PRESSURE MANAGEMENT IN URBAN WATER NETWORKS FOR WATER SCARCITY CONDITIONS

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ABSTRACT

With respect to population growth, increase of water consumption per capita and high cost of drinking water production and regarding limited water resources, optimum usage of existing water is considered as a vital issue especially in developing countries. Therefore managers and decision makers in water and wastewater sectors should consider this important issue in their plans. Pressure management is one of the most effective and practical methods for water saving in urban water distribution networks. In spite of many studies which describe the principles of pressure management theory, however, only few studies on pressure management at field are available. In this paper, effect of pressure management on reduction of water demand and consumers` consumption was studied. To perform the study, a small urban water distribution network was isolated. A modulated pressure reducing valve (PRV) with an ultrasonic flowmeter used to control and monitor the flow parameters. Some different pressure patterns were generated by the modulated PRV applied on the network and for each case total water inflow to the network and water consumptions of the consumers were measured. Results showed that a good pressure management could significantly decrease the water demand and consumption.

Keywords: Urban Water Network, Demand Management, Consumption management, Pressure management, Leakage .

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INTRODUCTION

Considering water scarcity, population growth, increase of water consumption per capita and high cost of drinking water production, optimum usage of existing water resources is a vital issue. In developing countries, this important issue has a greater significance because of limited water resources on one hand and population and industrial consumption growth on the other hand. To deal with the problem of drinking water shortage, conventional water resource management methods are not solely sufficient and modern water supply management methods must be used as a new way which enhances efficiency of water distribution system. Pressure management is one of the most effective solutions among the water demand management methods.

The main objective of reducing leakage in arid or semiarid regions is responding to water shortage. Another important objective relate to economical aspects, such that by reducing unaccounted-for water costs, consumption of electricity, storage, treatment and pumping are also reduces and because of water cost payment there is revenue for water and wastewater companies. Also if new demands of customers could be satisfied by decreasing the unaccounted-for water, there would be a great saving in cost of developing new resources (e.g. making new dams and reservoirs and construction and equipment of treatment plants).

Many studies have been recently carried out to reduce the unaccounted-for water, however only a few of them have considered the developing countries conditions. On the other hand efforts to decrease unaccounted-for water in developing countries turn into impasse by factors like improper leakage control, lack of effective management performance and general regulations and etc (Chowdhury et al. 1997).

Although pressure management is one of the best methods for water demand management, some operation managers ignore using this method in their water distribution networks and would prefer to use other methods such as water rationing when they face water scarcity. It may be because of lack of experience on pressure management. The main objective of this paper is to show the good results and practicability of pressure management especially in existing and old water distribution networks.

BACKGROUND

Excess pressure in network causes an increase in leakage, consumers' consumption, network bursts and a decrease in effective lifetime of equipment. For existing networks, pressure management is the most practical method for reduction of leakage. Therefore pressure management is a practical, effective and low cost solution to control amount of leakage solely or in combination with other methods such as using varied speed pumps and water surface elevation in reservoirs. Some advantages of pressure management are reduction in servicing costs, lower emergency services and lower dissatisfaction of consumers (Thornton and Lambert 2006). For each type of leakage, pressure reduction can reduce water loss. Many pieces of researches have been allocated to this interesting topic such as: (Lambert 2003, 2004) (Marunga et al. 2006) (Walski et al. 2006), (Tabesh and Humehr 2007), (Karamouz et al. 2006).Thornton and Lambert have shown that reduction of pressure and its stabilization in the network not only reduces the amount of existing leakage but also decreases occurrence of future leakages (Thornton and Lambert 2006).

Water and wastewater companies can save huge amounts of money by controlling leakage. For example a city of 25000 population was reported to save a cost of 100000 $ annually only with 5 percent reduction of leakage (Zimmerman et al. 1987). In a study in Melbourne of 4000 consumers, pressure management could save 20 to 55 percent of consumed drinking water in different areas (Burn et al. 2002).

PRESSURE MANAGEMENT BY MODULATED PRV

Water distribution networks are usually designed based on peak hourly demand. The water consumption in the first years of operation is lower than these values. The same is true for some days in winter and also some hours during the night time. Therefore in non-peak hours, the amount of pressure in the network is larger than the necessary values. In such conditions excess network pressure in low elevation regions especially in the night hours can cause pipe bursts.

Ordinary PRVs is adjusted base on a certain output pressure so that it cannot exceed beyond this adjusted pressure. On the other hand, output flow of PRVs must provide a minimum pressure needed by consumers in peak hourly demand. These conditions lead to an excess network pressure in non-peak hours. By installation of modulated PRV, the downstream pressure can be adjusted to the range of minimum required pressure during the both night and day time.

CASE STUDY & METHODOLOGY

A water distribution network in Tehran city was chosen for this study. Region is supplied with only one reservoir. After isolation of the region, assembled a modulated PRV in the entrance of the isolated region (Figure 1), moreover, a digital pressure regulator and a pressure logger were installed to induce different pressure patterns. Also an ultrasonic flowmeter was installed downstream of the reservoir used in order to measure input flow to the isolated region.

