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Design and Review of Automatic Urinal Flushing System based on Simple Hydraulics

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Abstract - *One of the major concerns during the time of pandemic like Covid-19 is to main social distancing at all times, Lots of preventive measures have been instated to avoid direct contact with any surfaces but what about using toilets and urinals in Schools, Colleges, Offices, Malls and other commercial institutions where the flushing systems are still operated manually by push button or flush trigger which requires direct contact. This concern leads people not to flush the urinal after use, which causes a foul smell and a hotspot for diseases. Complete cleaning without direct contact with the urinal is required to maintain the hygiene conditions. This can be achieved by installing Sensor operated mechanisms requiring electric energy which leads to high initial and operating costs, and there is a drawback of failure. In this paper, a simple solution using a mechanically operated flushing system is developed and reviewed, this system utilizes the pressure applied by the user to operate the flushing system through hydraulics. This system does not require any sensors or actuators thus the need for electric energy is eliminated, making this solution more economic and reliable. This automatic system ensures the conserved use of water as per standards and all of these are achieved in the absence of direct contact with the user.*

Key Words: ***Urinal Flushing, Save water, Hydraulic, Mechanical, Safe Toilet, Automatic flushing***

1. INTRODUCTION

It has been customary for one-third of the people to leave the toilet/urinal without flushing due to fear of coming into contact with the germs and bacteria, this affects the other two-third of the people. Leaving the toilet or urinal unflushed leads to a foul smell and a hotspot for diseases such as Nausea, Viral infections, Asthma, etc. At the times of pandemics like Covid-19 when people are solicitous, this becomes a serious issue since most of the flushing systems are still operated manually by push button or flush trigger which requires direct contact and the users feel uncomfortable to touch unhygienic parts of public toilet or urinals for their safety. So it becomes crucial to install automatic urinal flushing systems for the safety of the public and to prevent them from coming in contact with any surface. [1]

Already available automatic flushing systems are usually operated by sensors and actuators which require electricity to operate, this significantly increases the operation and installation cost of these systems making them unlikely to be used in public restrooms, small institutions, etc. In electrical systems, there is always a chance of failure which incurs more cost and a large quantity of water might get wasted. [2-3]

Thus a mechanically operated systems are preferred to overcome these issues. There are few types of mechanisms that can be implemented to drive the automatic flushing systems with each having its own pros and cons. This project focuses on the development and review of automatic urinal flushing systems that use simple hydraulics and pressure/load from the user to operate. The implementation of hydraulics significantly increases the life of the systems. [4]

This project utilizes a cylinder that receives the water and sends it to the urinal, the size of the cylinder is properly calculated such that the required minimum quantity of water as per the standards is supplied to the urinal. It also ensures the conservation of water by minimizing utilization and wastage of water. This proposed device does not requires any electricity so it is more economical and reliable, it can be installed easily and used in any kind of public places. This device helps in flushing urinals without any direct contact thus maintaining hygiene conditions in the sanitary facilities by keeping them clean after every use.

2. OBJECTIVES

The main Objectives of this project are to provide:

1. A fully functioning device that automatically flushes the urinal.
2. Improved operating life using hydraulics.
3. Conserved use of water.
4. A device that doesn't consume electric energy.
5. Disease-free and hygienic sanitary facility.
6. An affordable alternative for sensor operated automatic systems
7. A device that can be easily installed any place.

3. WORKING

Taking into consideration the existing issues, a low cost and fully functioning mechanical device is designed and developed as shown in figure 1.

