Westinghouse Waste Simulation and Optimization Software Tool – 13493

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ABSTRACT

Radioactive waste is produced during NPP operation and NPP D&D. Different kinds of waste with different volumes and properties have to be treated. Finding a technically and commercially optimized waste treatment concept is a difficult and time consuming process. The Westinghouse waste simulation and optimization software tool is an approach to study the total life cycle cost of any waste management facility. The tool enables the user of the simulation and optimization software to plan processes and storage buildings and to identify bottlenecks in the overall waste management design before starting detailed planning activities. Furthermore, application of the software enables the user to optimize the number of treatment systems, to determine the minimum design capacity for onsite storage facilities, to identify bottlenecks in the overall design and to identify the most cost-effective treatment paths by maintaining optimal waste treatment technologies. In combination with proven waste treatment equipment and integrated waste management solutions, the waste simulation and optimization software provides reliable qualitative results that lead to an effective planning and minimization of the total project planning risk of any waste management activity.

INTRODUCTION

During operation and D&D of a nuclear power plant or any other nuclear facility, different levels and sorts of radioactive waste are generated. This waste is subject to safe and professional treatment to avoid health and environmental impact. Furthermore, it is of major interest to decontaminate radioactive waste to recycle the material or to release it into a conventional waste stream and thus reduce radioactive waste disposal volume and cost. All other waste types that cannot be decontaminated must be conditioned for intermediate or final storage.

Facilities for treatment, decontamination, conditioning and storage of primary, secondary and final waste products and packages are required to complete this task.

Intensive preparation and planning has to be conducted to design, build and operate such facilities in a technologically and economically viable manner.

The Westinghouse waste simulation and optimization software tool supports these preparation and planning activities . It gives confidence in evidence based decisions and enables users to try out lots of 'what if' scenarios until one is sure that a decision is the right one.

DESCRIPTION

Applications for dynamic simulation can be found in virtually all areas of process engineering. This usually spans R&D, design, operations and training. The tangible benefits of using dynamic simulation can be seen in tighter design, smoother start-ups and optimized operation. Thus, proper implementation of dynamic simulation can deliver substantial benefits. These benefits are typically derived from improved process understanding. The challenge however is to have a software tool available that allows rapid screening (generation of diverse models through modularization) of system and process alternatives.

The Westinghouse waste simulation and optimization software tool is a Monte Carlo based graphical program that carries out a dynamic, probabilistic simulation with a graphical user interface. With these properties, the tool is able to consider many variables in parallel during waste management scenario simulation and optimization, such as equipment space requirements, equipment performance factors, volume reduction factors, storage capacities, different operating cost and disposal cost factors, variations in waste feed composition and various waste treatment methods in highly integrated waste management treatment facilities.

The starting point is the identification of the waste streams and the assessment of various treatment concepts. An integrated waste treatment concept that covers all relevant waste streams is the base for the simulation model. This model shall be built with information and guidance parameters to achieve precise final results. After loading suitable equipment data into the final model, process requirements and waste treatment data are fed into the simulation to generate primary simulation results. A manual sensitivity analysis or the automated optimization feature of the software generates the lowest possible lifecycle cost for the simulated waste stream. In addition, other target values might be subject to the sensitivity analysis or the automated optimization.

Usually, a simulation model is built according the following steps:

- scope definition and requested result complexity
- identification of waste streams and main parameters, e.g. total volume per stream, waste volume flow in defined discrete time intervals, specific activity, specific/required/preferred treatment method, etc.
- compilation of known limits and assumptions

- identification of adequate treatment methods and technologies
- compilation in an integrated waste treatment concept and preparation of flow diagrams
- definition of required limiting parameters, e.g. limited building dimensions, limited activity inventory, chronological/schedule limits, exclusion of technologies, etc.
- compilation of required process- and technology parameters (e.g. from existing equipment library or compilation of library)
- preparation of specification and functional requirements
- adjustment of user interface
- programming of simulation model and user interface according specification and functional requirements
- test runs, customer review, optional adjustment
- final validation and result generation
- result report

The depth of parameter details varies strongly with the scope of simulation. These steps are tentative approaches and must be discussed with each customer according to specific scope and requirements.

Parameters and specification

The preparation of a detailed specification and functional requirements with clearly defined definitions and scope is of ultimate importance. This work must be done in close cooperation with the final user of the software tool to define the objective and the required parameters. Only if the simulation produces realistic and credible results will it help the user in making a final decision. The specification includes all important objectives, selected treatment technologies and clearly defined parameter definitions that are to be filled with data. It also includes the necessary information to create all required analysis functions and the graphical user interface. Thus, the specification shall be the basis for all programming of the simulation model.

Simulation Model

The simulation is programmed according to the specification and the functional requirements. The model includes all properties and parameters to create the requested results, as well as the data and parameters that can be altered to perform a sensitivity analysis and to simulate different scenarios. Scenarios could be modifiable equipment parameters, operation costs, storage capacities and others. The model is preferably built with simulation modules, each representing different waste treatment equipment. New modules and simulation parameters can be added to the modules, as specified by the customer.

Graphical User Interface

The graphical user interface is designed according to the specification and the functional requirements. Input data variation (waste streams), other parameters and visualization of results eventually are shown in the graphical user interface. Thus, sensitivity analyses by varying the equipment parameters to simulate different treatment methods of a waste stream can be done to analyze the effects on the total life cycle cost or on the facility performance. The graphical user interface can be organized in different user levels. The following figures show examples of a possible user interface and results.

