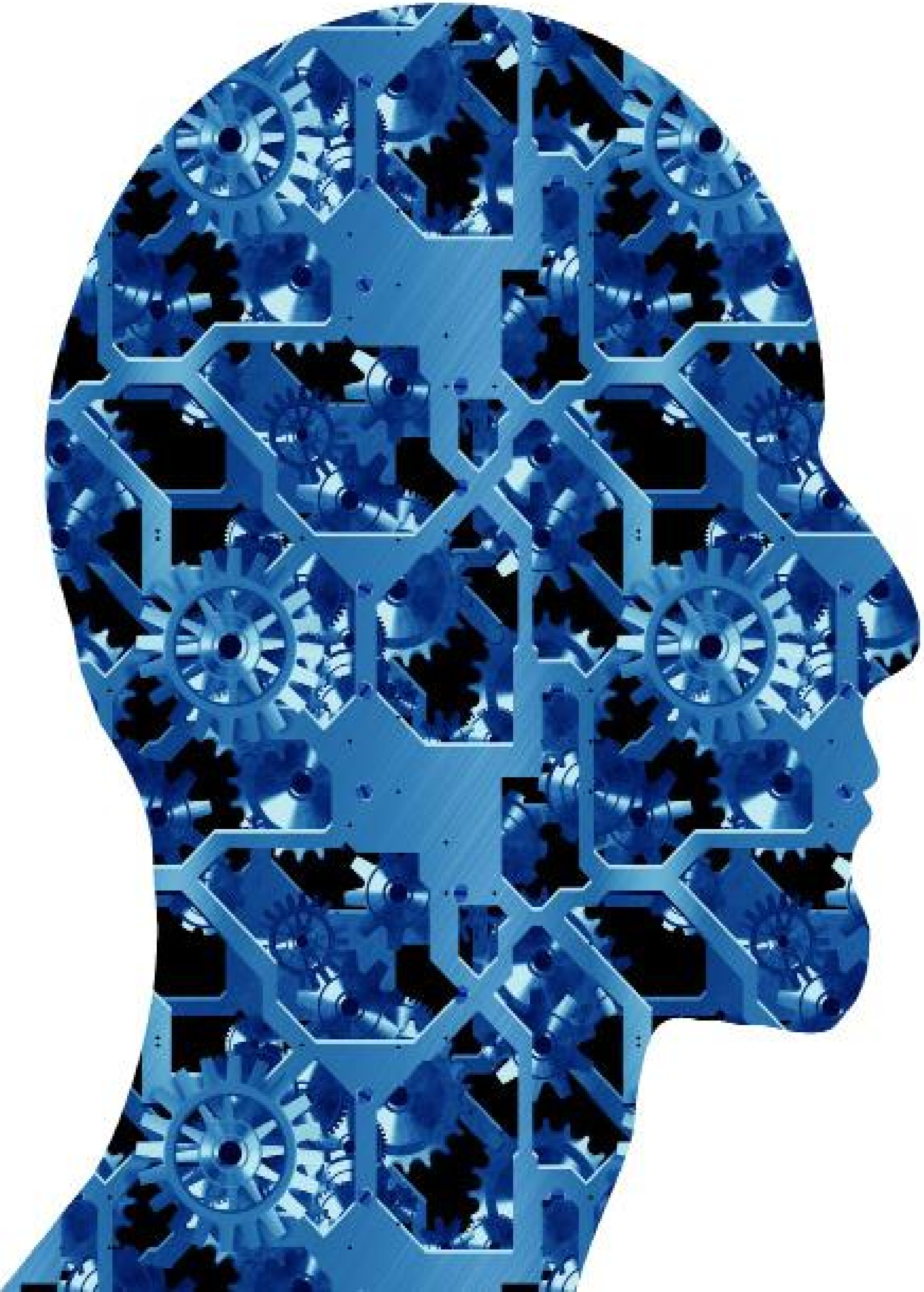

Data-driven Enthusiasm in Water Tech: A Game Changer

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I like cycling, preferably early in the morning, when nobody is around, the roads are empty and you are witnessing the sun coming up. With the COVID-19 lockdown I suddenly managed to make more miles on my racing bike than ever before, and even outperformed my car mileage. This did not happen since I got my first car, 30 years ago.

