe et. al., (2020) conducted a comprehensive survey of pressure control approaches in water supply systems. Their research analyzed various pressure control techniques and strategies highlighting the benefits of optimizing pressure control for efficient system operation. By adopting optimal pressure control approaches water utilities can improve system efficiency and reduce water loss.

Kallesoe et. al., (2015) explored adaptive reference control for pressure management in water networks Their study demonstrated that this approach effectively optimizes pressure levels in real time responding to changes in system conditions. The results showed that adaptive reference control can significantly reduce water losses while maintaining efficient operation.

Prescott et. al., (2008) improved control of pressure-reducing valves in water distribution networks. Their research showed that optimizing operation can improve system efficiency and reduce water loss. By adopting improved control strategies, water utilities can reduce leakage and improve system performance.

Karney et. al., (2008) investigated hydraulic transients and pressure management in water distribution systems. Their research highlighted the importance of controlling sudden pressure changes in pipelines which can lead to pipe damage and system failures. The study demonstrated that effective pressure management helps reduce the impact of hydraulic transients and protects the integrity of the water distribution network.

III. METHODOLOGY

The methodology of this project involves designing and experimentally analyzing a water pressure enhancement system to study water distribution at different floor levels. Initially, an overhead water tank is mounted on a rigid frame to provide a gravity-based water supply. A vertical PVC pipeline is connected to the tank outlet to allow water to flow downward through the system. Three outlet points are provided at different heights to represent water supply to multiple floors. Control valves and pressure gauges are installed at each outlet to regulate and measure the water flow and pressure. An impeller is installed along the vertical pipe to help enhance and regulate the water flow so that a more uniform distribution can be achieved at all outlet levels. During the experiment, water is allowed to flow through the system and the pressure readings at each level are recorded. The observations are then analyzed to evaluate how the impeller and pipeline arrangement influence the pressure distribution and to determine the effectiveness of the system in maintaining balanced water flow across different floors.

IV. PROBLEM STATEMENT

In multi-storey water distribution systems, uneven water pressure and flow between different floor levels is a common problem. Due to gravity and elevation differences, water pressure is generally higher at lower floors and lower at upper floors. This results in excessive flow at the ground floor and insufficient water supply at higher floors, causing an unbalanced and inefficient water distribution system.

Therefore, there is a need for a simple and economical method to regulate water pressure and achieve uniform flow distribution across all floors. This experimental investigation aims to address this problem by introducing an impeller setup inside the vertical pipeline. The impeller helps regulate water movement and improve pressure distribution so that nearly equal water flow can be obtained at the Ground Floor (GF), First Floor (F1), and Second Floor (F2).

V. WATER PRESSURE SYSTEM

Figure 1. Water Pressure System

VI. IMPELLER SETUP

Figure 2. Impeller Setup

The impeller setup consists of several small plastic blades mounted along a metal rod at equal intervals. When this rod is placed inside the vertical pipe the flowing water strikes the blades. The fig 4.8 shows the blades create resistance and turbulence inside the pipe which slows down the water velocity. Because of this resistance, the overall flow rate decreases and the pressure distribution along the pipe becomes more controlled.

Each blade acts like a small obstacle that partially blocks the water path. As water moves through the pipe it rotates or disturbs around these blades causing energy loss due to friction. This reduction in kinetic energy helps regulate the water flow to different outlet taps at each floor level.

In this system five impellers are installed along the vertical pipe at a uniform spacing of 5.5 cm between each impeller. The impellers are mounted inside the pipe to influence the movement of water as it flows upward through the vertical pipeline. When water passes through the rotating blades of the impellers, the flow becomes more regulated and evenly distributed.

This arrangement helps in reducing pressure variations that normally occur in multi-storey water distribution systems. By controlling the velocity and direction of the water flow the impellers assist in maintaining a more balanced pressure throughout the pipeline. This configuration improves the efficiency of the water distribution system. As a result, water can be supplied more uniformly to the ground floor, first floor and second floor ensuring that each floor receives nearly equal flow without significant loss of pressure.

VII. MATERIALS AND METHODS

The experimental setup for the water pressure enhancement system consists of several components used to simulate water distribution in a multi-storey building. The main materials used in this project include a plastic water storage tank (top drum) which acts as the primary water reservoir, PVC pipes and fittings for the vertical and horizontal water distribution network, PVC taps or control valves to regulate the water flow at each floor level, pressure gauges to measure the pressure at the outlets, and a metal supporting frame to hold the entire structure in a vertical position. An impeller mechanism is installed inside the vertical pipeline to regulate the water flow and help distribute water more evenly across the floors. An air vent pipe is also provided near the vertical pipeline to prevent air locking and maintain smooth water movement. At the bottom of the setup a collecting tank is used to gather the discharged water so that it can be reused for multiple experimental trials.

