Minimisation of water consumption: the case of an oil refinery

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1. Summary

Nowadays water is becoming a valuable resource due to its lack. Consequently, it is necessary to control its use. In this work, the heuristic algorithmic procedure Water Sources Diagram (WSD) was applied for targeting the minimum process water consumption in a Brazilian oil refinery by means of its regeneration, reuse and recycling. The studied cases involved the presence of multiple contaminants in water streams. This study refers to the utility system of an oil refinery due to its large consumption of water, almost 90% of the total consumption. The system consists of water treatment station, steam generation, catalytic cracking, cooling towers, petroleum desalination and efluent treatment station. Considering three contaminants (chloride, ammonia, phenol) and pH as controlled parameters, a new mass exchange network was proposed with a reduction in water consumption from 43.4 t/h to 35.1 t/h in the simplified flowchart. In the real case of the oil refinery analyzed the water consumption was decreased from 150 t/h to 141.7 t/h, which represents a reduction of 5.5%. Since the water flowrates in an oil refinery are elevated, an economic analysis based in data taken from the literature was carried out. It was found a cost reduction of US$ 56.8 million dollars/year. This shows the efficiency and applicability of WSD methodology.

Keywords: water minimization, multiple contaminants, mass exchange networks synthesis, water re-use, regeneration and reuse

2. Extended Abstract

The Water Source Diagram (WSD) procedure is based in the pinch technology, and was applied to problems with multiple contaminants by Gomes et al. (2007). In problems involving multiple contaminants, the mass exchange of all contaminants occurs simultaneously. If the mass exchange network is established taking into account only a reference contaminant**,** generally**,** the limit inlet concentration will not be respected for all contaminants. Contaminants are transferred following a determined relationship in each operation. In the present work it is considered that the relations of contaminant mass transfer to the water stream are linear in each operation following the suggestion by Wang and Smith (1994). These relations must be preserved in each operation.

The concentrations of reference contaminant are put in form of concentration grid. An operation is chosen as a reference to supply water to the others operations. One has chosen the reference operation as the one that uses primary water. Then the amount of mass transferred in each operation in each interval is calculated.

In order to assume the minimum water source consumption, three rules must be satisfied in the selection of the water source to be allocated to each operation in each concentration interval: i) use external water sources only when internal sources are not available, ii) transfer all the possible amount of contaminant inside a concentration interval, iii) for the operations that are present in more than one interval, when changing interval, the stream must continue to flow through the same operation until its end; this heuristic avoids the division of operations (Gomes et al., 2007).

In order to apply the WSD procedure, were necessary the following process data: i)• identify water using operations; ii) water mass exchange network of the selected processes iii) identify operations with limit flowrates; iv) Identify all contaminants and its concentrations.

The present work considered the WSD with regeneration and maximum reuse of water. The lower external water consumption was get water reuse from operation II to IV and used recycled water from ETDI to desalter. It showed water reduction from 43.4 t/h to 35.1 t/h in the simplified flowchart (19.1%). In the real case of the oil refinery the water consumption was decreased from 150 t/h to 141.7 t/h, which represents a reduction of 5.5%. The economic evaluation showed a cost reduction around of 13.8%, in the simplified flowsheet, or US$ 56.9 million.

Phenol, an contaminant present in the crude oil that worst its quality, was removed with the water reuse from operation II to operation IV, it usually is removed by water in desalter.

Another advantage is the better quality of water used in the desalter. The external water (fresh water) is improper to the operation of the desalter, because pH is very low (around 5.5), causing problems like the corrosion, that reduces the useful life of the equipment. The water proceeding from the catalytic cracking unit (UFCC), purges of the boiler and of the treatment of industrial effluents station (ETDI) has pH in the excellent band 7.0-8.0. Thus, the present work also reached this objective, to improve pH of the water destined to this operation.

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