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Influence of refrigerant solubility and surface geometry on the wetting properties of lubricating oil

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ABSTRACT

Experimental results are reported on the effect of refrigerant solubility on the wetting parameters (apparent contact angle and half-filling angle) of POE ISO 10 lubricating oil on carbon steel surfaces. The basic geometric configuration of the test section consisted of an oil film strained between two vertically aligned spheres. An ancillary configuration consisted of a sphere and a flat horizontal surface (infinite curvature radius). R-134a was used as the refrigerant in all tests. The influence of the diameters of the spheres and the spacing between them was also evaluated. It was found that an increase in the curvature of the surfaces gives rise to a reduction of the contact angle and an increase in the half-filling angle. In the sphere–sphere configuration, the contact angle was observed to be inversely proportional to the refrigerant solubility.

Influence de la solubilité du frigorigène et de la géométrie de surface sur les propriétés de mouillage de l'huile lubrifiante

Mots clés : Huile lubrifiante ; Mouillage ; Angle de contact ; Angle de demi-remplissage ; Solubilité

1. Introduction

In reciprocating compressors, automatic suction and discharge valves are designed to open and close in the littlest time possible once the cylinder pressure becomes equal to the pressures in the suction and discharge chambers. In real systems, viscous losses in the gas flowing through the valves, valve inertia and film adhesion in the lubricating oil between the valve and the seat are among the mechanisms responsible

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Nomenclature

h	distance between surfaces [m]
R	half-filling radius [m]
V	liquid mixture volume [m^3]
V_O	volume of pure oil [m^3]
x_R	solubility [–]

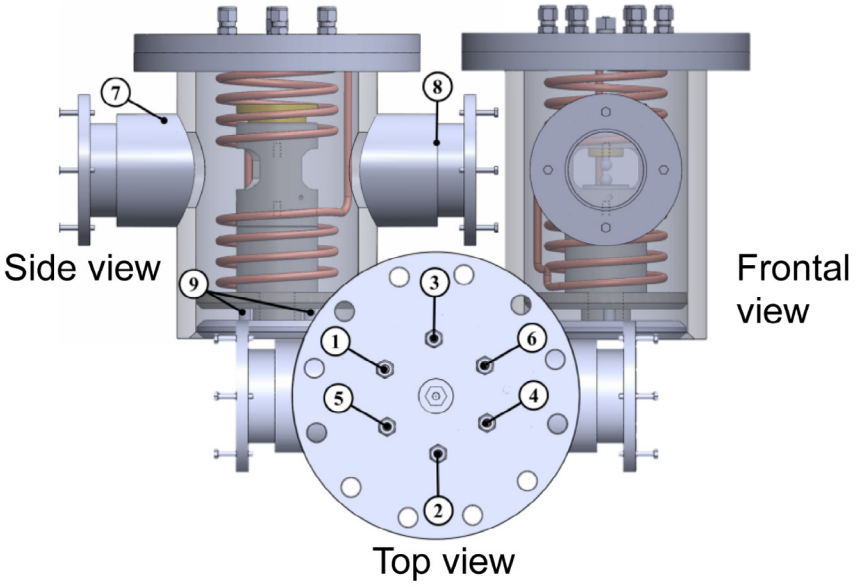
Greek letters

β	half-filling angle [°]
θ	apparent contact angle [°]
ρ_O	density of pure oil [kg m^{-3}]
ρ_R	density of saturated liquid refrigerant [kg m^{-3}]

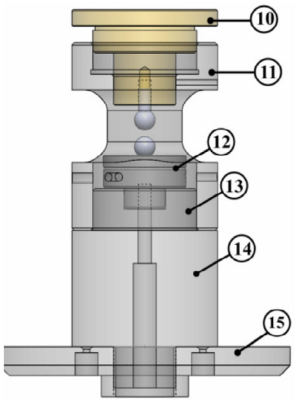
Subscripts

cl	contact point at the lower surface
cu	contact point at the upper surface
l	lower surface
ll	left side of the lower surface
lr	right side of the lower surface
u	upper surface
ul	left side of the upper surface
ur	right side of the upper surface

for the so-called valve losses. The adhesion (or stiction) force is caused by the deformation of the lubricating oil film that reaches the space between the valve and the seat through the piston–cylinder gap. The stiction force delays the valve opening, since a larger pressure difference between the cylinder and the suction and discharge chambers is necessary to overcome the adhesion effects. As a result, both the isentropic and volumetric efficiencies of the compressor are reduced.



(a)



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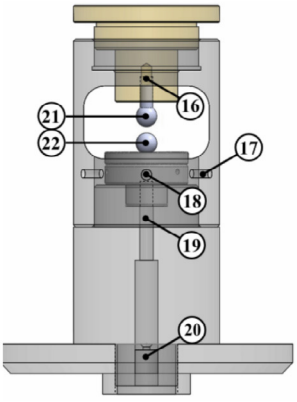

(c)

Fig. 1 – (a) Test cell. (b) Alignment system (side view). (c) Alignment system (frontal view).