Development of a Dynamic Computer Model for Water and Effluent Management at the Alunorte Refinery

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Abstract

Rainfall events are complex phenomena, as there is no dynamic pattern of occurrence since the climatic conditions have been changing over time. With high rainfall rates in recent years in the Amazon region, Hydro Alunorte has developed a dynamic computer simulator for the current configuration of water and effluent reservoirs at the refinery, allowing rigorous evaluation of storage, pumping and treatment capacity for heavy rainfall and with distributed incidence among the basins/sumps and possible interconnection/pumping arrangements between the various control basins. Legasys Storm was created in a transient regime and on Microsoft's .NET platform in C# language, which allows its use on any computer using the Windows operating system. The modeling is done using the mass conservation differential equations and the system of ordinary differential equations is numerically solved using the 4th order Runge-Kutta method. Through the simulations, it is possible to identify weak points for precipitation with a constant intensity or profile, evaluate scenarios with different pumping conditions, power failure, test operational procedures, assist in emergency strategies during heavy rain events and training in controlled environment for operations and maintenance teams.

Keywords: Heavy rainfall, Rainwater storage, Pumping system, Water and effluent, Dynamic simulator.

1. Introduction

Extreme rainfall events have emerged as one of the main consequences of climate change and global warming. These events consist of outliers of precipitation observed in each time interval. This correlation is justified by the following mechanism: with the increase in terrestrial temperature, there is a higher rate of evaporation and, consequently, there is an increase in atmospheric humidity and convective activities. Therefore, with the increase in the average temperature of the planet, there is an intensification of the hydrological cycle.

The Brazilian Amazon, in turn, has one of the highest rainfalls in the world, with an average of 2,300 mm/year. Considering a period of 30 years, from 1978 to 2007, the precipitation recorded in the Brazilian Amazon corresponded to approximately 9% of all precipitation on the solid surface of the planet [1]. It can also be noted that, considering the Brazilian Amazon, the highest rainfall rates are found in the states of Amapá and Pará.

The Hydro Alunorte is in the municipality of Barcarena, in the state of Pará, in the Amazon. The region has a well-defined seasonality of rainfall, which can be divided into two seasons: rainy (Amazonian winter), between January and June, and less rainy (Amazonian summer), between July and December.

The search for orienting tools is fundamental when working with highly complex climatic phenomena.

2. Process Modeling

With the complexity of climatic phenomena, a dynamic computer simulator was developed that allows a rigorous evaluation of Hydro Alunorte rainwater management system for different conditions of intensity and duration. Legasys Storm (LS) allows simulating scenarios with constant or profile rainfall, evaluate scenarios with different pumping conditions, test operational procedures, assist in decision making during heavy rain event and training in a controlled environment for the team of operation.

The software was developed by Hydro Alunorte's Process Engineering in partnership with Legasys, which is a technology company that studies, models, and interprets engineering and nature phenomena, creating exact solutions to problems.

Hydro Alunorte's Process Engineering department is responsible for carrying out the simulations requested by the departments responsible for the maintenance of large areas and/or equipment or by the Hydro project team. The results obtained provide orientation or recommendations for carrying out, deferring, or stopping, planned activities.

2.1 Description of the Work Domain

Hydro Alunorte has a robust management of rainwater. As can be seen in Figure 1, rainwater, from the Solid Waste Deposits (indicated by DRS1 and DRS2) or from the Refinery, can be directed to control basins and/or sumps. The system also includes treatment plants, drainage circuits, pumping stations and online monitoring instruments. This entire structure allows for operational storage, transfer, and treatment maneuvers to be carried out.

In industrial effluent treatment stations, the effluent is received in 9 (nine) control basins, which receive effluents through pipes from Solid Waste Deposits (DRS1 and DRS2) through the channel from the Refinery's drainage circuits.

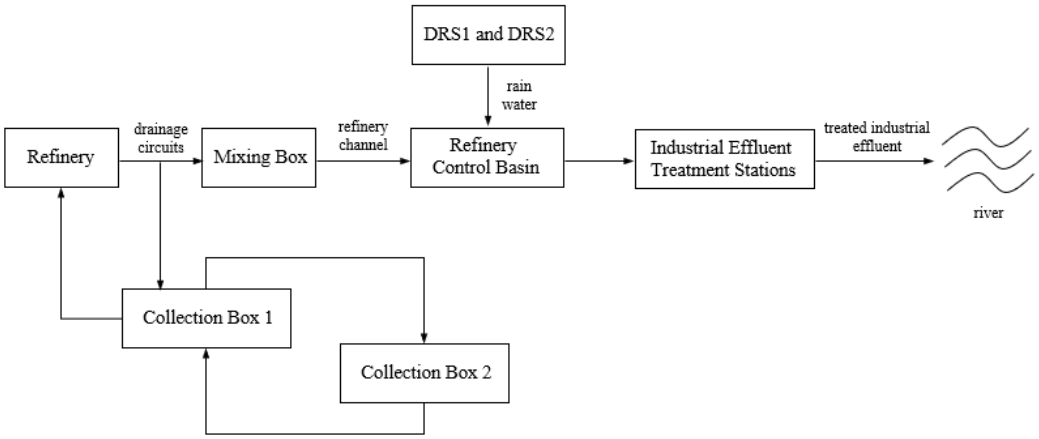

Figure 1. Simplified scheme of the flow of rainwater and effluent for treatment.

The drainage circuits receive, in addition to rainwater that falls on the Refinery, also water stemming from purging of the cooling towers and tanks, floor washing as well as condensate.

2.2 Simulator Development

The LS simulator was developed in .NET framework 4.5 in C# language, which allows its use on any computer that uses the Windows operating system, without the need to install any additional

The simulator seeks to equalize all basin levels to ensure process safety during scheduled maintenance.

5. Conclusions

The development of the dynamic computer simulator serves to evaluate the capacity of storage, pumping and treatment of effluents of Hydro Alunorte. One of the main objectives of the tool is to equate all the complexity of the water management system in a software that presents an intuitive, interactive interface, rich in information and that can represent rain events with constant intensity or with a profile containing peaks.

Considering the climate changes observed in recent years, the forecast of atypical rainfall intensification, its direct influence on the industrial scope and the fragility in the forecast of these occurrences, it is essential to evaluate ways to minimize the effect of these events and mitigate possible impacts. The use of computational models to evaluate scenarios is one of the safest and most modern viable techniques for this type of complexity.

6. References

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