The simulation system SIMBA is a versatile software for the modelling and dynamic simulation in the field of wastewater engineering. In its version 6, SIMBA allows the holistic analysis of sewer system, wastewater treatment plant (WWTP), sludge treatment and receiving waters. All the components necessary for a detailed analysis of the subsystems and their interactions are integrated into a single, comprehensive simulation system in a user-friendly way, using state-of-the-art modelling approaches.
SIMBA® is based on the numerical software Matlab®/SIMULINK™ by MathWorks Inc. and can be run under Windows (XP, Vista) operating system. The setting up of simulation models is based on the graphically linking of model blocks - these blocks represent unit processes (e.g. sewer section, primary treatment, activated sludge tanks). SIMBA’s central block library is the starting point for each simulation project. It contains universal blocks for the definition of wastewater and sludge flows. Additional blocks allow you to split and combine wastewater flows and also include sedimentation tanks and various reactor models (continuously stirred tank reactors, plug-flow reactors) in order to allow the simulation of any arbitrary chemical and biological treatment process.

From SIMBA’s central block library, a number of dedicated block libraries can be accessed which contain model blocks for the simulation of:
- Activated Sludge processes for wastewater treatment (ASM1, ASM2d, ASM3, ASM3biop)
- Biofilm processes of wastewater treatment (fixed-bed)
- Anaerobic digestion processes, sludge treatment
- Wastewater transport, storage and conversion processes in sewer systems
- Water transport and quality in natural receiving waters
- Control functions
- Animated visualisation of simulation results
For the simulation of WWTPs, a wide choice of transport/reactor models and activated sludge models is available. Transport/reactor models include, among others, model blocks for the description of activated sludge in tanks with intensive mixing and/or aeration by surface and pressurised aeration systems and primary and secondary clarification tanks. For cascades of tanks and batch reactors, dedicated blocks are available. Independent from these reactor models, the user can choose which activated sludge model is to be applied. Such models define a number of fractions of wastewater pollutants and micro-organisms as well as a number of chemical and biological processes which are considered important for the respective processes. For the description of reduction of organic load (COD) and nitrogen (nitrification, denitrification), the standard models ASM1 (Activated Sludge Model No.1) and ASM3 of the International Water Association (IWA) can be used.

Biochemical transformation models can be freely edited and modified in a user-friendly way using the SIMBA model editor, which is based on the Petersen matrix notation. Standard models (ASM1, ASM3d, ADM1, RWQM1) are supplied with SIMBA. Additional models developed by SIMBA users can be accessed from the SIMBA web portal.

These activated sludge models are implemented as predefined models in SIMBA:
- ASM1tm – Standard model of IWA with well-known modifications for improved applicability
- ASM1sbr – Version of ASM1 dedicated for Sequencing Batch Reactor (SBR) plants (slightly modified for quiescent phases)
- ASM2d – ASM2d of IWA with extended biological phosphorous removal
- ASM3m – ASM3 of IWA with parametrisation according to recommendations of HSG researcher’s simulation group
- ASM3biop – ASM3 of IWA with an extension by EAWAG for biological phosphorous elimination

Users can define their own model blocks based on their own activated sludge models.

Model blocks for primary and secondary clarification

For the modelling of sedimentation processes in the primary and secondary clarifiers, a wide selection of models of differing complexity is available:
- Simple model for primary clarification according to Otterpohl/Freud with COD elimination as function of residence time
- 3-layer primary clarifier model (variable sludge layer)
- Ideal sedimentation tank (ideal solid/liquid separation; no storage)
- Ideal sedimentation tank with storage (solid/liquid separation user-configurable; simple storage)
- Secondary clarifier model according to Takács (10-layer model; specific sedimentation function)
- Secondary clarifier model according to Otterpohl/Freund (10 layers, macro/micro flocs)
- 3-layer secondary clarifier model with variable sludge layer
Sewer systems

Hydrological and hydrodynamic modelling approaches

SIMBA6 offers high flexibility for the selection of modelling approaches for sewer systems:

**Hydrodynamic**
- Complete solution of Saint-Venant-equations
- Seamless integration and extension of computational kernel of SWMM5 (cf. www.epa.gov)

**Hydrologic**
- Simplified, conceptual modelling
- Transport pipes within the sewer network
- Ancillary structures according to DWA A128
- Pollutant load calculations and long-term simulation

Arbitrary combination of both modelling approaches

Within SIMBA6, it is also possible, to model parts of a drainage network using a hydrodynamic approach (e.g. flat main collector sewers), whilst other parts of the same network (e.g. upstream subcatchments) can be modelled using a faster hydrologic modelling approach. This feature of SIMBA6 allows you to adjust the complexity of a sewer network model to the specific needs of each particular project.

