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# Thermal design of a tray-type distillation column of an ammonia/water absorption refrigeration cycle

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The goal of this paper is to present an analysis of a segmented weir sieve-tray distillation column for a 17.58 kW (5 TR) ammonia/water absorption refrigeration cycle. Balances of mass and energy were performed based on the method of Ponchon-Savarit, from which it was possible to determine the ideal number of trays. The analysis showed that four ideal trays were adequate for that small absorption refrigeration system having the feeding system to the column right above the second tray. It was carried out a sensitivity analysis of the main parameters. Vapor and liquid pressure drop constraint along with ammonia and water mass flow ratios defined the internal geometrical sizes of the column, such as the column diameter and height, as well as other designing parameters. Due to the lack of specific correlations, the present work was based on practical correlations used in the petrochemical and beverage production industries. The analysis also permitted to obtain the recommended values of tray spacing in order to have a compact column. The geometry of the tray turns out to be sensitive to the charge of vapor and, to a lesser extent, to the load of the liquid, being insensible to the diameter of tray holes. It was found a column efficiency of 50%. Finally, the paper presents some recommendations in order to have an optimal geometry for a compact size distillation column.



## 1. Introduction

Worldwide population increase is directly accompanied by an electrical and basically all other forms of energy demand boost. Air conditioning, refrigeration, and heating systems are accountable for a considerable fraction of the electrical energy matrix in many countries. The increase in energy consumption and the scenario of energy shortage in near future have brought back the concept of a rational and efficient use of energy and its transformations into useful mechanical, electrical, and thermal energy. In this context, absorption refrigeration cycles are a key component in both refrigeration and air conditioning systems that can be powered by waste thermal energy at basically very little operational costs and electricity consumption. Thermal energy sources needed for powering those cycles can be supplied by waste heat from thermal processes, by solar energy, by exhaust gases from engines and turbines, and by basically any other available heat source above its operational temperature. Therefore, if one includes an absorption refrigeration cycle in a cogeneration or trigeneration system, i.e., the simultaneous generation of electricity, heat and cold from a single source of energy, this concept of an integrated power plant becomes a more efficient, economical and environmentally more friendly. The most common working fluids in absorption refrigeration cycles are the pairs of fluids ammonia/water and lithium bromide/water, being the former natural fluids. An ammonia/water absorption refrigeration cycle (*AARC*) achieves subzero cooling temperatures, since the refrigerant is ammonia, while the lithium bromide/water technology is bound by the lower theoretical temperature of 0.01 °C, because water is the working fluid refrigerant. This work deals with ammonia/water mixtures.

A critical element of any *AARC* is the distillation column in which a simultaneous heat and mass transfer process takes place in the two-phase, two-component mixture of ammonia/water. The distillation column must provide ammonia vapor at a high grade of purity. Otherwise, if the ammonia vapor is too wet, the water content can continuously be accumulated in the evaporator causing a degradation of the cycle *COP* (coefficient of performance) [1,2]. Ahachad et al. [3] compared the *COP* of a simple effect *AARC* operating with and without a purification system. In place of the rectifier they tested a vapor bubble purifying system. The *COP* of the absorption chiller with vapor bubble purifying system improved from 15 % to 35 % and the required area of solar collectors, used as a heat source, was lowered by 10%; their highest *COP* obtained was 0.4.

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