HYDRAULIC PEROFORMNACE OF FAUCET AERATOR AS WATER SAVING DEVICE AND SUGGESTIONS FOR ITS IMPROVEMENTS

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Abstract

Conserving both water and energy with water-efficient technologies is extremely beneficial to the environment. Water conservation is defined as any action that reduces the amount of water withdrawn from water supply sources, reduces consumptive use, reduces the loss or waste of water, improves the efficiency of water use, increases recycling and reuse of water, or prevents the pollution of water. The faucet aerators used in kitchen and W/C taps regulate and reduce the water consumption by the process of aeration. This helps to reduce the usage of water, results in non-splash flow hence these fittings into water taps acts as water saving devices. These devices (faucet aerators) are simple to install and cost effective (Cost ranges between Rs. 150-Rs. 450) for normal usage at domestic and industrial installations. If we use faucet aerators and shower heads, we can save money on our heating and water bills. Previous works have revealed that users' requirements include temperature stability, adequate water volume and its distribution. All of which are substantially controlled by the faucet aerators. The experiments were carried out at the Fluid Mechanics Laboratory, School of Engineering and Technology, Jain University, Bangalore, wherein the hydraulic test rig was installed for conducting the performance test on aerators. The main aim is to conserve the water by usage of faucet aerators; to assess the hydraulic performance of existing faucet aerators and to determine the most suitable type.

Keywords: *Air, water, conservation, hydraulic, performance, geometry, pipe, flow rate, pressure, pipeline*

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1. INTRODUCTION

Aerators reduce the water coming through the faucets by mixing it with air. The aerator acts as a sieve, sending a single flow of water into many tiny streams. This introduces the air into the water flow. Since there is less space for the water to flow through, the water flow is reduced. The wastage of water must be avoided by giving encouragement for the usage of water-saving devices such as aerators, [A. Mounder, 1993] showerheads in hotels, residential and public toilets.

The aim is to reduce the water input (up to 50%) without sacrificing the consumer satisfaction. The hydraulic performances of commercial aerators (using experimental and numerical methods) as water-saving devices are determined and suggestions are made for improvement in water-saving devices based on hydraulic (line pressure, flow-rates) and geometrical parameters (reducing or increasing mesh size). Standard faucet aerators being flow control aerators are small in size but can create significant water savings. The Water Management can be divided into two groups:-

- System Users – Household, Industry, Agriculture.
- System Operators – Municipal, State & Local Government and Private Suppliers.

In the present day scenario, water conservation is a necessity. This is done by minimizing the water input.

The faucet aerators govern the flow rate less than 10 litres/ min allowing the entrainment of air thereby result in fine droplets. Correspondingly the volume of water used is reduced. The low flow device results in water savings of 20% to 50% of the normal usage.

Fig 1.1 Water Saving Devices – Faucet Aerator

Aerators compress the water flow into a higher-pressure discharge than regular faucets. They also introduce air bubbles into the water, making it feel like there is a larger water flow. However, the water pressure is maintained, which is why most people don't notice a difference in the amount of water coming out of an aerated faucet. Since the water is somewhat compacted by an aerator, it may even increase the water pressure in a faucet that typically has lighter-than-normal water pressure.

Some aerators now come with flow restrictors [Andrew P. Jones1993]. Essentially, this is a temporary "off" switch. These are particularly handy when we are doing dishes. A restrictor will turn the water off at the nozzle with a quick flip of a lever. When we need the water, another quick flip starts it flowing again. It's one more feature to help us save water [Sandra, 1982].

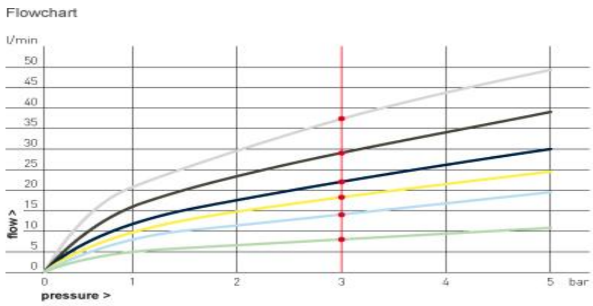
Aerators can be used in residential and commercial buildings W/C and bath as well as in public toilets [Cortez.M, 1993] which are installed in flushing systems, taps, shower-heads, etc.[Swaffield,1988]

2. NEED FOR THE STUDY

Laminar flow controls deliver a precise volume of water at faucets, showerheads, and hose outlets. Unlike conventional water-saving fixtures that deliver varying flow rates in response to varying line pressure [NAHB,1992]. American Water Works Association has highlighted the importance of water saving devices [3, 7, 9, 10, 18, 21]

During 1994-1997, the New York City Department of Environmental Protection (DEP) has installed water-saving devices in faucets and showerheads as a part of the water conservation project. An important evaluation of project results in multi-family buildings found an average reduction in water use up to 29% or 315 Liters per apartment per day in Saudi Arabia [2,8,20,22] experiments have been carried to investigate effective water saving technologies using faucet aerators, low plumbing fixtures.

