Water Treatment Plant

Modelling and Simulation Services

KHACE

We undertake the modelling and dynamic simulation of water treatment plant to support the design and development of plant hydraulic behaviour and process and operational controls.

By modelling the controlled flows of water from source of supply through treatment units such as flocculators, filters, chlorinators, intermediate storage vessels and pumps through to treated-water delivery, our simulations can predict the behaviour of continuous and sequence process controls and their effects on water flows, pressures and hold-ups in vessels.

Past simulations have been used to study:

- -Sizing of vessels in the treatment path - to minimize vessel capacities and construction costs while still coping with changing operational and unusual flow conditions, such as plant trips.
- Investigating hydraulic interaction; e.g. between adjacent filters during washing operations.
- Supporting plant commissioning – by providing initial tuning parameters for feedback controllers of flows, levels and pressures, and by revealing to commissioning engineers in advance the significant behaviours to be expected from a new or modified plant.
- Investigating commissioning problems – by comparing actual behaviour with modelled behaviour – to help pinpoint the likely sources of any deviations of actual plant behaviour from design behaviour.

MODELLING

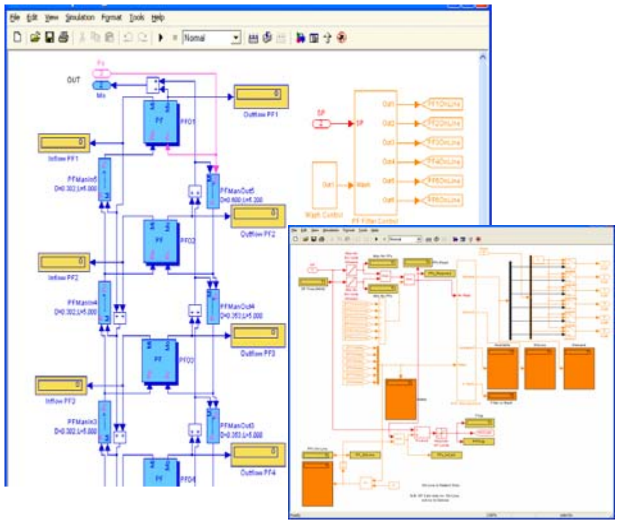
In accordance with our in-house modelling and simulation engineering principles: we use only commercially available, off-the-shelf, general-purpose dynamic simulation software as our modelling environment. This ensures that our models are accessible to the customer and can made available and adopted readily by the customer for further in-house development, with the assurance of ongoing support from the simulation software supplier.

For our simulation studies we use MATLAB® and Simulink™ – possibly the worlds most popular general-purpose dynamic simulation software environment.

Our models are aimed primarily at simulating the behaviour of pressures, flows and accumulations (in vessels) of water by means of dynamic models of pipe work, valves, pumps, vessels etc. and their associated manual and automatic feedback and sequence controls.

PREDICTION AND AVOIDANCE OF HYDRAULIC PROBLEMS

By exercising the dynamic simulation through operational and control sequences, including increasing and decreasing production rates and filter



Parallel-Filter Models and Scheduling Control

wash sequences, it is possible to verify that process variations lie within acceptable design limits, or to reveal potential problems such as unexpected hydraulic interactions or unacceptable liquid level excursions in vessels.

For example: it is typically important that transient rates of change of water flow through treatment filters not exceed maximum design specifications – to avoid disturbing the filter bed and the established filtration regime within the bed. In one design study it was revealed how an ad-hoc valve stroking strategy intended to reduce filter disturbance by incremental stepping produced significantly worse transient flow disturbances in hydraulically-coupled adjacent filters than did a simulated steady and continuous single valve movement. These sorts of unexpected results could be difficult to observe or diagnose later on the real plant; whereas the simulation allows one to look into the model details to reveal individual internal flow disturbances that would not be detectable by means of installed flow meters.

VALIDATION OF DESIGN SPECIFICATIONS

Because the dynamic simulation must include an implementation of the proposed process control systems and operating strategy, the simulation may be used to validate the functional aspects of control system design specifications.