So far, I managed to cycle 6,000 kilometers, in single trips of 40 – 215 kilometers, mostly on my own, enjoying every single one of them. At the beginning of the year I bought myself a bike computer (for those who are interested: A Wahoo Elemnt Bold) with a heartbeat monitor and started to collect a vast amount of data. Opposite to many others I am not fond of sharing these data publicly, but I like to analyse these to find trends, improve performance and – above all – increase my enthusiasm for the sport.

One of the interesting topics which is reported a lot in literature is the calculation of the calories burnt by cycling. Even in the early 70's scientific research has been published, indicating the superb energy efficiency of cycling versus walking: 20 – 40 kcal/km versus 70 – 90 kcal/km. Cycling outperforms by far most of the other species on earth if the energy input per kilometer is considered, mainly caused by the absence of vertical mass transfer in cycling.

Nowadays algorithms are used, taking into consideration your gender, mass, age and heartbeat to calculate your kcals spent during cycling. Although the individual algorithms you may use are giving different results, it is useful if you want to analyse your own performance during the season. I started to analyse the results of the algorithm used in my bike computer, by plotting the kcal burnt per kilometer during the season, which for me started in March this year. Interestingly so far with my practicing I saves around 25% in my specific energy consumption, even with my average speed slightly increasing. These encouraging data are making it even more fun to jump on the bicycle and go for another round.

WATER TECH

This principle of data driven encouragement to increase the knowledge of your achievements, to create a fun factor, and at the same time improve performance is equally the trigger for optimizing equipment in a professional environment. In the water utility business operators are often responsible for a variety of processes and production sites. They should therefore rely on specific indicators of each process to discover anomalies, or deviations from normal process conditions. These indicators should be easy to interpret; they should mark the sweet spot, allowing the operators to focus their activities. Even better, if the operator is triggered by the "fun factor", he/she would like to add value to the process by sharing know-how and experiences with the technology provider.

The mechanism described has been very much so faced by the development and implementation of a remote monitoring and control tool for sand filters, marked Sand-Cycle. After an initial development phase with one of our water utility clients in the Netherlands (Water Authority Wetterskip Fryslan), this tool has become a valuable indicator at a large number of sites in both waste water treatment plants and drinking water production facilities. It is a perfect example of how the interaction between the plant operator and the technology provider is nourished for the benefit of optimizing assets. Let me explain what it is all about.

Asset management in water utilities

Asset management is a key issue for water utilities. Simultaneously the waste water treatment assets should be capable of meeting the requested process performance targets at the lowest possible operational expenditures. In the last centuries utilities have invested heavily in process equipment, including effluent polishing processes to meet more stringent criteria for suspended solids, BOD, nitrate-N, total-N and/or phosphorus. These assets are now challenged to meet even more stringent effluent targets. But operator attendance is reduced, and operator tasks are intensified. This paradigm requires a significant shift in monitoring and control strategies. Remote sensing, expert judgement and big data analysis are key to support the optimization of the assets.

Moving bed sand filtration and key operating features

Moving bed sand filtration (MBF) is a mode of filtration often used in water and waste water treatment, and is based upon uninterrupted filter operation. Various makes of continuous filters are marketed, e.g. DynaSand by Nordic Water. Filter media cleaning is continuously taking place while the filter is in operation and hence a 24/7 availability of the process is guaranteed. The water to be treated flows in an upward direction through the sand bed. During the upward filtration process both impurities are retained within the pores of the filter bed and biological conversion of ammonia or nitrates may take place.

The filtrate is discharged in the upper part of the filter via a fixed overflow weir. Simultaneously the filter bed is constantly moving downward (typically with velocities of 0.3 – 0.8 m/h), as it is sucked into the airlift at the center bottom of the filter. The suction of sand and retained solids is induced by the airlift principle: feeding a small amount of compressed air into the airlift pipe starts the suction process, forcing a mixture of dirty sand and water upward through a central pipeline.

