Studying Transients in Water Supply Systems

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Abstract: *Transient operating states occur in water supply systems under pressure. Transient operating states place such extreme loads on the pipes that they might cause burst water pipes, so to be able to avoid damages and operation failures due to burst pipes they are needed to be studied and modelled. To highlight the importance of transient phenomena, we present the measurements carried out at Pannon-Víz Zrt (the local Hungarian Water Utility Service) and their results in our study.*

Keywords*: Transient, burst water pipe, pump, transient operating state*

1. Introduction

If the valve openings and closings, pump start/stopping are not carried out slowly enough in the systems of large water pipes at pumping stations, they might generate quick changes in pressure. In extreme situations, transient phenomena can endanger the soundness of the pipe itself. At a pump station a pump shutdown caused by a power failure can have so severe consequences that even pipe burst might occur if the automatic or controlled closing valves are designed or operated poorly.

2. The phenomenon of transiency

A transient operating state is a kind of flow in time and space which is initiated by the impacts of some occurrence started from a steady (stationary) state and lasts until the development of another steady state [1].
The main reasons of the occurrences of transient phenomena are:

- power failures at pump stations leading to stops and the changes of flow velocity during pump startups,
- a sudden change in flow at filling or emptying pipelines,
- isolating pipeline sections, operating valves too quickly leading to big flowrate changes,
- rinsings and the changes in flow rate occurring at the opening / closure the drains during water inspection [2].

Due to the reasons mentioned above it is necessary to analyze the transient states developing in the system.

If the quantity of the water in the pipe alters, the movement of the water in the pipe is not permanent. After closings and openings, the pressure in the pipe oscillates in the surroundings of the hydrostatic pressure with a gradually decreasing intensity. After a quick closing a positive, meanwhile after a quick opening a negative pressure surge or wave develops. [3]. These types of oscillations can be calculated and modelled. Its basic idea was worked out by Lorenzo Allievi, an Italian scientist, in 1904 [4].

3. The venue of the measuring process

Pannon-Víz ZRt, the largest water and sewage service in Győr-Moson-Sopron county, operates several regional drinking water supply systems. Our measuring instruments were installed at the booster station in Pápai út, Győr, and the reservoir in Hegyalja út. We applied 2 pieces of TRAREC® measuring instruments to monitor the transient state in the pipeline system. Model number LL1-12078 got installed in Pápai út and LL1-12078 in Hegyalja út. Figure 1 shows the distance between the two measuring instruments.

Fig. 1. Measurement venues (Pápai út-Hegyalja út)

The distance between the two measuring devices is 4700 meter. The pipes are NA600 asbestos-cement pipes. 3 pumps - a NP150/400 and two DAN250 type pumps - can be found in the booster station in Pápai út. Fig. 2 shows the position of the two measuring instruments.

Fig. 2. Measurement venues (Pápai út-Hegyalja út)

4. Describing the measuring instrument

The applied measuring instrument - in fig. 3 - was developed and patented by Budapest Waterworks.
TRAREC® comes from the shorter version of TRANSIENT RECORDER.

Main characteristics of the measuring instrument:

- patented measurement and evaluation system
- normal or high-frequency measuring method
- selective data storage for long measurements
- variable parameters for different applications [5]

Fig. 3. TRAREC® measuring instrument

Table 1 shows the parameters of the measuring instrument.

Table 1: TRAREC® the parameters of the measuring instrument

Pressure sensor	0 -15 bar; (maximum 40 bar)
Accuracy	0.1%
Measurement frequency	50-1000 measurements / sec
Data storage frequency	1 - 60 s
Data segmentation	20 bit
Duration of measurement	1-2 weeks
Data communication and charging	USB 2

Table 2 shows the calibration data of the measuring instrument and summarizes some measured values.

Table 2: TRAREC® calibration data of the measuring instrument

Parameters of the measuring instrument		
Name	LL1-12078	LL1-12079
Sequence number	12078	12079
Version	1.0	1.0
Serial number	12078	12079
Pressure range (mwc)	211.00 mwc	211.00 mwc
Calibration	0.86111	0.86466
Pressure shifting	-9.58 mwc	-10.20 mwc
Measurement		
Starting date	07.02.2018	07.02.2018
Sea level (m)	0.00 m	0.00 m
Frequency of measurements	256 Hz	256 Hz
Frequency of data collection (sec)	1 sec	1 sec
Transient		
Starting date	07.02.2018	07.02.2018
Length of time	12 days 00:00:00	12 days 00:00:00
Storage time (sec)	10 sec	10 sec
Pre-storage time (sec)	2 sec	2 sec
Monitoring the deviation	Yes	Yes
Maximum number of transients	1000 pcs	1000 pcs
Results		
Starting date	05:00 am 07.02.2018	07.02.2018
Finishing date	04:59 am 19.02.2018	19.02.2018
Number of stored transients	233 pcs (2472 sec)	578 pcs (7402 sec)
Number of detected transients	249 pcs	767 pcs

5. Presenting measurement results

We used the PressEval software for evaluating the results of the measurement. Measuring instrument LL1-12078 sensed 233 transients, while LL1-12079 perceived 578 transients. Analyzing transients I applied a 1- hour method, namely the number of occurrences of transients during an hour was evaluated.