Figure 1. Satellite photo of studied region, yellow lines (thin lines) show distribution network, white lines (thick lines) show the region border

Since at the beginning of study the optimum pressure pattern was not exactly known, therefore after preparation of isolated region and setting up the equipment, different pressure patterns were applied to the modulated PRV as try and error process to find the best pattern. This process continued by applying more pressure reduction to the PRV until the first complaint was received from the customers. These patterns are shown in Figure 2. For each patterns inflow was recorded in 10 minute intervals and the measurements were continued for a week. Output pressure of PRV before installation of modulated PRV was 50 meters. It should be noticed that output pressure patterns of PRV were adjusted such that the costumers didn't face any pressure shortage and no complaint was reported during the study.

In Tehran city, the water and wastewater company is responsible for providing pressure at most five floors buildings. Taller buildings have booster pump for providing additional required pressure.

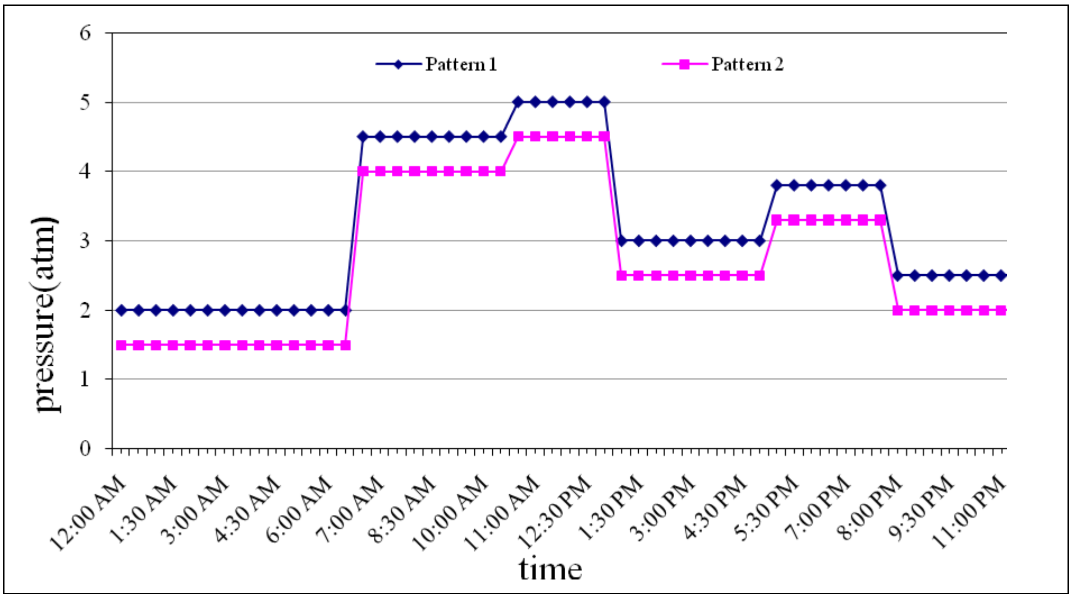

Figure 2. 2 patterns applied on the modulated PRV

Different conditions and information of measurements are shown in Table 1. For better comparison of mentioned patterns (Figure 2), average amount of applied pressure patterns during 24 hours is also mentioned in table.

Table 1. Different conditions of measurements

Phase	**Measurement dates**		**Output pressure of PRV**
	from	**to**	
1	07/10/13	07/10/20	Constant 50m
2	07/10/20	07/10/27	Pattern 1(average 31.94m)
3	07/10/27	07/11/3	Pattern 2(average 26.94m)

RESULTS & DISCUSSION

After completion of measurements, the data was analyzed and following results are obtained.

Total inlet flow

The ultrasonic flowmeter measured input flow to the isolated region during measurment period. Results are shown in Table 2 briefly.

Table 2. Inflow discharge to the isolated region

phase	Output pressure of PRV	Inflow discharge (m^3/day)
1	Constant 50m	999.9
2	Pattern 1(average 31.94m)	904.1
3	Pattern 2(average 26.94m)	790.3

As results of Table 2 show the total ammount of inlet flow reduces from 999.9 m3/day in phase 1 to 790.3 m3/day in phase 3.

In Figure 3, reduction of inlet flow to the pilot is shown versus reduction of reduced pressure in percent. In Figure 3, the calculated data is fitted by a line showing the trend of data. In this figure, reference outlet pressure was outlet pressure of PRV in phase 1 e.g. 50 meters.

