Engineering Failure Analysis 18 (2011) 735–746

Contents lists available at ScienceDirect

Engineering Failure Analysis

journal homepage: www.elsevier.com/locate/engfailanal

Failure analysis of reciprocating compressor crankshafts

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ARTICLE INFO

Article history:
Received 13 July 2010
Accepted 6 December 2010
Available online 15 December 2010

Keywords:
Crankshaft
Reciprocating compressor
Failure
Overload

ABSTRACT

An analysis of the premature failure in a high number of crankshafts from the same model of a four cylinder reciprocating compressor used in bus climate control systems has been carried out.

The analysis included visual examination, crankshaft chemical composition and hardness analysis and a dynamical model of the system. The simulation included several sub-models:

- Thermodynamic model of the refrigerating cycle.
- Compressor torque dynamical model.
- Finite element model (FEM) of the crankshaft.
- Dynamic lumped system model.

Results from the lumped model were incorporated into the FEM in order to evaluate the stresses due to the torsional dynamic in the crankshaft.

Several conclusions can be drawn from this study:

- Analysis of the compressor revealed that the torsional dynamic controls the stress in the crankshaft and that the influence of the gas forces on the crankshaft stress is only minor.
- The appearance of the fracture was consistent with a torque overload.
- The maximum stress in the crankshaft, as obtained from the FEM and lumped model, was located in the keyway, and this location belongs to the fracture surface in most of the broken crankshafts. The influence of the stress concentration factor imposed by this geometry is therefore very high.
- The compressor speed range was found to continuously cross the three lower resonance frequencies.
- The exhaust valve of the compressor should be redesigned in order to reduce gas forces, power consumption and pressure drop.

1. Introduction

The first automobile to be equipped with air conditioning as we know it today appeared in 1939 (Packard) and this technology has been under constant development ever since. Indeed, today around 70% of new automobiles world-wide incorporate this system. In the case of buses almost all vehicles are fitted with this technology. One of the most important

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doi:10.1016/j.engfailanal.2010.12.004