Oil-free piston compressors

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Introduction

Material wear and working gas deterioration limit life time and reliability of Stirling compressors. The aim of the project is to design a high performance oil-free piston compressor for application in cooling systems. The proper material selection regarding sliding, anti-wear properties and the piston cylinder assembly design is considered for improved efficiency.

Methods

Experiments A home developed vacuum tribo-tester is used for friction and wear measurements in vacuum and inert gas atmospheres on the pre-selected materials. The new design concepts and the selected materials performance will be demonstrated and validated on the gas spring test rig.

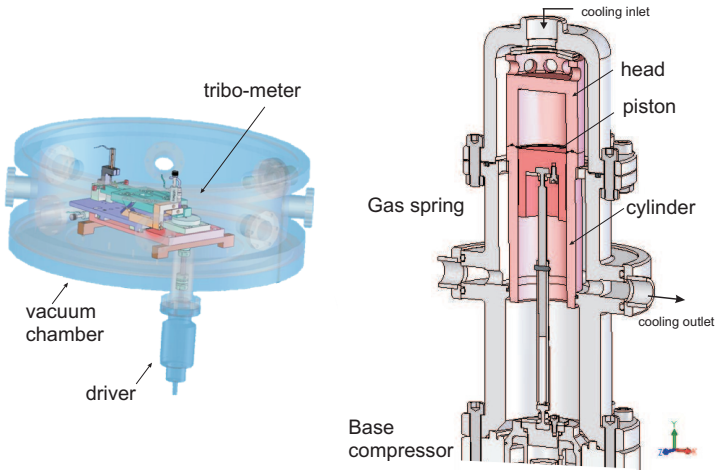

Figure 1 : The vacuum tribo-tester and gas spring

Calculations 1) The FE code DiekA is used for thermo - mechanical simulations of the piston - cylinder assembly under transient thermal loads (from both compressed gas and friction). The thermo-elastic instability leading to seizure can be analyzed, see preliminary results in Figure 2.
2) A new model for piston - gas film interaction is developed considering piston shape, dynamics and operating conditions. Simulations of the pistons secondary motion were performed. Figure 3 shows the trajectory of point 'a'. The influence of design parameters is investigated to find an optimum piston shape that reduces the radial motion and tilting creating a stable, uniform gas film.

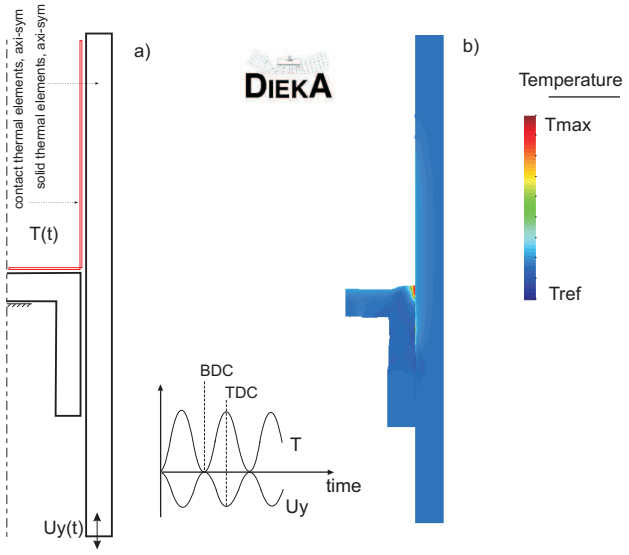

Figure 2 : a)Half cross-section of the piston-cylinder fit b) Deformed shape and temperature field after seizure

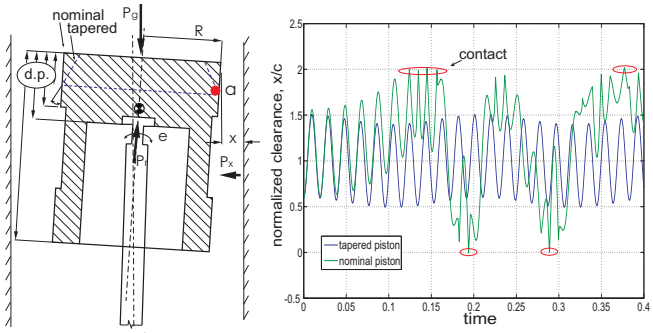

Figure 3 : Schematic drawing of piston and results of secondary piston motion simulations

Discussion

The integrated approach of structural mechanics, thermal engineering and tribology aims to design an advanced piston compressor. Based on numerical results design concepts will be proposed. The following companies joined the project Stirling BV, Grasso BV, Bekaert BV, Thales C-N, NPT BV, Philips DAPC,ANSYS Europe Ltd.