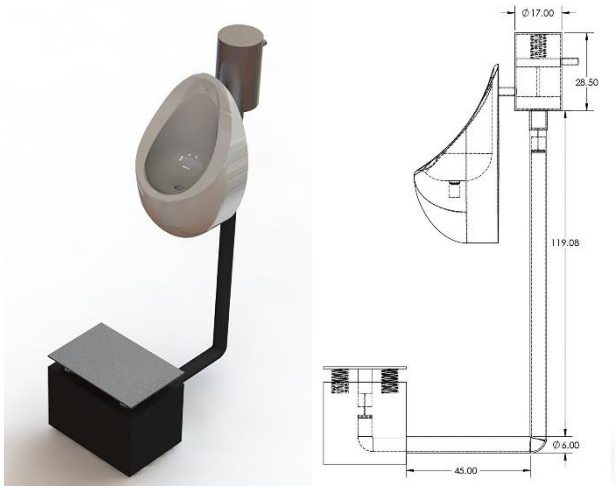

Figure.1. 3D model of the device

The working is as simple as given, at first the entire device is in an idle state at which there is no person to use the urinal. In this state the inlet valve of the water storage cylinder is closed and the outlet valve is opened as shown in figure 2. There is no water coming in through the inlet valve nor going out through the outlet valve and there is no water present in the cylinder.

For better understanding of the device some parts are made transparent in upcoming images so that the internal parts are visible, this is only for representative purpose.

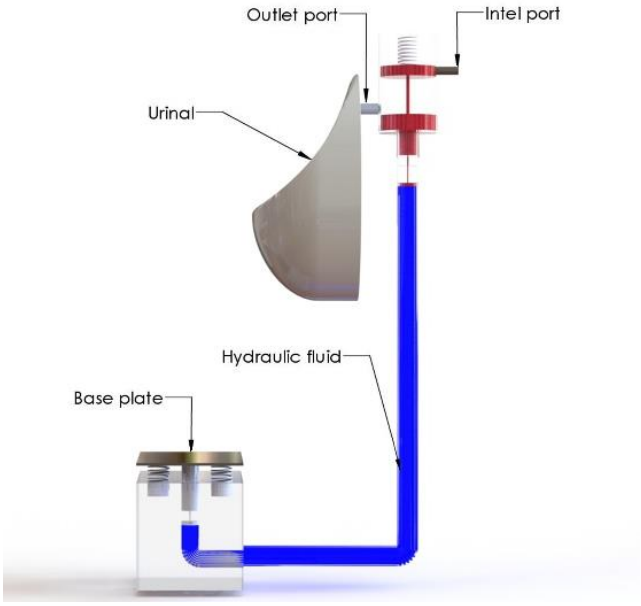

Figure.2. Ideal State

Later when someone wants to use the urinal, the user steps up in the base plate. Since the base plate is mounted on springs which tends to compress under the load or pressure exerted by the user, the base plate moves in downward direction. Due to this compression phenomena, the pressure is exerted on the hydraulic fluid at the user end. With regards to Pascal's law of simple hydraulics the pressure or force exerted on one end is transmitted undiminished to the other end [5] that is mounted with the valve control mechanism of the water storage tank.

This valve control mechanism governs the opening and closing of the inlet and outlet valve. When forced is applied in the upward direction by the hydraulic fluid, the platform raises up to a value of 5cm, making the inlet valve to open and outlet valve to close as shown in figure 3.

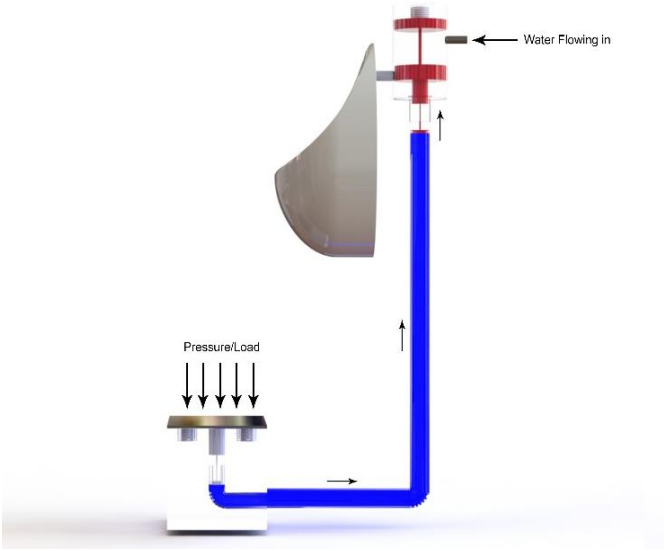

Figure.3. Device is Active

This allows an open passage for the water to flow but not exit the cylinder as the outlet is closed. Once the cylinder is full up to the capacity there is no space for more water and the flow stops. The cylinder is designed in such a way that it only holds the required quantity of water as per standards, not less not more, thus preventing water from getting wasted.

