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EXPERIMENTAL ANALYSIS OF A VARIABLE-SPEED COMPRESSOR

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ABSTRACT

An experimental analysis of a variable-speed reciprocating compressor for household refrigeration, with an operating speed range of 2000 to 5000 rpm, is herein presented. The main parameters describing the compressor performance as a function of the shaft speed, are presented for a standard operating condition. A efficiency breakdown analysis is outlined. The motor characteristics and the inverter control system are discussed. It has been identified that the compressor efficiency at low speed, is penalized by the lower compression and motor efficiencies, while at the high speed the negative effects are the low mechanical and valve efficiencies. The maximum compressor efficiency stays around 60 Hz which corresponds to its original design speed.

INTRODUCTION

Experimental evaluations were performed on a regular reciprocating compressor, where the standard induction motor was replaced by a Brushless Permanent Magnet (BPM) motor, providing a capacity variation by controlling the motor speed. Additionally, small changes were introduced on the oil pumping mechanism to assure full lubrication for all the mechanical components, to speed levels below 1500 rpm.

A refrigeration system utilizing the technique of capacity modulation, may reduce its energy consumption by eliminating the on-off cycling losses, enhancing the heat exchangers performance, and allowing the compressor to work on a more favorable condition. Also smaller compressors may be used. Besides the energy consumption aspects, other advantages like better food conservation quality, quick freezing ability and lower noise level, may also be obtained by utilizing a variable speed compressor.

The current analysis is solely based on the compressor itself. The objective is to outline the compressor performance characteristics as function of the operating speed.

MOTOR CHARACTERISTICS

A conventional induction motor for the compressor is not suitable due to the high power losses at low speeds when operated with an inverter, resulting in low electrical efficiency. The BPM motor, on the other hand, has the characteristic of high efficiency and easy control strategy over a wide speed range. Nevertheless, the BPM motor needs a rotor position detector for proper operation. Since the use of internal sensors is not suitable for hermetic compressors, the back EMF structure was chosen for the rotor position detector.

Inverter Design

The control strategy of the inverter design is shown on Figure 1.