Investigation of the applicability of an optimized flushing strategy for drinking wat er networks at Suzhou City Water

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Abstract

Based on different research projects an optimized flushing strategy for drinking water networks was developed in Germany. This approach is based on the processes of the accumulation and the mobilization of deposits in drinking water pipes. Within a SINO-German joint research project SIGN it should be investigated if this flushing strategy can also be used under conditions which are common for China. The results show that this optimized flushing strategy can be applied in the same way as in Germany. Due to the positive experience the Chinese partners started to discuss the way of implementation of the optimized approach into the network operation strategy.

Keywords: brown water, drinking water quality, network management

INTRODUCTION

Good management practice for the distribution network is essential for safeguarding the drinking water quality in the network. Therefore, pipe flushing plays an important role in the removal of deposits. Deposits may build up due to an input of particles with the drinking water and due to corrosion processes in unprotected metallic pipes. It is common to flush only after brown water events or to conduct an end-pipe flushing program. Both strategies are often not very effective for cleaning networks and obtaining sustainable effects. As a result of intensive research the processes of the accumulation and mobilization of deposits in the network were identified (Richardt, 2010). Based on this, an approach for the development of demand-oriented flushing plans in respect to the velocity of the formation of deposits in the pipes was developed. This technique is already being used in practice by a number of German water suppliers for the optimization of their network management strategies. Furthermore, the results have been considered within the technical standards of the DVGW (DVGW: German Association for Gas and Water). Within the SINO-German joint research project SIGN it should be investigated if this optimized flushing strategy can also be used under conditions which are common for China. In this paper, the basics for the development of a demand-oriented flushing strategy will be described and the experience of the application at the Chinese water supplier Suzhou City Water will be outlined.

ACCUMULATION AND MOBILIZATION OF DEPOSITS

The cleaning of drinking water pipes by flushing has only a temporary effect as, immediately after the net-cleaning measure, the build-up of deposits starts anew. The velocity of the formation of loose deposits depends particularly on the particle content of the distributed water, the characteristics of the particles in the bulk water, the corrosion velocity of the unprotected pipes, and the flow velocity in the pipes. Therefore, flushing the drinking water pipes is a measure that needs to be repeated regularly to avoid the accumulation of a critical deposit level. Using general flushing intervals without information about the velocity of deposit accumulation, this can result in high deposit levels with a certain risk of frequent quality problems. On the other hand, if the flushing intervals are shorter than required, the expenditure for the net-cleaning measure will not be at optimal.

The accumulation of deposits in a network is a process of sedimentation and adsorption of particles (Böhler et al., 2004, Vreeburg, J., 2007, Richard et al., 2010, van Thienen, 2011). As a result of sedimentation, particles settle on the bottom half of the pipe wall. Turbophoretic effects are responsible for particles settling on the entire circumference of the pipe (Vreeburg und Boxall, 2007). In corroding pipes, the layer of loose deposits is formed by a chemical reaction of the pipe material, and, therefore, it is distributed to the entire circumference.

The amount of loose deposits that may build up in a drinking water pipe is not unlimited. It is defined by the flow velocity. From the investigation conducted by Richardt et al. (2011) and Ripl et al. (2010) it was concluded that, due to the low shear stress, particles accumulate only in the viscous sub-layer. Richardt (2010) found a mathematical correlation between the maximal turbidity that can be mobilized and the thickness of the viscous sub-layer. This means that the lower the flow velocity, the higher the amount of the deposits which can accumulate. Figure 1 shows schematically the relationship between the flow velocity and the maximal amount of loose deposits which can accumulate.