Once the user steps downs from the base plate, the springs are relieved from the pressure or the force thus the spring tension brings back the base plate to its original position. The entire hydraulic system comes back to its idle state, this reversing of state is assisted by the springs mounted on the base and also by the spring fixed inside the water storage tank, it also lowers the platform of valve control mechanism making the inlet valve to close and the outlet valve to open as shown in figure 4.

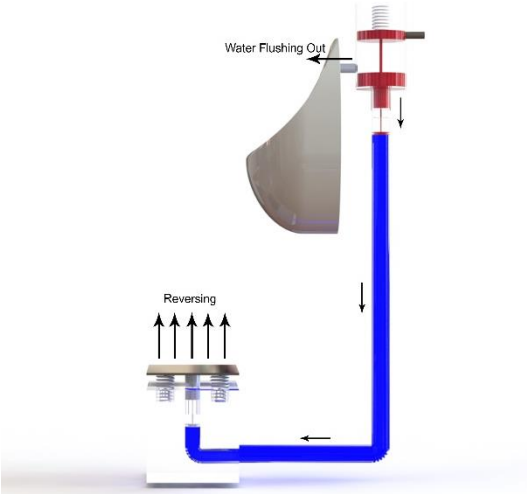

Figure.4. Reversing back to Ideal State

The water stored in the water storage tank flushes into the urinal as soon as the outlet opens and cleans the urinal. By this the goal of the project is attained, that is to clean the urinal without any human aid. A fully functional automatic urinal flushing system is designed and developed.

4. DESIGN SPECIFICATIONS

4.1 Base Plate:

It is a rigid flat plate that provides a platform for the user to stand during his period of use. For reducing the shaking effect during compression of springs, a raised cylinder like platform is provided below the plate that directly fixes into the base. The dimensions of the plate are (30cm x 45cm) with a thickness of 0.75cm and as represented in figure 5.

4.2 Base:

It a solid body that acts as the housing for the spring mechanisms and hydraulic cylinder. It connects the hydraulic cylinder and base plate through a small opening. Its dimensions are (30cm x 45cm x 30cm) and as represented in figure 5

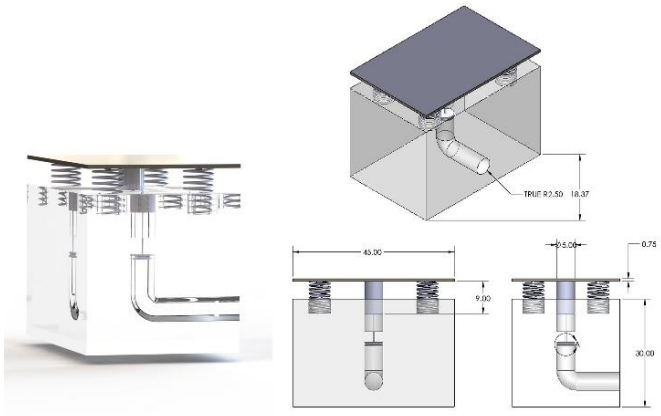

Figure.5. Base and Base plate

4.3 Springs:

The springs are designed in such a way that it compresses efficiently when load or pressure is applied and it provides necessary strain or expansion when load or pressure is relieved. There are 5 spring used in this project, four springs are mounted between the base plate and base and one spring is mounted between the valve control mechanism and water storage tank. The springs are designed by the following procedural values: [6]

From calculating deflection δ, Stiffness k,
We get required,
Height (h) = 9cm
Outer diameter (OD) = 6cm
Inner diameter (ID) = 5.2cm