Fig. 4 shows the measurements made by the two measuring instruments.

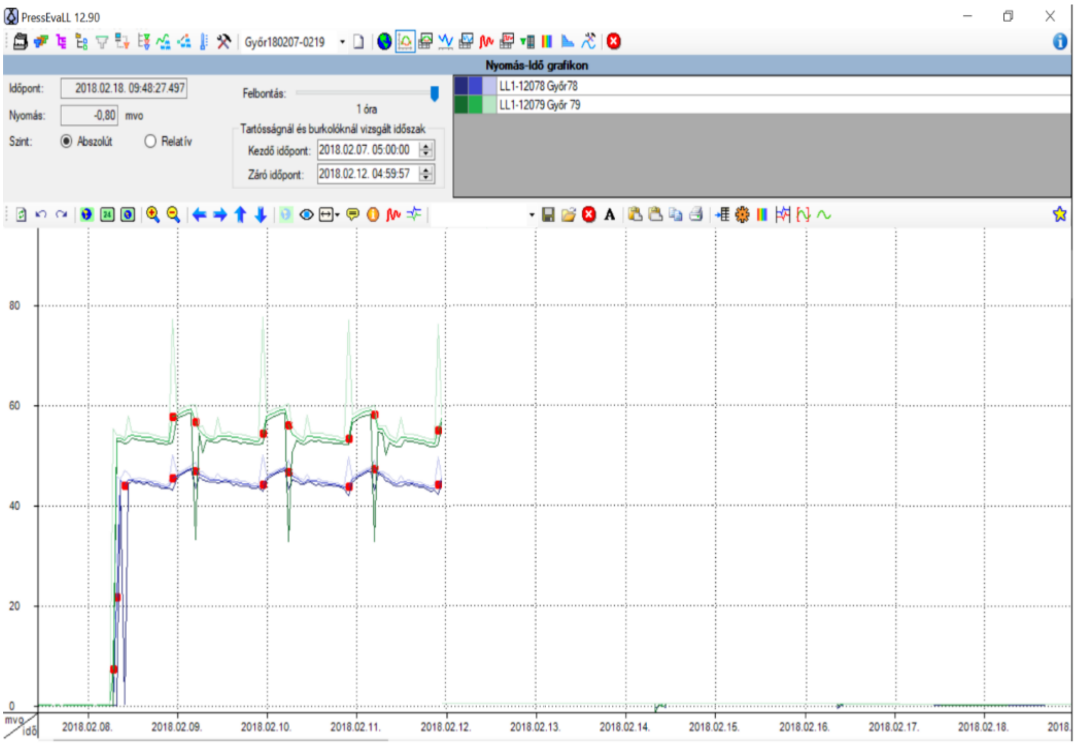

Fig. 4. Program PressEvaLL

Fig. 5 illustrates the measurements of LL1-12078 measuring instrument.

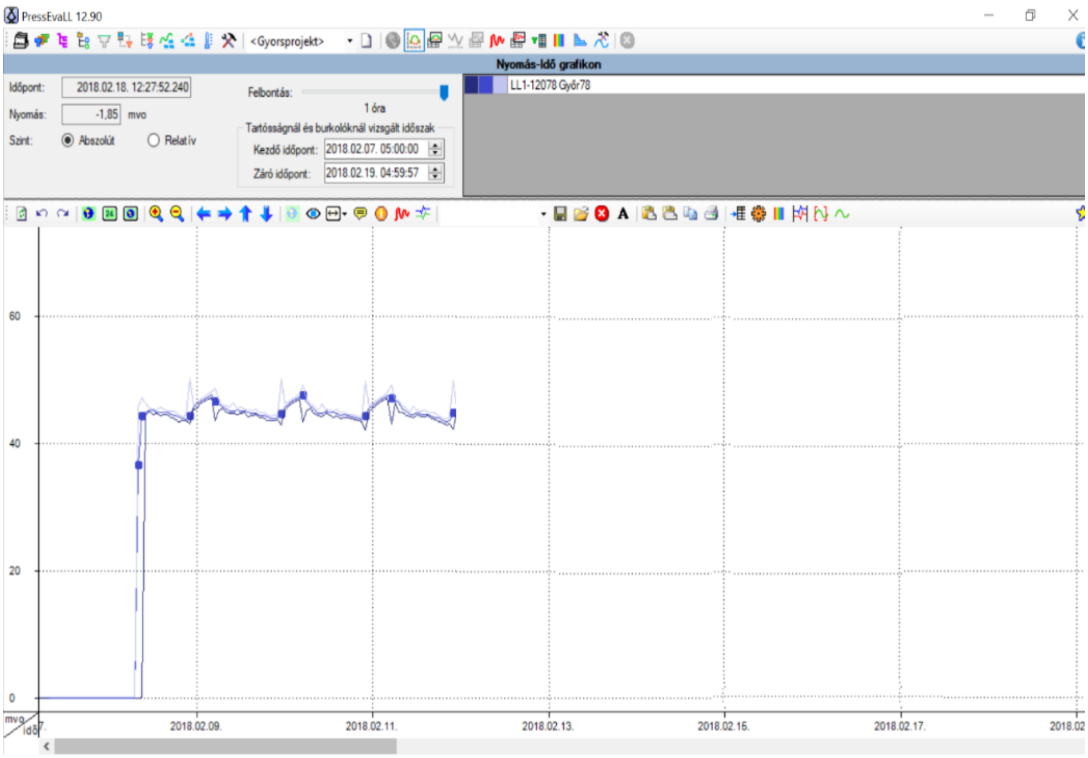

Fig. 5. Program PressEvaLL LL1-12078

Fig. 6 illustrates the measurements of LL1-12079 measuring instrument.