In many cases the modelling exercise for the simulation has typically revealed inconsistencies and incompleteness in the control system descriptions; e.g. in the descriptions and timings of valve sequence operations in filter wash sequences, leading to unnecessary losses of treated water. By revealing these problems at the design stage, the specifications to control-system vendors can be improved; so avoiding the significant costs of doing remedial work for problems that would otherwise be revealed only during factory acceptance testing or perhaps even later during on-site commissioning.

CASE STUDIES

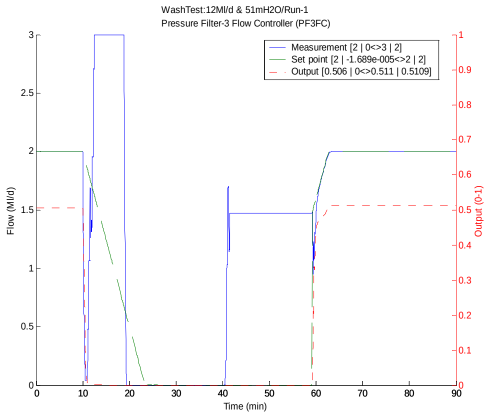
As part of a plumbosolvency project: at a water treatment plant in West London the operator needed to measure the flow of water in a long large-diameter underground concrete tunnel carrying water collected from open filter beds to an large chlorination tank – for the purpose of proportional dosing of a treatment chemical. Breaking into the pipe work or tunnel to install a flow meter would have been very expensive. By modelling the plant between filter beds and downstream pump house we were able to demonstrate how an inferential measurement of flow, based on differences in levels between an upstream well and the downstream chlorination tank would be sufficiently accurate for the purposes of the inner proportional-dosing -loop of a cascade control scheme, with trim by an outer loop using analyser measurements.

For a new deep-well supplied pressurised water-treatment plant in East London, there were two main concerns: the design and control of an in-line de-gassing vessel, and the potential for significant impact on the plant of significant pressure fluctuations in the delivery pipe network downstream, caused by nearby pumping operations, By modelling and simulating the entire plant, and applying to the model actual measurement data records of downstream pressures, we were able to both predict pressure and flow fluctuations within the plant and to show how these could be reduced to acceptable levels by using the de-gassing vessel as a dynamic-decoupler using appropriate controller design and tuning parameters.

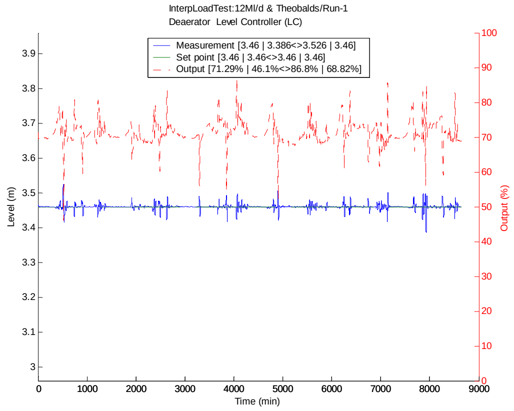
BENEFITS

It is often the case that the builders of a dynamic simulation are the first to gain an overview of the complete project design requirements, and to experience how the completed system is likely to perform against those requirements.

This is especially the case where different parties are contracted individually, with each concentrating on



Simulated Filter Flow Controller Response to a Wash Cycle Sequence



De-Aerator Level Controller Response to Downstream Pressure Disturbances

their own contractual requirements within the overall project, sometimes with no individual authority responsible for making the dynamic systems work as a whole. In these circumstances the simulation study, carried out by experienced process and control-system engineers, can play a very valuable role in highlighting potential problems at the earliest possible stages.

Formal tests using pre-specified and agreed test-case scenarios can give rise to unexpected results, requiring detailed explanations and leading to improved understanding and design procedures.

In many cases a major part of the value of a simulation study precedes the formal test-case results, as the modelling and simulation engineering exercise itself prompts queries and discussions and highlights ambiguities or uncertainties in the proposed design: if a design can't be made to work in simulation, then it is unlikely to work satisfactorily at commissioning!

Customer's comprehensively report that their simulation studies have been worthwhile, with feedback from plant commissioning reporting behaviours very similar to those predicted by the simulation studies.

FURTHER INFORMATION

Additional information is available on-line at:

http://www.khace.com/services/simulation/watertreatment.html

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