Taking control of the sewers

The barriers to real time control of sewer networks have been eliminated, say **Manfred Schütze** of Ifak Magdeburg, **Detlev Peikert** of Segno Industrie Automation and **Michael Pabst** of Leibniz University, Hanover

Hildesheim Wastewater treatment plant – just before inlet pumps; the digester (below) D Peikert

Even though real time control of sewer systems has been topic of many presentations and publications, including some in the UK, its actual uptake and practical application seem to be somewhat slow. These limiting factors have now been overcome by the development of an easy-to-implement, yet comprehensive, global control algorithm, which has been applied in the sewer system of the city of Hildesheim in Germany (110,000 PE).

Real time control, in the context of urban drainage engineering, denotes actively influencing the flows in the sewer system. This can be done by dynamically varying controllable devices such as gates, movable weirs and pumps, depending on the current state of the drainage system.

It is obvious that such active control allows better utilisation of the existing sewer infrastructure and the reduction of pollution discharges. Furthermore, it allows the sewer system to be better prepared for future changes of flow patterns, including those induced by climate change. Additional benefits are obtained through the prudent operation of sewage pumps, such as increased energy efficiency. If joint control of sewer system and wastewater treatment plant is performed, further environmental benefits ensue – thus taking further the integrated approach as advocated by the *Urban Pollution Management Manual* in 1994.

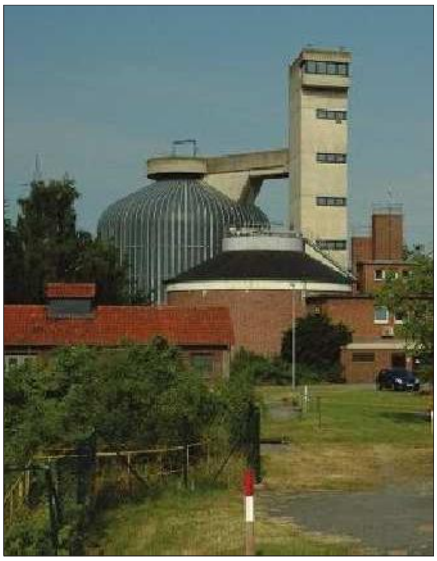
Application

The key question is – why is real time control not applied more widely in practice? Despite this bundle of benefits of real time control, it still does not seem to be applied widely in practice.

The main misconceptions are that it is complicated, time-consuming and costly. There has been a range of activities and publications promoting the application of real time control, including those by the UK Water Industry Research and the German Water Association (DWA) and there are successful applications reported in countries, including the UK.

Still, there appears to be a certain reluctance by water companies and consultant engineers to consider real time control as a beneficial means to better utilisation of the existing system, even, in some cases, avoiding costly infrastructural measures, such as the construction of new storage tanks. In order to facilitate the development of control systems, the real time control working group of the DWA proposes in its recent guideline document a step-wise approach to the evaluation of the control potential for a given site.

After a preliminary ad-hoc assessment of the drainage system, this involves a simulation study on a coarse system model. At this stage, also various types of control, varying in their degree of complexity, can be assessed, guiding in the decision which level of complexity might be the most appropriate for the given drainage network and for the given technological and monetary boundary conditions.



A common misconception is that real time control always has to be complicated and complex – often it is associated with rainfall prediction using radar techniques, complex sensoring, data transmission needs and so on. As a number of applications, both in practice and in simulation studies, show, simpler forms of real time control, such as relying only on water level and flow information, can lead to improved system performance. The optimum cost-benefit ratio is not necessarily achieved for the most complex control system, but for a fairly moderate degree of complexity.

A second reason why the uptake of real time control appears to be slow, is believed to be that their development, in particular for complex sewer networks, is time-consuming and costly. Generally speaking, there are two main approaches to formulate a control algorithm: (1) if-then rules, sometimes extended by concepts of fuzzy logic, and (2) the use of mathematical optimisation techniques applied on a system model (often simplified). The latter approach is sometimes called model-based predictive control. Both approaches have their advantages and disadvantages. Both have in common that the set up of the control system is a tedious and, therefore, time-consuming task.

Global control algorithm

At the Ifak Institute for Applied Research, a general control algorithm has been developed, which can be applied in a straightforward way to any dendritic sewer system. Each controllable device in the system is equipped with an intelligent control box containing this algorithm.

These boxes are being fed with system information such as water levels and flow information. Communication between these boxes ensures that good global control is achieved of the system by ensuring storage capacities in the system being utilised in an equally balanced way, thus avoiding overflows in one part of the system whilst other parts of the system still have unused storage capacity.

Simulation studies for sewer networks, using Ifak's simulation system SIMBA with its features for flexible specification of control algorithms using IEC 61131 Structured Text notation – have proven the successful operation of this general control algorithm (see, for example, Schütze and Haas, 2010).