The intensive scouring movements separate the impurities from the sand particles. At the top of the pipeline the sand grains are released in the washer section and start to settle in a hydraulic washer. The grains are finally washed by a small amount of clean filtrate, flowing counter currently through the washer assembly. An essential feature is the homogeneous sand circulation over the full filter area. Therefore, it is crucial for the sand to be sucked into the airlift evenly from all directions.

Due to the continuous sand circulation the filtration process is time-independent: with a constant feed water quality the filtrate quality will also be constant in time. The actual sand circulation rate affects the filtration efficiency for both solids removal and biological conversion processes in the filter bed. Monitoring and controlling the actual sand circulation rate is therefore key to optimize plant performance and reduce plant malfunctioning and down-time.

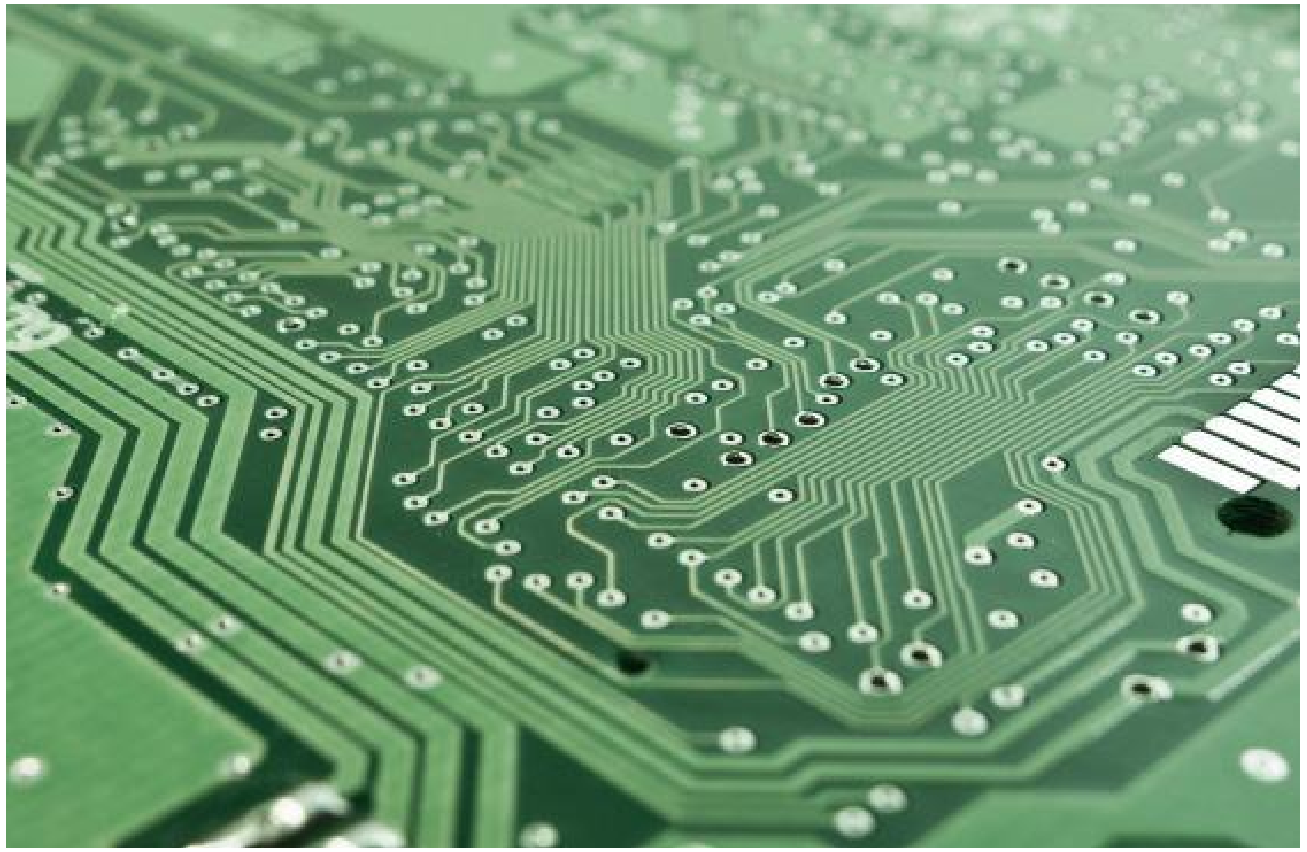
The developed tool (Sand-Cycle) proved to be an excellent platform to help operators to keep the plant in good shape and to take specific actions, based upon the automated feedback. The tool uses RFID technology, which is well-known from tagging cats and dogs. The same principle of "tagging" sand filters proved to be an excellent method to verify the proper performance. With the successful introduction of RFID technology in monitoring and controlling water treatment equipment, we feel this is just the beginning of a more widespread use for other applications in the water business.