Preferred Material is Stainless 17.7 ASTM A313

For the given Wahl stress factor
Number of active coils = 8

4.4 Hydraulic Cylinder:

It contains the hydraulic fluid. One end of the cylinder is connected to the base and another end is connected to the water storage tank and acts as the skeleton of the device. The stroke length is (45cm in horizontal direction and 120cm in vertical direction), bore is (5cm) and thickness is (0.5cm)

4.5 Hydraulic Fluid:

Hydraulic fluid transmits the pressure applied on one end to another end without any loss in pressure. The hydraulic fluid is represented in blue colour for representation purposes. Choosing the correct Hydraulic fluid is very crucial as it performs the core work and it has a vital role in improving the working life of the device. The hydraulic fluid is selected as per the following conclusions:

For the given purpose and requirements we need hydraulic fluid/oil with a viscosity of 32.

Therefore the hydraulic fluid used is
L-HM 32 (SAE 10W) Anti-wear hydraulic oil.

4.6 Water storage tank:

It is a temporary reservoir in which the required quantity of water to be used in the urinal is stored before flushing. It is calculated and designed in a way that it is holds only the minimum required quantity of water as per standards [7]. The calculations and water holding capacity of the water storage tank are as given below:

Volume of cylinder (V_c) = $\pi r^2 h$ (1)

Here, Radius (r) = 8cm
Height (h) = 11cm (space within the valve control mechanism where the water is stored.)

Therefore, $V_c = \pi (8^2)(11) = 2211.981\ cm^3$

Volume of rod (V_r) = $\pi r^2 h$ (2)

Here, Radius (r) = 0.5cm (radius of rod which occupies the water storing space)

Height (h) = 11cm

Therefore, $V_r = \pi (0.5^2)(11) = 8.639\ cm^3$

Total water storing capacity = $V_c - V_r$ (3)

$= 2211.681 - 8.639$

$= 2203.042\ cm^3$

Total water storing capacity in litres = 2.2 L

The dimensions of the water storage tank are represented in figure 6

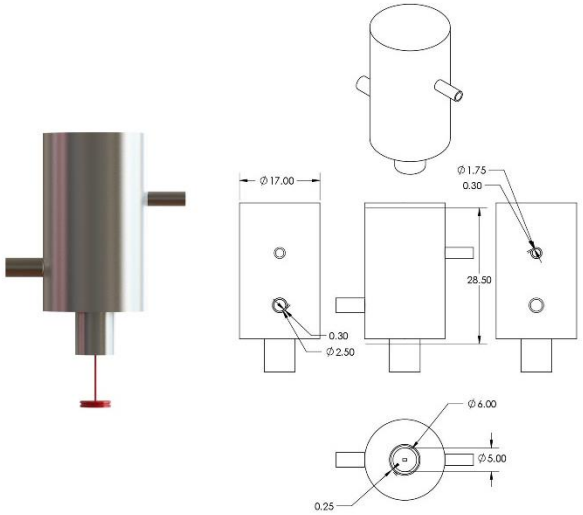

Figure.6. Water Storage Tank

4.7 Valve Control Mechanism:

It controls the opening and closing of the inlet and outlet valve. It is placed within the water storage tank. It is directly controlled by the pressure exerted by the hydraulic fluid and the spring. It is the main innovation of this device. The dimensions are represented in figure 7