European Standard for faucet aerators was given by NEOPEARL, Inc.171 Mattatuck Heights Waterbury, CT 06705, in 2000 and is as given in Chart 1. Bassam Hasbini (2003) and T.Kondo (2006) has carried out experimental study on different types of faucet aerator and highlighted the importance of aerator geometry, stop valve on water and energy saving



Flow rate class	Flow rate range per l/min	Dynamic pressure
Z	7.5–9.0 l/min	3 bar
A	13.5–15.0 l/min	3 bar
S	18.0–19.8 l/min	3 bar
B	22.8–25.2 l/min	3 bar
C	27.0–30.0 l/min	3 bar
D	34.8–37.8 l/min	3 bar

In our country a limited study is carried-out on "water-saving devices" mainly carried by few leading research institutions in the country like FCRI, Pallakad, and CWRDM, Kozhikode (on sprinklers). M/S Parryware and Hindware companies have brought out several water-saving fixtures in the market. They have suggested the following measures along with use of water saving devices:

- Installing high-pressure, low volume nozzles on spray washers;
- Using fogging nozzles to cool product;
- Replacement of high volume hoses with high-pressure, low volume flush toilet.

Ranganathan (2007) carried a limited study on Water Efficient Faucets and Fixtures used in Home. The Critical dimensions for water efficient flushing are obtained based on computer simulation techniques.

All the above study does not clarify the mechanism of water saving in a faucet aerator. It has also not suggested any governing parameters responsible for water saving in these devices. The present study aims at the following:

- To determine the water-saving of existing faucet aerators based on experimental investigations.
- To verify their claim for water saving.
- To suggest modifications in design to further improve their performance.

3. FAUCET AERATOR PARTS

The typical parts of an existing commercial faucet aerator are: Steel body, Water-Inlet, Wire meshes & other internal geometry, restrictions (for stream-lining of flow). The important geometric parameters are, Air-Inlet (for mixing air with water and reduce the flow rate), and number of Plastic Restrictors (function is to save the water by distributing the flow).

MODELS –DESCRIPTION

Model-11 **Model-12** **Model- 13**

Fig. 3.1 Hydraulic test rig and Parts of a Faucet Aerator

Table-1: Description of Faucet Aerator Models

Aerator types	No. of meshes	AREA OF AIR PASSAGE $(Cm)^2$	AREA OF FLOW $(Cm)^2$	BLOCKAGE (%) Pipe Area
Mode-l1 (Parryware)	2 (dissimilar)	0.691	1.1	0.134
Mode-l2 (Jaguar)	1	0.628	1.21	0.048
Mode-l3 (Ess-Ess)	2 (dissimilar)	0.628	0.95	0.222

3.1 Experimental Set-Up & Methodology

The hydraulic-rig performance tests of 4 different types of aerators were conducted using the hydraulic-test rig at School of Engineering & Technology, Jain University, Bangalore at different pressures–manifold pressure and line pressure(0.8, 1.0, 1.2kg/cm^2). The time required in seconds(s) for a flow of ten (10) litres (l) was calculated for each sector angle of flow regulator for the 12.5 mm to 19.05mm pipe line size for three different line pressures. The flow rate is computed. Experiments are carried out with & without faucet aerators to estimate the water savings for three models for a given line pressure, and temperature. The percentage of water savings is calculated for the available models. The most efficient model of faucet aerator determination of the most efficient model aerator is identified.

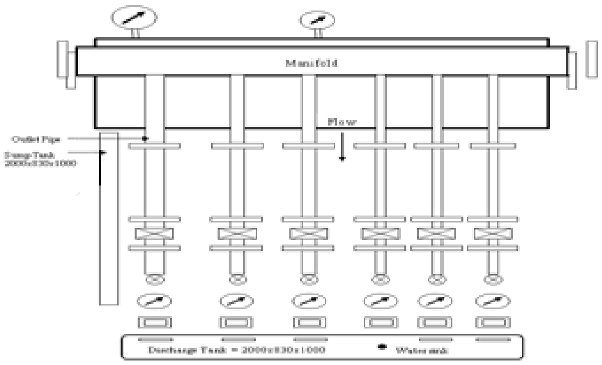


Fig. 3.1 Experimental Set-Up

4. RESULTS AND DISCUSSIONS

The majority of the faucet aerators tested obeyed a simple pressure-flow relationship with flow being proportional to the square root of the internal pressure at the showerhead. $Q = k\sqrt{\Delta P}$, where Q = flow rate in cm^3/sec, ΔP = Pressure difference (kg/cm^2) in the faucet aerator and 'k' is a form of discharge coefficient. This is in accordance with the theory for turbulent flow through a constriction. The value of the constant 'k' will depend on the nature of the constriction (and also on the units chosen for Q and P). The collected data is analysed to determine the water saving efficiency of the three different types of faucet aerators at different flow rates. To obtain the desired results, the line pressures and line size is also varied. Following are the variables identified in a faucet aerator:-