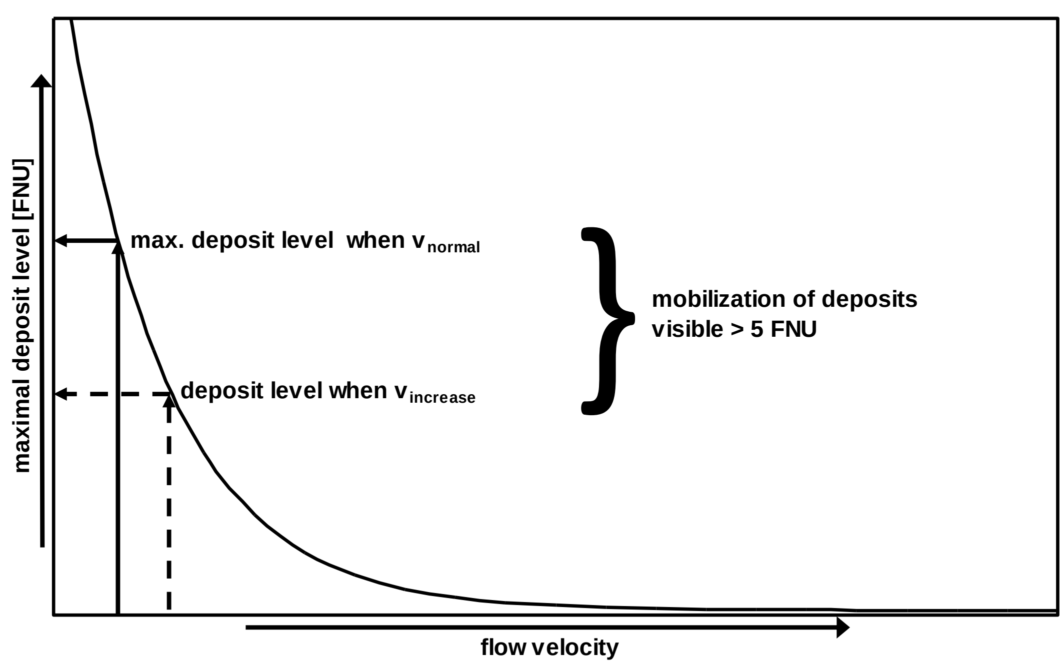

Figure 1: Scheme of the relation between flow velocity and resulting deposit level

A brown water event is predominantly an effect of the mobilization of loose deposits. This happens if the layer of deposits is thicker than the viscous sub-layer. Furthermore, the resulting shear strength needs to be higher than the cohesive and adhesive forces in the film of loose deposits. From this, it must be concluded that brown water events are the result of higher flow velocities in comparison to the "normal" flow conditions under which the deposit layer accrue.

The definition of demand-oriented flushing intervals for drinking water pipes is based on the approach that a certain deposit level is acceptable, which will not be re-suspended under a defined flow stress. For example, if the daily maximal flow velocity in a pipe is approximately 0.05 m/s under normal conditions and the maximal deposit level has reached an increase in the flow velocity of approximately 0.1 m/s can whirl up a visible amount of deposits. If it is known that this scenario may occur, perhaps due to a higher water demand during the summer-time, the maximum acceptable deposit level is defined by this situation. This means that the special scenario occurring under certain conditions defines the maximally acceptable deposit level.

The relationship between the flow velocity and the maximally resulting deposit level was mathematically formulated in the calculation program named OptFlush (Richardt, 2010). This function is based on the results from more than 120 net-cleaning measures in different drinking water networks. This program is used for the calculation of demand-oriented flushing intervals for drinking water pipes.

MEASURING PROGRAM AND VISUALIZATION OF THE DEPOSIT SITUATION

For the calculation of demand-oriented flushing intervals, the data of the velocity as well as hydraulic data are necessary. The procedure of the data generation und processing is schematically shown in Figure 2.

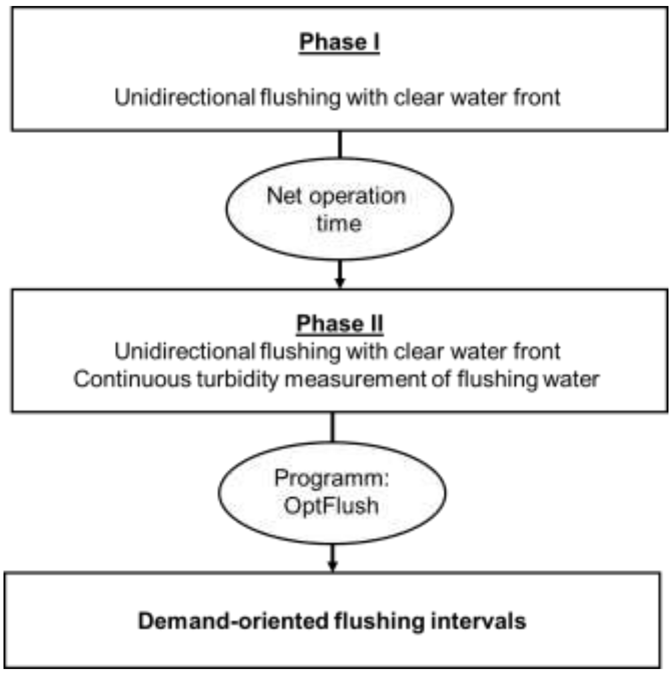

Figure 2: Scheme of data generation and processing for calculation of flushing intervals

For the generation of relevant data for the calculation of flushing intervals, first, the network area needs to be cleaned thoroughly in a unidirectional way with a clear water front of maximal flushing velocity. Before this can be carried out, a flushing plan showing the hydrants used and the valves that must be adjusted must be developed. After cleaning, the network area needs to be operated under normal conditions for a certain period. After this period, the pipes show the individual amount of deposits formed under this certain conditions. Flushing needs to be repeated with measuring continuously the turbidity of the flushing water for each flushing segment.