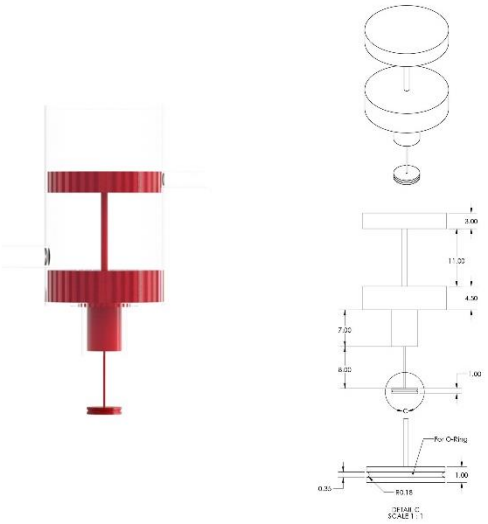

Figure.7. Valve control mechanism

4.8 Inlet and Outlet valve:

It provides the passage for the flow of water to enter and exit the water storage tank. The inlet valve is designed in such a way that, the flow rate is uniform for a given velocity and the time taken to fill the water storage tank is (5.3 seconds) which is the typical time taken by a user to urinate. The outlet valve designed in such a way that, the water quickly flushes into the urinal so that the waiting time for the next cycle is minimum. The diameter of the inlet and the outlet valve are (1.75cm) and (2.5cm) respectively, with a thickness of (0.3cm).

4.9 O-ring:

O-ring is a mechanical gasket used to seal the hydraulic fluid within the hydraulic cylinder and prevent it from leaking out. There are two O-rings used in this device, one is mounted in the base plate piston and another one is mounted in the valve control mechanism piston as given in figure 8. For the given application the O-ring is selected with the following specifications:

Width (t) = 3.5mm
Internal diameter (ID) = 46mm
Outer diameter (OD) = 53mm
Hardness = 70A (medium)
Material = Buna-N Rubber

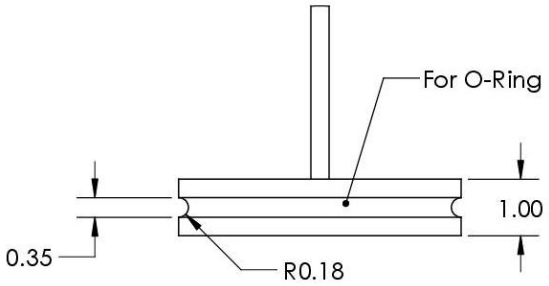

Figure.8. O-ring and Piston cut specifications

4.10 Urinal:

The urinal is the basin in which the user urinates. The water supply port is connected to the outlet of the water storage tank. This device can be used with any type of urinal, there is no restriction on the type of urinal to be used. This devices makes it possible to retrofit into pre-existing and newly designed urinal. The basic requirement that the urinal should have is that it should be designed as per standards. Some urinals may have diameter for the inlet port different from that is being used in this project, to overcome this an extender pipe can be utilized to connect the inlet port of the urinal and outlet port of the water storage tank.

5. COMPARATIVE STUDY

Table.1. Presenting comparison between three types of flushers [8]

	Mechanical Flusher	Electrical/Sensor Flusher	Automatic Mechanical Flusher
• Power Consumption	No	Yes	No
• Cost	Low	High	Moderate
• Water Consumption	High (>3L)	Moderate(2-3L)	Low(<2.2L)
• Efficiency	Good	Good	Good
• Human Interaction	Yes	No	No
• Life	High	Low	High
• Issues	Water wastage, human interaction, contamination,	High Cost, Risk of failure, Low life,	Need special care while Installation

6. FURTHER ENHANCEMENTS

The compression of the base plate and springs causes a sudden motion in the vertical direction when the user steps in and out of the urinal. This sudden moment can be minimized by introducing a geared mechanism between the base and the base plate. The geared mechanism helps to stabilise the motion uniformly.

Further this device can be implemented in toilets with few modifications in the design following the same principle.

An accessory cylinder containing disinfectant fluid can be connected with the water storage tank, so that disinfectant can be flushed along with water. [9]

7. CONCLUSIONS

Everyone has the rights to sanitation, it's the responsibility of society to provide people with proper hygiene conditions. The proposed innovation provides a reliable and low-cost alternative for mechanical flushing and Sensor operated flushing systems. This device works on simple mechanical principles and it can be easily fitted in any public place or can be retrofitted in any pre-existing devices. It ensures automatic flushing of urinals after every use without any direct contact between the user and the flusher, thus eliminating the transmission of any diseases and also simultaneously conserves water by limiting the flow of extra water. Thus resulting as the most economical, eco-friendly, reliable and efficient device.

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