The experimental method involves filling the top storage tank with water and allowing it to flow through the vertical PVC pipeline under the effect of gravity. As water flows downward, it passes through the impeller which rotates and creates a controlled motion that helps redistribute the water flow. The pipeline has three outlet points representing the Ground Floor (GF), First Floor (F1), and Second Floor (F2). Each outlet is equipped with a pressure gauge and a control valve to measure and regulate the flow rate.

During the experiment, the valves are adjusted and pressure readings are recorded at each level to observe the variation in pressure and flow distribution. The collected data is then analyzed to evaluate the performance of the impeller setup in enhancing water pressure distribution and achieving nearly equal flow at all three floor levels.

VI. RESULTS AND DISCUSSION

The experimental results show that water pressure and flow rate vary at different outlet levels due to the effect of gravity and height difference. Initially, the lower outlet received a higher flow rate while the upper outlet experienced comparatively lower water flow. After installing the impeller on the vertical pipe, a noticeable improvement in the distribution of water was observed. The impeller helped in regulating the flow and reducing the variation of pressure between the three floors. As a result, water discharge from all three outlets became more balanced compared to the initial condition. The pressure gauges also indicated a more stable pressure distribution across the outlets. This demonstrates that the impeller setup plays an important role in enhancing the water pressure and ensuring a more uniform flow in a multi-level water distribution system.

The results show that water flow was higher at the lower floor and lower at the upper floors due to gravity. After installing the impeller on the vertical pipe the water distribution improved and the flow became more balanced at all three outlet levels. The impeller helped regulate pressure and reduce flow variation between floors resulting in a more uniform water supply.

Table -1: Water Flow Level Analysis

S. No	Setup/Condition	Ground Floor for 1 Litre in Sec	First Floor for 1 Litre in Sec	Second Floor for 1 Litre in Sec
1)	No Impeller	3.20	2.95	5.30
2)	Full Impeller	3.45	3.02	4.60
3)	Impeller on Top	3.03	2.55	3.71
4)	Impeller on Bottom	3.44	2.90	4.47
5)	4 Impeller on Top, 6 Impeller	3.16	2.92	4.80
6)	10 Impellers on Top	3.27	2.39	4.77

From the experimental observations shown in Table 5.1, the configuration with the impeller placed at the top position of the vertical pipe provides the most suitable and balanced water flow distribution among the three floors. In this condition, the time required to collect 1 litre of water is 3.03 s at the Ground Floor, 2.55 s at the First Floor and 3.71 s at the. second floor.

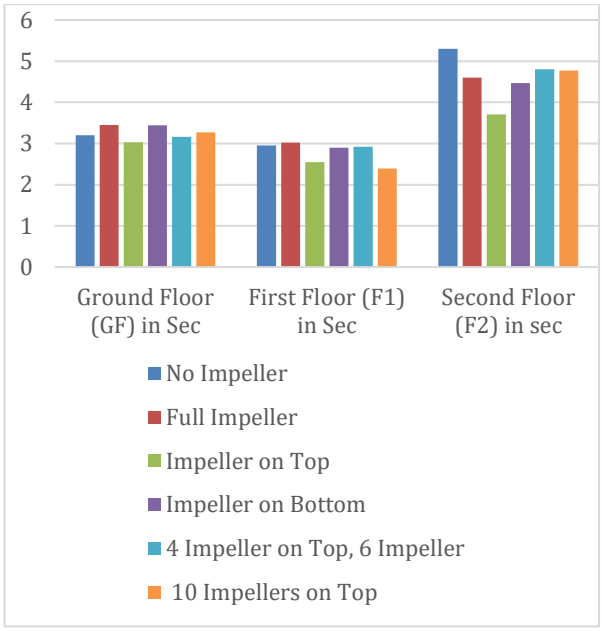

Figure 2. Bar Chart analysis of Flow parameters

The bar chart of water flow levels measured at the Ground Floor (GF), First Floor (F1), and Second Floor (F2) for different impeller configurations. The results indicate that the Impeller on Top setup records comparatively lower flow values of 3.03 s at GF, 2.55 s at F1, and 3.71 s at F2. These lower values suggest that placing the impeller at the top helps regulate and control water movement in the vertical pipe, leading to more stable distribution. In contrast, configurations such as No Impeller and 4 Impellers on Top + 6 Impellers show higher flow values, indicating uneven water distribution. Hence, the Impeller on Top configuration provides better control and balanced water flow across the three floors.

The water flow levels at GF, F1, and F2 for different impeller configurations. The Impeller on Top setup recorded lower flow times (3.03 s at GF, 2.55 s at F1, and 3.71 s at F2), indicating better control of water movement. Compared to other configurations, it provides more stable and balanced water distribution across the three floors.

