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Experimental evaluation of desuperheating and oil cooling process through liquid injection in two-staged ammonia refrigeration systems with screw compressors

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ABSTRACT

This paper examines the problem of achieving desuperheating through liquid injection in two-staged refrigeration systems based on screw compressors. The oil cooling process by refrigerant injection is also included. The basic thermodynamic principles of desuperheating and compressor cooling as well as short comparison with traditional method with a thermosyphon system have also been presented. Finally, the collected data referring to a big refrigeration plant are analyzed in the paper. Specific ammonia system concept applied in this refrigeration plant has demonstrated its advantages and disadvantages.

1. Introduction

For large differences between evaporation and condensation temperatures, the multi-stage compression with desuperheating is being used as the most efficient measure for refrigeration cycle improvement. According to [1,2] internal desuperheating can be achieved by:

- Injecting superheated vapor from the low-stage compressor discharge line into the intercooler at inter-stage (middle) pressure;
- Mixing superheated vapor from the low-stage compressor discharge line with some other lower temperature vapor (saturated or superheated) at inter-stage pressure;
- Injecting throttled liquid from the condenser or sub cooled liquid into superheated vapor of the low-stage compressor discharge line at inter-stage pressure.

Different approaches are used to deal with the problem of vapor-compression process optimization. According to Ref. [3] the optimum inter-stage pressure is very close to the saturation pressure corresponding to the arithmetic mean of the refrigerant condensation and evaporation temperatures and in the actual cycle maximum COP occurs at lower inter-stage temperature than in the ideal cycle. The inter-stage pressure is always higher when any of the intermediate systems are used than when they are not used [4]. Several works were carried out to optimize vapor-compression refrigeration systems with design and adequate rating [5], with process modeling [6,7] or exergy-method analysis [8]. Desuperheating could be achieved as “internal” process with heat recuperation or liquid injection within the same installation using existing refrigerant [9]. Active compressor cooling improves the system COP and the compression power of the system can be reduced by up to about 16% [10]. A similar study for heat pump systems was presented by Feng [11]. According to Refs. [12,13] this concept is highly effective from the heat transfer point of view. Many researchers deal with the problem of investigating influence of liquid injection on other system components performances like on condenser and compressor [14], compressor discharge temperature [15,16], vapor-compression process modeling [17–21], or oil composition used in compression refrigeration systems [22]. The oil cooling with liquid injection has direct influence on the compressor cooling capacity reduction. This reduction will be

Abbreviations: LPC, low pressure compressor; HPC, high pressure compressor; COP, coefficient of performance; TEV, thermo expansion valve; EM, electric motor drive; SCADA, supervisory control and data acquisition; ISAC, integrated standard automation concept.

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