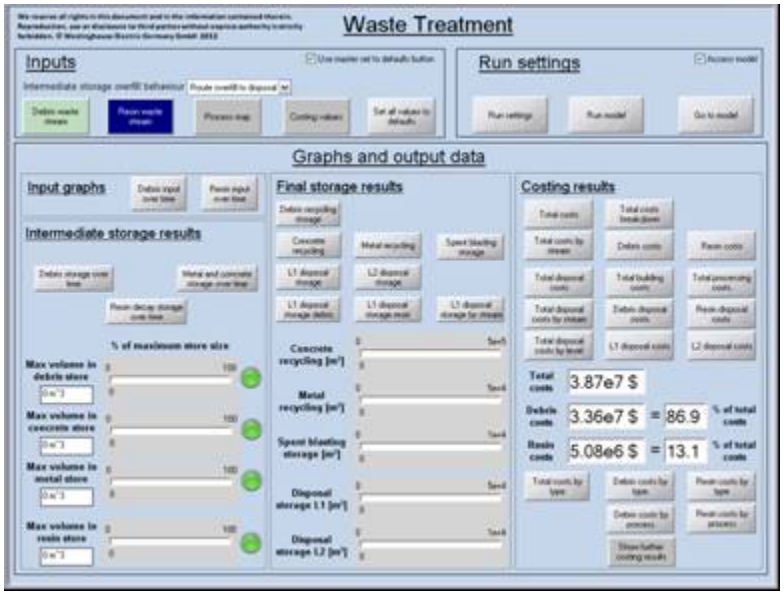

Fig. 1. Example of a graphical user interface, level 1

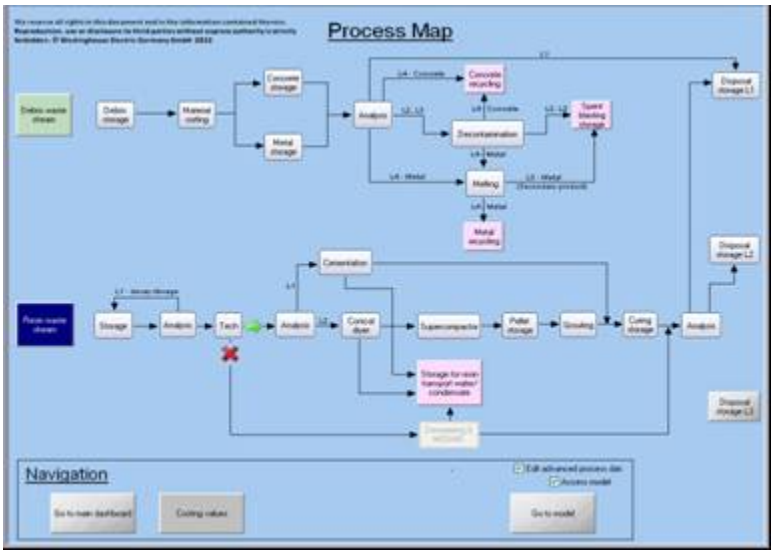

Fig. 2. Example of a graphical user interface, level 2 (block flow diagram)

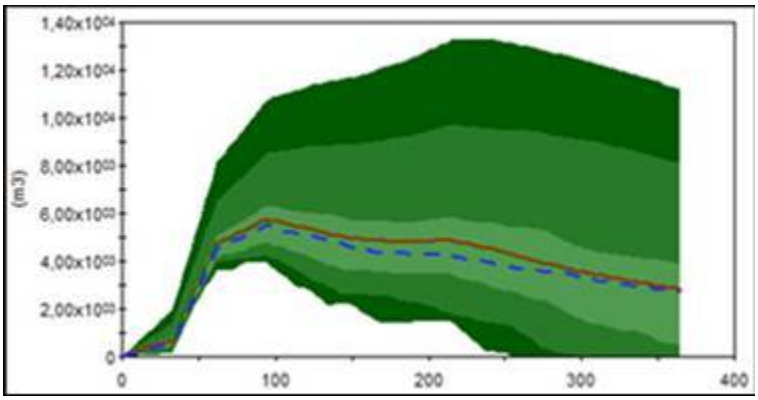

Fig. 3. Example of a result graph:
facility throughput over time with fluctuation probability (green shades),
median (blue) and mean (red)

Sensitivity analysis and optimization

The simulation model is used to perform sensitivity analyses by altering specific parameters. It is possible to change operating parameters of the equipment, as well as boundary conditions or other limiting factors. The results and scenarios are saved separately and can be analyzed separately.

The optimization function of the software tool is an automated calculation based on the given simulation model and its parameters (and boundaries) to minimize or maximize the value of a selected parameter. Thus, minimum life cycle cost of the overall facility or minimum space requirement for storage can be calculated.

The following figure shows an example of a possible result and scenario comparison.

Fig. 4. Example of result and scenario comparison

CONCLUSION

The Westinghouse waste simulation and optimization software tool helps users to identify the process setup necessary to achieve the overall lowest life cycle cost by providing a better insight and understanding of complex interacting and integrated processes and facilities. Detailed cost analysis and cost driver identification, as well as sensitivity analysis in a complex environment and process bottleneck identification are key capabilities of the simulation tool. Using the simulation enables virtual trial and error without risk to identify the best applicable treatment technology. The Westinghouse waste simulation and optimization software tool is built to support the user with reliable data for mature decisions.