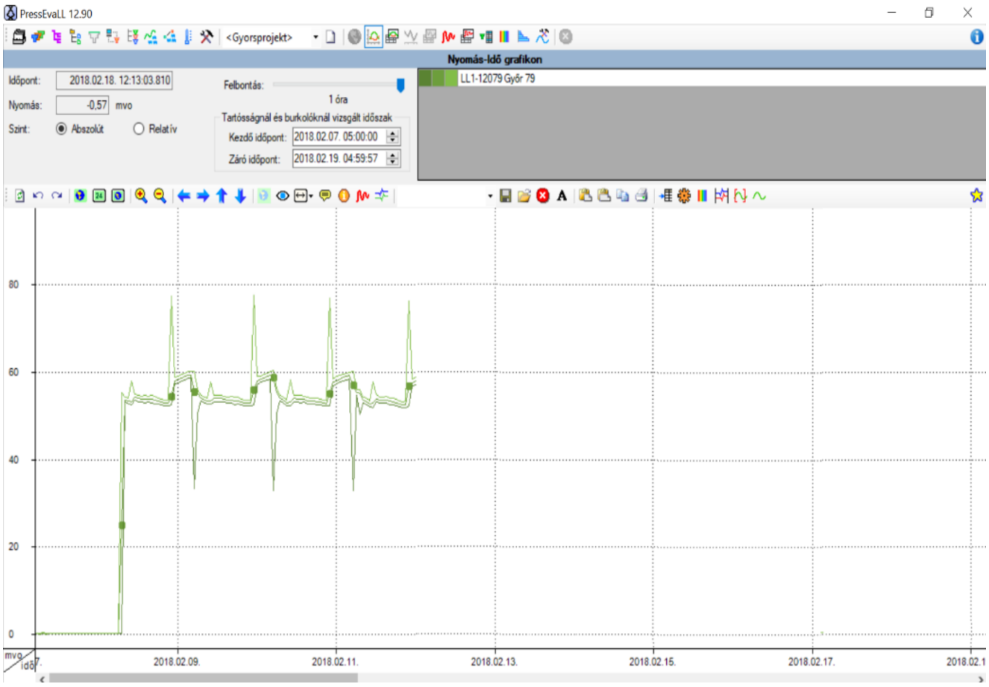

Fig. 6. Program PressEvaLL LL1-12079

In Table 3 I collected the absolute, minimum and maximum values of pressure changes.

Table 3: Pressure changes

Date [h:m:s]			**Absolute change [bar]**		**Minimum change [bar]**		**Maximum change [bar]**	
	Measurement instrument 79	**Measurement instrument 78**	**Measurement instrument 79**	**Measurement instrument 78**	**Measurement instrument 79**	**Measurement instrument 78**	**Measurement instrument 79**	**Measurement instrument 78**
08.02.	07:31:52		5.475		-5.488		93.833	
		08:11:14		4.499		-0.185		5.962
08.02.		09:41:01		4.299		-9.142		5.252
08.02.	22.41:47	22:41:51	2.462	0.708	-16.035	-4.452	15.822	1.9729
08.02.	05:04:10	05:04:33	2.326	0.471	-1.924	-1.079	1.639	1.661
09.02.	23:21:25	23:21:30	2.485	0.719	-15.537	-4.315	16.349	6.501
10.02	05:53:14	05:53:36	2.335	0.515	-2.195	-1.178	1.069	1.888
10.02	22:31:54	22:31:58	2.454	0.774	-15.978	-6.8	16.178	9.582
11.02	05:25:30	05:25:52	2.349	0.605	-1.696	-3.336	1.881	3.748
11.02	22:06:48	22:06:52	2.403	0.74	-15.864	-4.031	16.648	5.877
12.02	05:21:46	05:22:09	2.323	0.564	-2.366	-3.648	1.881	3.819
12.02	07:38:03		7.651		-46.995		7.412	
		07:54:46		4.641		-12.393		2.214

The process of the transient can be seen clearly from the table. E.g.: the transient starts its travelling at 22:41:47 and reaches the next measuring instrument at 22:41:51. The table demonstrates that the phenomenon of transiency is detectable in the system. The next task is to observe what causes the phenomenon of transiency.

6. Conclusion

In our study we intended to draw attention onto the existence of the phenomenon of pressure transiency and its importance. Our goal is to reveal what might cause the appearance of transient in the system. Later we are going to make a geometric and mathematical model.

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