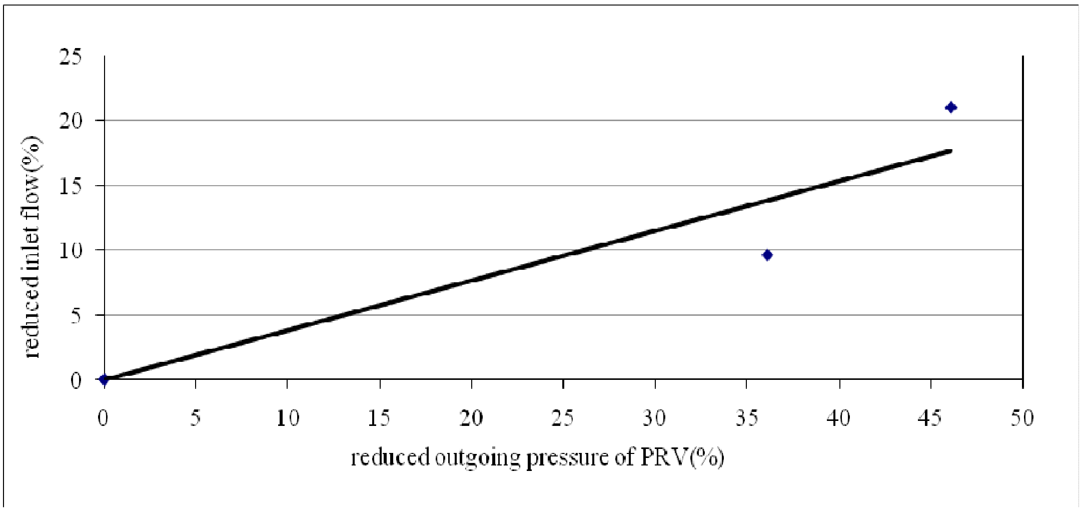

Figure 3. Reduced outgoing pressure of PRV (%) versus reduction of inlet flow (%)

Results of figure 3 show that with no complaints of consumers, total inlet flow reduced about 20 percent in final phase. Inlet flow is composed of network leakage and consumer's consumption, reduction of inlet flow means lower consumers' consumption and/or lower network leakage.

The Consumers' Water Consumption

To study the effects of pressure management on the consumers' consumption, 64 consumers were selected as sample of total consumers and their domestic water consumptions measured by reading their flow meters in different phases during the study period. Results for domestic water consumptions are shown in Table 3.

Table 3. The consumers' domestic water consumption and saved water values in the different phases

phase	Output pressure of PRV	The Consumers' Domestic Water consumption (m^3/week)	Water Consumption Reduction (%)
1	Constant 50m	1419	0
2	Pattern 1(average 31.94m)	1222	14
3	Pattern 2(average 26.94m)	985	31

As the results of Table 3 indicate, by reduction of outlet pressure of the PRV, the consumers' water consumption reduced.

In Figure 4, reduction of the consumers' water consumption versus reduced pressure is shown in percent. Figure 4 shows more than 25 percent water saving for the consumers' consumption in phase 3. In this figure, reference outlet pressure was outlet pressure of PRV in phase 1 e.g. 50 meters. It should be also mentioned that no complaint was received from consumers with regard to lack of pressure after applying patterns to the modulated PRV.

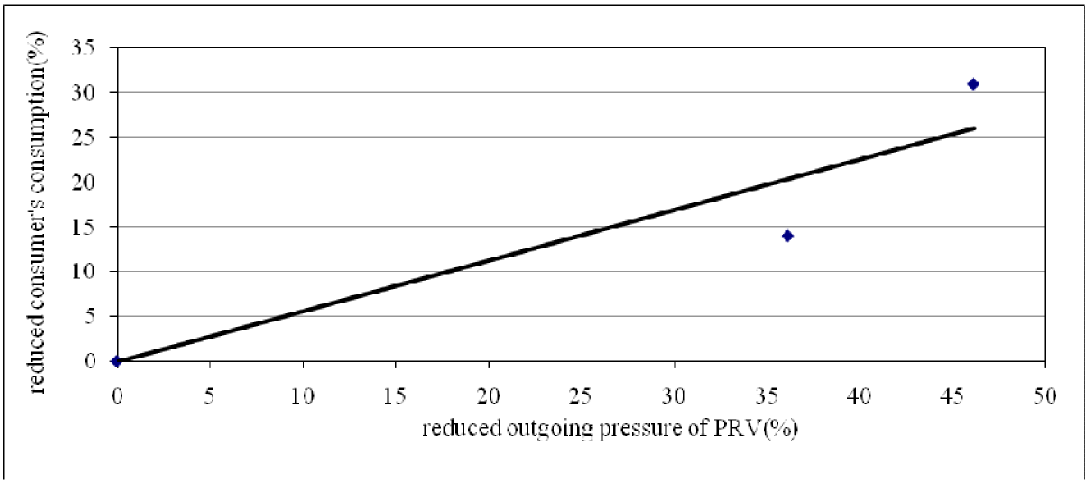

Figure 4. Reduced outgoing pressure of PRV versus reduced the consumers' consumption

CONCLUSIONS

In present study, results of pressure management in an isolated network are analyzed. Results showed that by adjusting the upstream network pressure, about 20 and 25 percent of total inlet flow and the customers` water consumption were respectively reduced.

It is experienced that pressure management is practical method for water saving even for old water distribution networks.

This study also showed that in the selected area which was a regular and a general sample of Tehran water network, there was a considerable potential for water saving.

Since pressure management in addition to saving of drinking water has some more benefits, applying this solution is recommended as practical and economical method especially for existing networks.

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