RFID tagging

To monitor the movement of sand grains in a MBF passive RFID tags are applied. RFID tagging is an ID system that uses small radio frequency identification devices for identification and tracking purposes. An RFID tagging system includes the tag itself (the transponder), a read device and a host system application for data collection, logging, processing and transmission. A passive RFID tag is briefly activated by the radio frequency scan of the reader. The electrical current is small - generally just enough for transmission of an ID number.

The electronic identification system consists of two basic elements: the transponder and the reader. The transponder (ID tag) is attached to the object to be identified (e.g. a cat) or – in our case - mixed up with the sand grains in the filter bed. It contains no batteries and is sealed in a housing designed to survive harsh environmental conditions. The reader energizes the transponder by means of an electromagnetic field, which is emitted by the antenna. It then receives the code signal returned by the transponder and processes it. The reader excites the transponder inductively by means of a polarized low frequency electromagnetic field. Each transponder has a unique code, which cannot be duplicated. Although RFID tagging is used in many applications, such as tracking wildlife and livestock, the use in the water business is new, creating powerful options for monitoring and control.

Each transponder is detected while passing the reader, which is integrated in the airlift. The codes, dates and times of the passing transponders is transmitted via a decoder onto the datalogger, equipped with a GPRS modem to transmit the data to the back end of the online data server. The Sand-Cycle data server is converting the raw field data into relevant output data, by using dedicated algorithms. Output is available 24/7 for the operators via the data server front office and is presented in various dash boards.



An example of a dashboard is indicated in Figure 1. It is indicating one of 24 similar filter units installed at waste water treatment works Franeker, the Netherlands. The dashboard reveals the actual status of the filter, indicating a set of real time parameters, which are calculated based upon the field dataflow of the RFID tags. The operator has access to all 24 dashboards, and moreover – each time an anomaly is recorded by the algorithm, the operator immediately receives a notification via dashboard post. Both the operator and the technology provider may communicate with each other via the same dashboard posts.

Big data, the fun factor and game-changer

Big data are described as large amounts of data that are available from disparate systems, such as condition monitoring systems. The term often refers to the use of advanced methods to extract value from data. With the advances in information technology we now have the capability to store and analyze a more complete picture of asset health, based on sets of data, drawn from various sources. The ever-decreasing cost of electronics makes it more cost effective to fit equipment with Fsophisticated sensors which can do more than just measure a simple parameter but can also do additional analysis and diagnostics on the equipment. When these sensors are connected to a communications backbone, this greatly increases the volume of data that is available for analysis and has the potential to enable real-time analysis.

The developed tool for real time monitoring of MBFs in water and waste water treatment plants is an example of how big data analytics has potential in the field of WwTWs. Introduction of the tool is a first step towards linking various datasets and finding relationships to make the process work better at varying operating conditions. The goal is to increase reliability (reducing plant failures) and optimizing plant performance. It also initiates options for advanced filter control, resulting in higher performances. Ultimately the "fun factor" which drives the operator to optimize his assets by using tools like this are making the difference as it will both lead to increased process performance and further product development by the technology provider, using the operators feedback.

Big data represent a huge opportunity to improve equipment reliability and reduce maintenance and refurbishment costs. The advantage of cheap wireless technologies now means that sensor information can now be transferred wirelessly. Operation warnings and diagnostics can be shared quickly. If water utilities are receptive to this approach it will also bring in the expert judgment of the technology providers and boosting the know how to operate assets at the best possible conditions. With the objectives to meet ever more stringent effluent quality criteria it will make the difference between failing to meet these criteria or not.

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Figure 1. Typical Sand-Cycle dashboard (WWTP Franeker, the Netherlands)