For the measuring of the turbidity in the flushing water, the flushing velocity, and the pressure the flushing device FlushInspect was used. This device is produced by the German company FAST. The figure 3 shows FlushInspect installed in a pickup car of the water supplier Suzhou City Water and the colour of the flushing water resulting by a mobilization of deposits cause by the increase of the flow velocity during the flushing.

Figure 3: Flushing device FlushInspect installed in a up pickup car of the water supplier (left) and mobilization of deposits due to the increase of the flow velocity by the flushing

The TZW has developed a tool which enables linking the turbidity curve recorded by FlushInspect with the geographic coordinates of the pipes. With this, the situation of deposits in the network can be visualized accurately. Figure 4 depicts the deposit situation in the pilot area of the water supplier for the basic cleaning and after 3 month of network operation. The results show that in some of the pipes no formation of deposits occurred whereas in other pipes relative high amounts of loose particles had been accumulated.

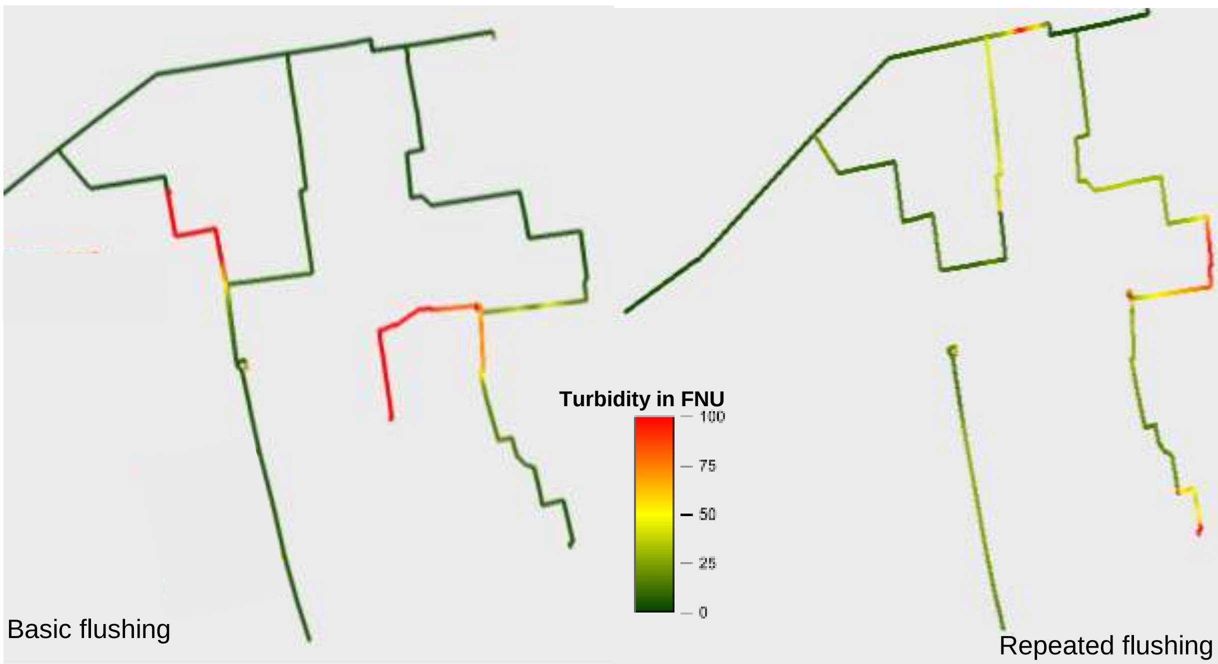

Figure 4: Deposit situation in the pilot area based on turbidity measurements in the flushing water (left: basic cleaning, right: repeated cleaning after three month of network operation)

CALULATION OF FLUSHING INTERVALS

For the calculation of the flushing intervals with OptFlush, the data from the flushing and the flow velocity are necessary. The turbidity curve of each flushing segment is to be evaluated in respect of maximum value, as this represents the point with the highest amount of deposits and, therefore, the highest risk of a mobilization. The daily maximum flow velocity from the hydraulic simulation is needed for determining the maximally possible deposit level. A security factor is used to define the deposit level permissible for each pipe. Using the necessary data, the flushing intervals can be calculated with OptFlush. Figure 5 shows schematically the procedure of the calculation.