The partners acknowledge the funding of the German Ministry of Economy and German Ministry of Education & Research for the various phases of this development. References available from manfred.schuetze@ifak.eu

Case study: Hildesheim, Germany

The new general global control algorithm has been applied to the city of Hildesheim's sewer system in Germany. The project is being carried out in cooperation with Segno, an automation company that implements this algorithm in standard process controllers, and University of Hanover researchers who can confirm the validity of the algorithm by additional simulation studies.

Hildesheim's sewer system is partly a combined sewer system and partly a separate sewer system. Overall storage volume amounts to 17,200m^3, corresponding to a specific storage volume of 26m^3/Aimp.

Four of the ten storage tanks in the system have been selected for control. Their outflows are controlled dynamically, aiming at minimisation of total overflow volume.

The results of the control algorithm, which are obtained by simulation for different control settings, show that using the control algorithm for four controllable tanks leads to reductions of overflow volumes by 38% for the simulated series of rainfall events. Considering five more storage tanks in the control scheme, a reduction of 49% can be achieved.

The control boxes for the system being implemented in the Hildesheim sewer network are in standard PLCs. GPRS was envisaged as the communication technology between the control boxes, however, due to the specific conditions in Hildesheim, broadband internet is used. Communication is being routed via the central control station.

Supplemented by an engineering tool, implementation of the control boxes is a straightforward process, smoothly transferring from conventional control of constant throttle flows towards dynamic global real time control.

Anchors dropped at Fleetwood site

As part of a £58M investment programme to enhance United Utilities' Fleetwood wastewater treatment plant on the Fylde coast, an adjacent brownfield site was purchased to extend the existing works. However, the bearing capacity of this former landfill site was so low that contractors KMI+ asked iron technology specialist Saint-Gobain PAM UK to provide an anchorage solution for the pipes which avoided the use of massive thrust blocks and concrete piles.

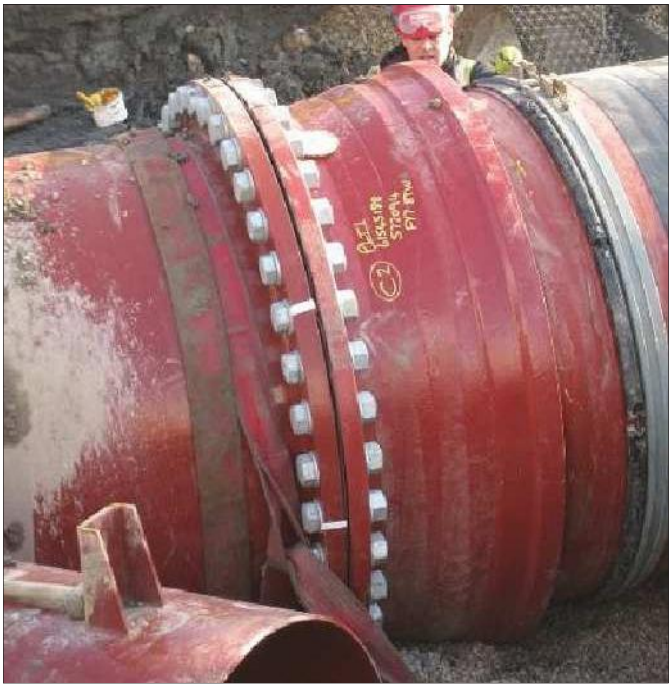
All pressure pipelines are subject to thrust forces whenever they change direction and particularly at bends, tees, blank ends and valves. It is at these points that some form of restraint is essential.

Traditionally, for socket and spigot pipelines, this anchorage has been provided by concrete thrust blocks. This can be challenging in areas where space is limited, the underground environment is busy or, as in the case of the Fleetwood site, the surrounding soil is unstable.

The Fleetwood plant is designed to treat almost 200Ml/d of wastewater, so large pipes up to 1600mm diameter were required to transport the flows. Pipes of this size are subject to huge operating pressures. For example, a 1600mm diameter pipe operating at 1 bar (10m head) would exert a static thrust of 309kN at a 90° bend.

According to Simon Meredith, sub-agent from KMI+, a thrust block large enough to resist forces such as this would require concrete piles to hold it into position, otherwise it would sink and potentially damage the pipeline. "Because all structures at the new site would have required 20m long concrete continuous flight auger (CFA) pile foundations to reach adequate bearing strata, we approached Saint-Gobain PAM UK to provide a self-anchoring system."

Lorraine Parrott of Saint-Gobain PAM UK explained: "We used a specially designed software package to determine which joints required anchoring based on factors such as diameter, fitting type, proposed operating pressure and depth of cover. The result was an innovative, high performance anchoring system, comprising a range of Saint-Gobain PAM anchor gaskets, mechanical anchors and PAMLOCK joints, which was quick and easy to install.



The large pipes needed to transport flows at Fleetwood are subject to huge operating pressures

"In addition, we carried out a soil resistivity test to ascertain the level of outer protection required on the pipework. This enabled the pipes to be delivered pre-wrapped to reduce work on site."