Each of these modelling approaches allows:
- Uniform and non-uniform spatial distribution of rainfall
- Arbitrary biochemical transformation processes within the network (modelling of the sewer as a physical, biological and chemical reactor)
- Simple and complex open and closed loop control concepts
- Analysis of RTC potential according to the German guideline DWA M180

Furthermore, SIMBA allows the seamless integration of sewer system simulation with models of the other subsystems (WWTP, sludge treatment, river water systems).

User-friendly input and output, animation

- User input and output, for example when defining the sewer network, are graphically supported
- Freely configurable evaluation routines allow fast and easy evaluation providing textual and graphical information: Summary information (rainfall, discharge and overflow volumes and pollutant loads, storage utilisation), discharge frequencies and durations
- Animated representation of arbitrary information (e.g. flows, water levels, concentrations) in longitudinal sections and plan views in hydrodynamic simulation
Anaerobic processes

The modelling of anaerobic processes (anaerobic wastewater treatment, sewage sludge digestion) increasingly gains in its importance due to continuous demands for the optimum energy operation of plants. Further incentives for the application of digestion models are given by the current developments within the biogas sector. The anaerobic sublibrary provides options for the modelling of plants for anaerobic sludge digestion, anaerobic wastewater treatment and anaerobic fermentation of organic loads.

This dedicated library contains:
• Various anaerobic models (Siegrist, ADM1)
• Model blocks for primary clarification with sludge removal
• Model blocks for gravity thickening and mechanic thickening as well as dewatering of sludge
• Anaerobic reactor blocks (surcharge reactor, storage) with gaseous phase
• Interface models for linking with activated sludge models
• Integrated modelling of wastewater treatment and sludge treatment

Anaerobic models allow the prognosis of:
• COD, TS degradation
• Gas production, gas synthesis (carbon dioxide, methane, hydrogen)
• Nitrogen release
• Organic acids and pH

Energy

It proves to be efficient to utilise the high information content of the simulation and to compute, simultaneously, the energy consumption (or production) of the plant. For this purpose, a number of models is available describing the energy consumption of various process steps and parts. The configuration effort is kept to a minimum as, for each process block, only the appropriate energy models are offered to the user. Only their parametrisation is required. Furthermore, all data necessary for the calculation on energy demand/production are recorded automatically. With very limited additional effort for the user, extensive information can be generated with the simulation model of the plant.
SIMBA6 also allows the simulation of flows and water quality in receiving water bodies. Any arbitrary biochemical transformations can be modelled. A seamless integration with sewer systems and wastewater treatment models and also with control algorithms is possible.

**Flow calculation**
- Hydrologic flow modelling
- Hydrodynamic flow modelling

**Quality models**
- Can be specified and modified freely by the user
- Predefined models available (e.g. RWQM1, Lijklema)

**Applications**
- River water quality simulation
- Analysis of wastewater discharges from sewer system and WWTP
- Integrated real time control
- Sequential and parallel integrated simulation

A new, additional model within SIMBA6, contains the Lagrange modelling approach for pollutant transport without the introduction of errors by numerical dispersion effects: transport and conversion processes are modelled, based on the core principle of “water parcels” moving along the river, thus avoiding numerical dispersion errors. Dedicated routines for the joining and splitting of these conceptual water parcels facilitate speed-optimised simulation.

**Modelling approach according to Lagrange**

**Evaluation according to UPM Manual and BWK-M7**

New evaluation routines for the analysis of results of river water quality simulation
- Freely configurable textual and graphical output
- Flows and water quality
- Frequency-duration-based threshold values for oxygen, ammonium and ammonia according to the British Urban Pollution Management (UPM) Manual and to the German BWK-M7 document

Evaluation of river water quality according to BWK-M7

Evaluation of river water quality according to UPM Manual
After the design of a control system and its test by simulation, it then needs to be transferred into practice. The practical implementation, however, is dependent on the respective run-time system, which needs to be considered during the system design. This frequently represents a source of errors, due to typing errors or functional differences between SIMULINK blocks and the functions of the runtime environment.

In order to avoid such problems (and errors sources), SIMBA6 contains a block module, allowing the description of control algorithms in IEC 61131-3 ST (Structured Text) notation. IEC 61131-3 ST is a standardised programming language for process control systems. Hence, for any process control system supporting this IEC standard, a one-to-one implementation is possible.

Even for systems not supporting this standard, the new SIMBA6 block facilitates the implementation of control systems, since it does not need to be described by SIMULINK block diagrams but can be expressed in Structured Text language with its similarities to conventional high-level languages (such as FORTRAN, PASCAL, JAVA).
The institute ifak, as an independent and non-profit research institute (with charitable status) is active in applied research in the field of process control and automation technology, industrial communication, measurement and analysis technology, information management for environmental systems and automation, mechatronics and intelligent transport systems. As a recognised institute associated to the Otto-von-Guericke-University of Magdeburg, ifak is one of the leading centres of competence in the modelling and control of urban wastewater systems.

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