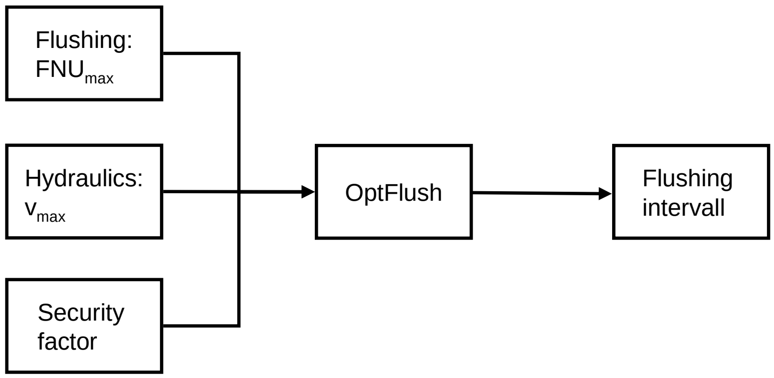

Figure 5 Procedure of calculation of demand-oriented flushing intervals

The results from the deposit situation (Figure 4) of the calculation of the demand-oriented flushing intervals are shown in Figure 6. For the pilot area 4 different flushing intervals were calculated. For the main pipe (pipe 1) resulted 8 years of operation. Pipe 2 und pipe 6 have an operation cycle of 4 years and pipe 3 and pipe 5 should be flushed every 2 years. The shortest flushing interval was determined for pipe 4, due to the fast accumulation of deposits.

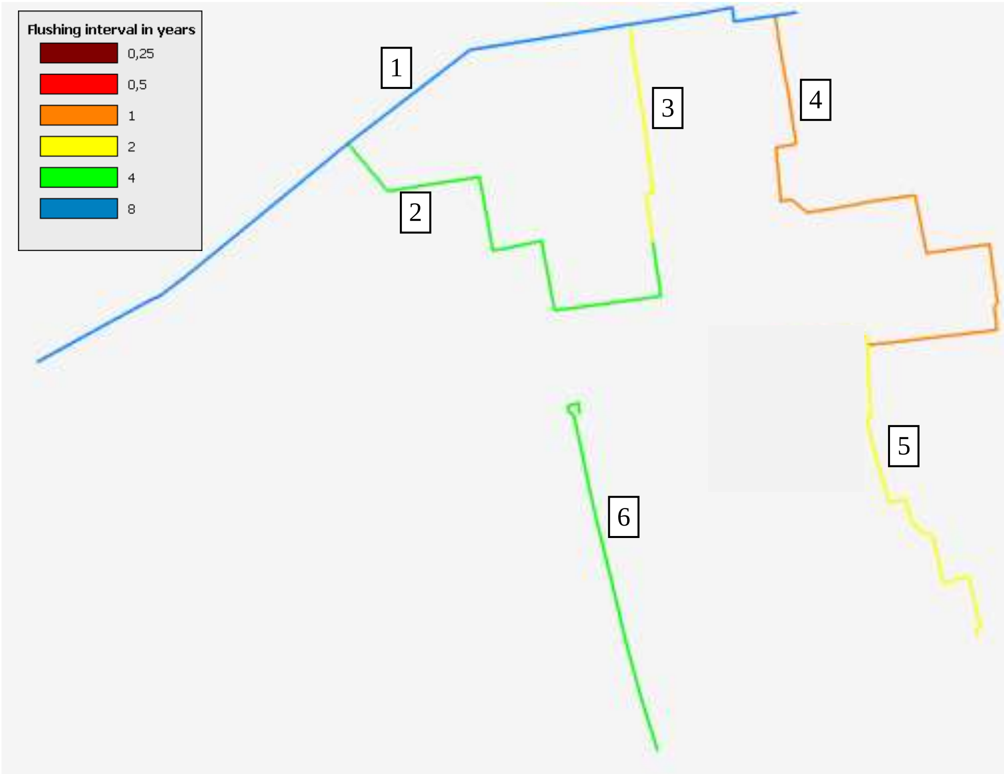

Figure 6: Results of the calculation of demand-oriented flushing intervals for the pilot area

APPLICABIITY OF THE FLUHING STRATEGY

With starting the SINO-German research project SIGN the applicability of the demand oriented flushing strategy was intensively discussed between TZW, Tongji University and Suzhou City Water. Both Chinese partners were very interested to test this approach developed for German drinking water networks under Chinese conditions. Tongji University and Suzhou City Water were very committed to select a pilot area and to support the research activities with all the necessary equipment and man power. The results show that this optimized flushing strategy can be applicated in the same way as in Germany. Due to the positive experience Suzhou City Water and Tongji University started to discuss the way of implementation of the optimized approach into the network operation strategy under Chinese conditions.

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