## A HYBRID METHODOLOGY FOR OPTIMIZATION OF MULTI-STAGE FLASH-MIXER DESALINATION SYSTEMS

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Abstract— In this paper, a new strategy involving an evolutionary algorithmic procedure for the optimization of Multiple Stage Flash (MSF-M) Systems is presented. A "detailed model" of an MSF-M System is developed according to rigorous material, momentum and energy balances for each stage. The model of the MSF-M System is represented as a complex NLP, which incorporates a high number of nonlinear constraints that difficult the global optimum determination. Here we present a hybrid methodology that uses optimal solutions obtained from a "thermodynamic method" to find the "economic global optimal solution". A pre-processing stage (solving successive NLPs) is used to initialize the final NLP problem. A Case Study and a discussion of the results are presented.

*Keywords*— MSF-Mixer Desalination System. Optimal Synthesis and Design. Hybrid Methodology.

## **I. INTRODUCTION**

In previous papers (Scenna, 1987a,b; Scenna *et al.*, 1993), a simplified model was presented using a Thermodynamic Based Methodology, which allows finding optimal solutions involving both structural and operational conditions of MSF-M systems. In practical designs, models with a more detailed description become necessary (for example pressure drops, inter-stage flowrates and liquid levels are critical due to operative conditions), but generally they are very difficult to solve using the above-mentioned approach.

From the Mathematical Programming point of view, we can use NLP models (Mussati *et al.* 2001) for system description. In this paper, a strategy to determine the optimal design for the MSF-M System is presented. It involves solutions obtained in a first step involving a thermodynamic model. Thermodynamic solutions are used to initialize an MSF-M rigorous model when an economic objective function is considered (which includes the capital and operation costs).

This idea is based on previous work (Scenna and Aguirre, 1993) to solve the synthesis of dual-purpose desalination plants. Indeed, several researchers (Gundersen and Grossmann, 1990; Bek-Pedersen *et al.*, 2000) have used thermodynamic functions in different ways to make the MINLP or NLP solution easier, pro-

posing a "physical insight" to solve complex synthesis problem.

Here, we introduce a formal context for using of thermodynamic models for solving a complex optimization problem based on previous experiences and results. Also, a discussion about the global optimality of the achieved solution is presented. In addition, a general procedure to handle the link between "thermodynamic" and "economic" based solutions will be approaches.

## II. RIGOROUS NLP FORMULATION FOR THE MSF-M SYSTEM OPTIMIZATION

Figure 1.a shows the flow-sheet of an MSF-M System. A typical flash stage is shown in Fig. 1b. The evaporator is divided into stages; each stage has a seawater condenser, a brine flash chamber, a demister, distillate collecting and a transfer system.



Figure 1a. Diagram of MSF-M Desalination Process.



Figure. 1b. Schematic Representation of the jth stage.

The seawater (feed) enters at temperature T0 and it is heated at the maximum temperature (Tmax) as it flows in series through the condenser tubes of each stage and brine heater. It then flows into the first stage inlet box and is evenly distributed across the width of