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OBJECT-ORIENTED OIL REFINERY SIMULATION FOR FAST AND ACCURATE INVESTMENT ASSESSMENT

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ABSTRACT

As an oil company's business expand rapidly, its demand for investment assessment rises accordingly. This poses the challenge that investments must be evaluated quickly and accurately. This papers describes standard, verified and validated elements from which oil refinery simulation models can be built in order to meet those requirements and how these models work.

1 INTRODUCTION

Oil refineries are susceptible to many exterior influences, such as the availability and price of oil specifications, fluctuation of market demands and legal changes. All this uncertainty means refineries must keep constantly evaluating possible changes to its installations to remain competitive or take advantage of opportunities.

Simulation can help evaluate proposed changes under situations which are still under consideration. As the demand for these evaluations rise and the complexity of refineries increase, the simulation models must be built quickly without loosing accuracy.

2 OIL REFINERIES

An oil refinery is a complex industrial plant with the goal of transforming the crude oil in useful derivatives. The crude oil and the derivatives are stored in tanks to buffer production variations and oscillations.

The whole refining process is very complex and involves many areas of expertise. Nevertheless, this paper focuses on the simulation of the product flow in the refinery. Generally, the main steps in a refinery related to this flow are: (1) receive and store the crude oil; (2) distillate the oil, producing the first derivatives; (3) treat and mix the derivatives to make final products; (4) store the products until they are demanded; and (5) deliver the products to the market.

3 SIMULATION SCOPE AND METHOD

Refineries are complex plants, but not all units communicate with all others. This happens because the many products a refinery makes are usually composed by a relatively small number of intermediary derivatives. It follows that it's possible to model the production flow of separate families of products. This means that these production chains can be modeled independently.

A second scope-limiting point is the distillation. It separates the refinery's operation from its supplying. The worst case scenario for a refinery is when it must work at full capacity. For that to happen, a nec-

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essary condition is that the refinery has crude oil timely available. This enables a separation between oil supply and production studies. In the first, the goal is to guarantee that the refinery will receive the crude oil according to it's necessity. In the second, which is this paper's focus, the goal is to make sure the refinery can supply the expected markets.

In order to simulate the production flow, a pseudo-continuous simulation strategy is applied. In this strategy, the time steps are discrete and the flow rates are converted to amounts that are transferred at every clock step, appearing continuous.

During the simulation, the elements described in the next section compete under defined priority rules in order to be executed until a stop condition is met. The priority rules consider operational targets, such as fulfilling demands or keeping inventory levels around a predetermined amount.

4 SIMULATION ELEMENTS

The proposed simulation elements are defined by their function in the model and classified in four groups: Products, Tanks, Resources and Operations.

Products are moved around by the simulation model's operations. They may need some mixing and certification time after an operation has finished preparing them and may result non-conforming to quality standards with some predefined probability.

Tanks are where the products are stored. In general, they are dedicated to only one product, due to their construction characteristics. Given their fundamental role in refinery systems, it is important to have sufficient and suitable tanks. Their main characteristics considered in the simulation model are their capacity and quantity. Similar tanks often grouped together in tank farms associated with the products they can store.

Resources are pumps, valves and pipelines which define restrictions on the model. Resources or groups of resources are associated with operations. An operation which depends on an unavailable resource cannot be selected to run.

Operations are the elements responsible for transferring products from one tank to another. It is important that operations keep the volume balance of the refinery. Products' formulations are also defined in the operations. Operations can be grouped in a seven special cases regarding their source and destinations tanks. They are described by pairs of the form $(S \to D)$, which means the source is a set S of tanks or tank farms and the destination, a set D of tanks or tank farms. $\varnothing$ means the source or destination is out of the model's scope and 1 means the set has a single element.

The operation groups are: Transference $(S \to D)$, Separation $(1 \to D)$, Mixing $(S \to 1)$, Conversion $(1 \to 1)$, Demand $(1 \to \varnothing)$, Receiving $(\varnothing \to 1)$ and Offer $(\varnothing \to D)$.

5 TESTS AND VALIDATION

A model built around the proposed elements was tested in FULLER (2009) against a model (built using ProModel) extensively used in Petrobras, the biggest oil company from Brazil. The results obtained from the new model were compatible with those from the old one, but they were obtained much faster.

REFERENCES

Fuller, D. B. 2009. "Um simulador de refinarias de Petróleo". *Masters dissertation*. Universidade Federal do Rio de Janeiro. Rio de Janeiro, RJ.