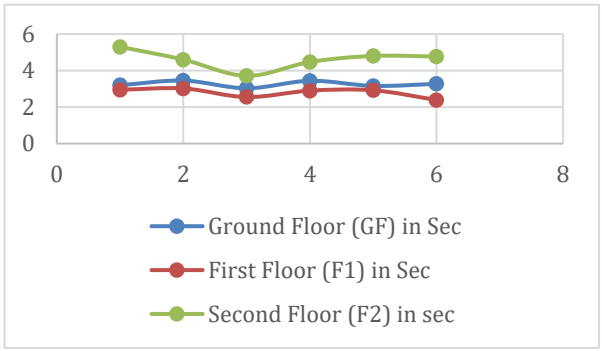

Figure 3. Line Graph Analysis of Flow Parameters

When the Impeller on Top configuration is considered, the flow values for all three floors become 3.03 sec (GF), 2.55 sec (F1), and 3.71 sec (F2). These values are relatively lower and closer to each other compared to other setups. This indicates that placing impellers on the top helps control and reduce excessive flow resulting in a more balanced distribution.

Therefore, the impeller on top configuration is selected as the best flow rate condition, because it provides more uniform water distribution and improved flow balance across all floors in the gravity-based water supply model.

Table 2. Better Water Flow Levels on Each Floor

S. NO	Stages For Impellers on Top Position	Time Taken (Sec) for (1Litre)
1.	Level 1(Ground)	3.03
2.	Level 2(Ground+1)	2.55
3.	Level 3(Ground+2)	3.71

SELECTION OF BEST FLOW RATE

The impeller placed at the top of the vertical pipe is selected as the best configuration based on the experimental results obtained from the water flow measurements at different floors. In this setup, the time required to collect 1 litre of water is 3.03 seconds at the Ground Floor, 2.55 seconds at the First Floor, and 3.71 seconds at the Second Floor. Compared to other conditions such as no impeller, full impeller, bottom impeller and multiple impeller arrangements this configuration provides a more balanced water flow between all three floors.

When the impeller is installed at the top position, just below the water tank outlet it regulates the water velocity at the initial stage of flow. The impeller blades create controlled resistance and mild turbulence which helps reduce excessive flow at lower levels and allows sufficient water to reach the upper floors. This improves the pressure distribution along the vertical pipe and reduces the difference in flow rate between the floors.

FLOW RATE IMPROVEMENT

Future improvements of the water pressure enhancement system can include the use of a booster or variable speed pump to maintain uniform pressure across all levels. Automation through flow sensors and control valves can help regulate water distribution more accurately without manual intervention. Incorporating a microcontroller-based feedback system and digital pressure sensors can enable real-time monitoring and control. Additionally, optimizing the impeller design and using smoother pipes can reduce losses and improve overall efficiency, making the system more suitable for practical applications.

FLOW IMPROVEMENT SUGGESTED

The installation of five impeller sets inside the vertical pipe significantly improves the flow rate distribution across all three floors. The impellers help to regulate and redistribute the water flow, reducing the excess flow at lower levels and enhancing the flow at upper levels. This results in a more uniform and steady flow rate throughout the system. Additionally, the reduction in pressure variation minimizes flow fluctuations, leading to improved efficiency and better utilization of the available water supply.

VII. PRESSURE CALCULATION

Hydrostatic Pressure Equation

The pressure in the system can be calculated using the hydrostatic pressure relation:

$P = \rho g h$

Where:

P = Pressure (Pa)

ρ = Density of water (≈ 1000 kg/m³)

g = Acceleration due to gravity (9.81 m/s²)

h = Height of water column (m)

1. Ground Floor (GF) – h = 1.5 m

$P = 1000 \times 9.81 \times 1.5$

$= 14715Pa.$

Pressure in bar:

$P = 14715/100000$

$= 0.147bar.$

2. First Floor (F1) – h = 1.0 m

$P = 1000 \times 9.81 \times 1.0$

$= 9810Pa$

$P = 0.098bar.$

3. Second Floor (F2) – h = 0.5 m

$P = 1000 \times 9.81 \times 0.5$

$= 4905Pa$

$P = 0.049bar.$

VIII. CONCLUSION

In multistory buildings an uneven water pressure problem often occurs where the top floors experience low water pressure while the bottom floors receive excessively high pressure. This imbalance happens due to gravity and frictional losses in narrow outlet pipes which reduce the flow rate at higher levels. The need for this project arises from the requirement to provide a stable and sufficient water supply to all floors especially the upper levels. To overcome this issue a large diameter PVC pipe is used at the top floor tank outlet to reduce friction and allow a greater volume of water to flow smoothly under gravity increasing pressure at the higher floors. Additionally, pressure gauges are installed to measure and monitor the water pressure at different levels, ensuring accurate comparison and effective performance analysis. This approach provides a simple, low-cost and efficient solution to achieve uniform water distribution.

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