MODEL- 1 (12.7 mm pipe)

Table-2: Discharge for different line pressures

Q (Cm³/s)	Q_0 (cm³/s)	$(Q/Q_0)^2$	R_e	R_{e0}	R_{e0}/R_e
LINE PRESSURE 1.2 (kg/cm²)					
153.84	338.98	0.205	18761	41338	2.203
149.25	322.5	0.213	18201	39329	2.160
144.92	256.4	0.319	17674	31348	1.773
126.58	170.9	0.547	15436	23841	1.305
94.33	111.11	0.719	11504	13550	1.177
18.08	32.73	0.304	2205	3991	1.809
LINE PRESSURE 1.0 (kg/cm²)					
151.5	135.13	0.795	18937	17971	0.949
151.5	132.74	0.772	18937	18160	0.959
151.5	128.2	0.715	18937	18009	0.951
147	116.278	0.624	18373	15855	0.863
135	87.719	0.414	16875	11272	0.668
104	37.81	0.3025	13000	2990	0.23
LINE PRESSURE 0.8 (kg/cm²)					
138.8	263.15	0.277	17351	32092	1.849
135	238.09	0.321	16875	29036	1.721
131.5	230	0.327	16430	28000	1.709
128	208.33	0.377	15998	25406	1.588
119	166.67	0.860	14875	20325	1.366
86	100	0.384	10748	12195	1.135

Where

Re – represents Reynolds number with water saving device

Re_0-represents Reynolds number without water saving devices

Q- Discharge with water saving device.

Q_o- Discharge without water saving device.

Figure 5 and Figure 6 clearly shows that 12.7mm pipeline is more effective as compared to 19.05mm pipeline for faucet aerator as water saving devices. The maximum value of % water saving of 55% is reported for 12.7mm pipeline as against 32% in 19.05mm pipeline.

Hence the mixing efficiency of air with water has more effect in 12.7mm pipeline for models of faucet aerators.

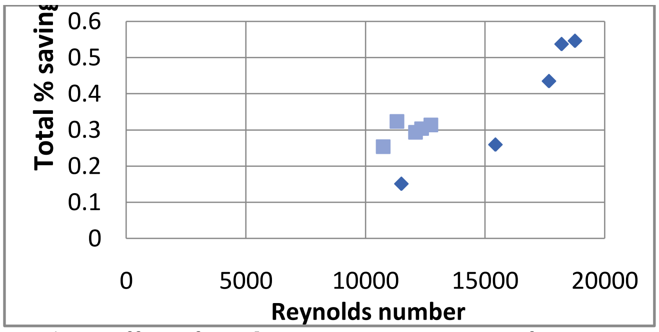


Fig. 5 Effect of Pipeline size on water saving for a 1.2 kg/Cm^2 line pressure

- For 19.05 mm pipe
- For 12.7 mm pipe

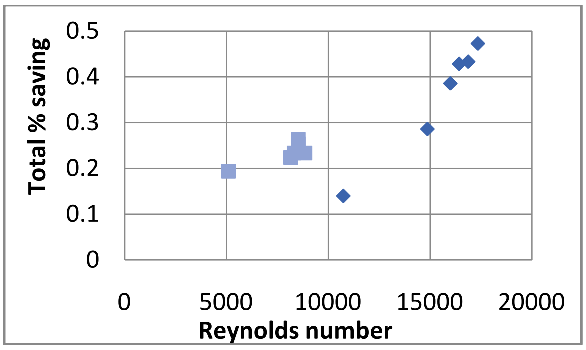


Fig. 6 Effect of Pipeline size on water saving for a 0.8 kg/Cm^2 line pressure

5. CONCLUSIONS

- Based on the experimental results of the 3 aerators of different geometrical configuration which are operated on similar hydraulic conditions (for a given pipe size) it is observed that water saving is relatively more with 2-dissimilar mesh combination as compared to single mesh or 3-mesh type.
- The length of air passage need to be equal to diameter of aerator for maximum saving of water for a given line pressure and flow rate.
- The highest water saving is 47% for model number-2 (M/s ESS-ESS Gurgaon) when air mixing is maximum at 22.6%
- Since the Aerator-2 shows the maximum water saving with the length of air passage equal to 6.5 mm, therefore for improvising new designs the length of the air passage should be comparatively reduced.
- The graphical relationship is obtained for discharge with saving devices (Q) with main flow rate (Q_0) for different line pressures (1.2bar, 1.0bar, 0.8bar).
- The wire mesh of aerator should not occupy the entire portion of the flow area. For maximum saving of water the preferred ratio of pores in aerator to the total flow area should lie between 0.85-0.98.
- The mesh should have pores bearing the same dimensions to obtain a high efficiency.
- The maximum line pressure with maximum air entrainment can effectively bring about the greatest ability to save water.

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