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A Study on High Efficiency Wing-vane Compressor - Part 1: A Simulation Analysis of Dynamic Model -

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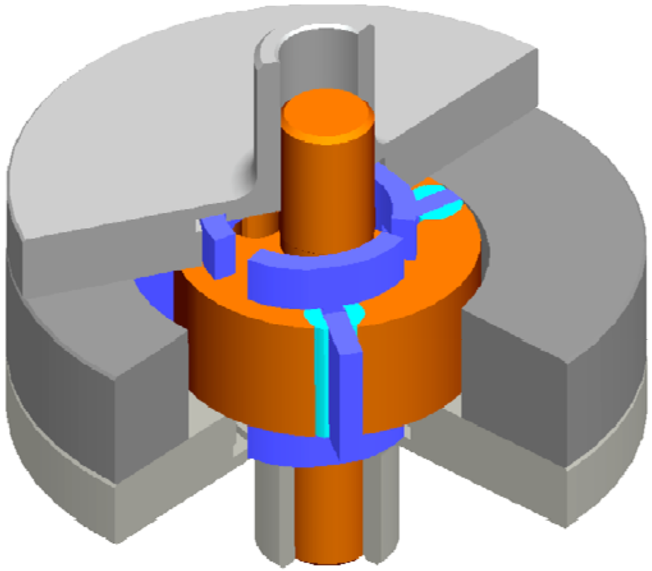
We introduce the new type compressor **"Wing-vane compressor"** with 3 parts as follows,

Part 1:
A Simulation Analysis of Dynamic Model

Part 2:
Lubrication Characteristic of The Partial Arc Guide Bearing

Part 3:
Experimental Evaluation of The Prototype



Wing-vane compressor

Part 1:*A Simulation Analysis of Dynamic Model*

CONTENTS

1. INTRODUCTION

■Air-conditioning and cooling systems

Package Air Conditioner & Multi Systems

Room Air Conditioner

■Refrigerant

HFC (Hydro fluorocarbon)

□Mainly used as refrigerant
□Affect global warming

R410A
GWP:2090

R32
GWP:675

To prevent global warming

□Need to develop technologies
for the use of **low GWP refrigerants**

R1234yf
GWP:1

■Problem

Compared with R410A,
R1234yf has a low density.
Larger sizes are required in compressor

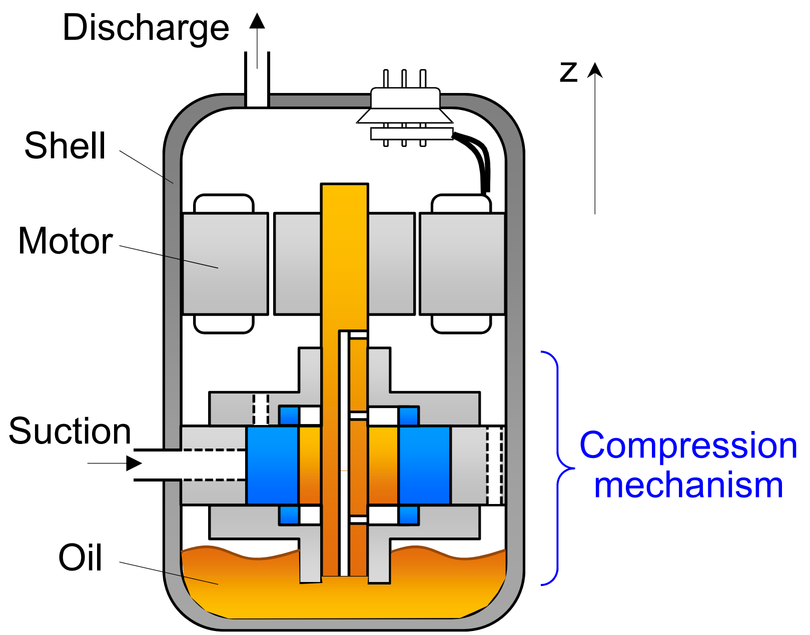
Developed ***"Wing-Vane Compressor"***
To prevent an increase in size without performance degradation.

2. BASIC STRUCTURE

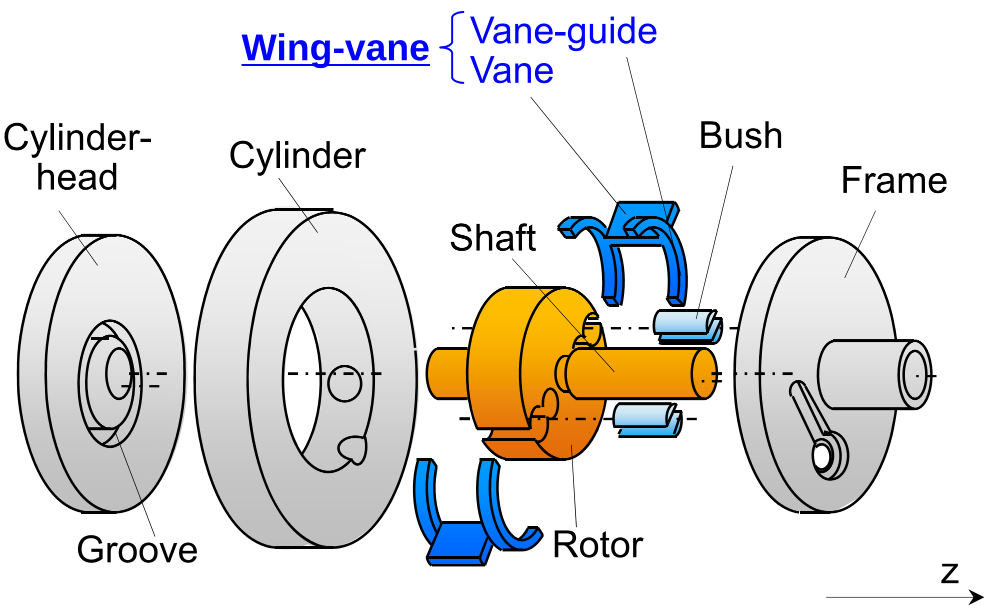
■The compression mechanism is composed of a frame, cylinder, cylinder-head, rotor, shaft, four bushes, and two wing-vanes.

■The wing-vane is composed of one vane and two vane-guides

■The vane-guides are fitted into the groove in the frame and the cylinder-head.



Longitudinal section



Disassembly view of compression mechanism

Fig.1 Basic structure of wing-vane compressor

2. BASIC STRUCTURE

■The tip of vane does not contact with the cylinder inside.

■The wing-vane compressor can achieve a high efficiency and small size using this structure.

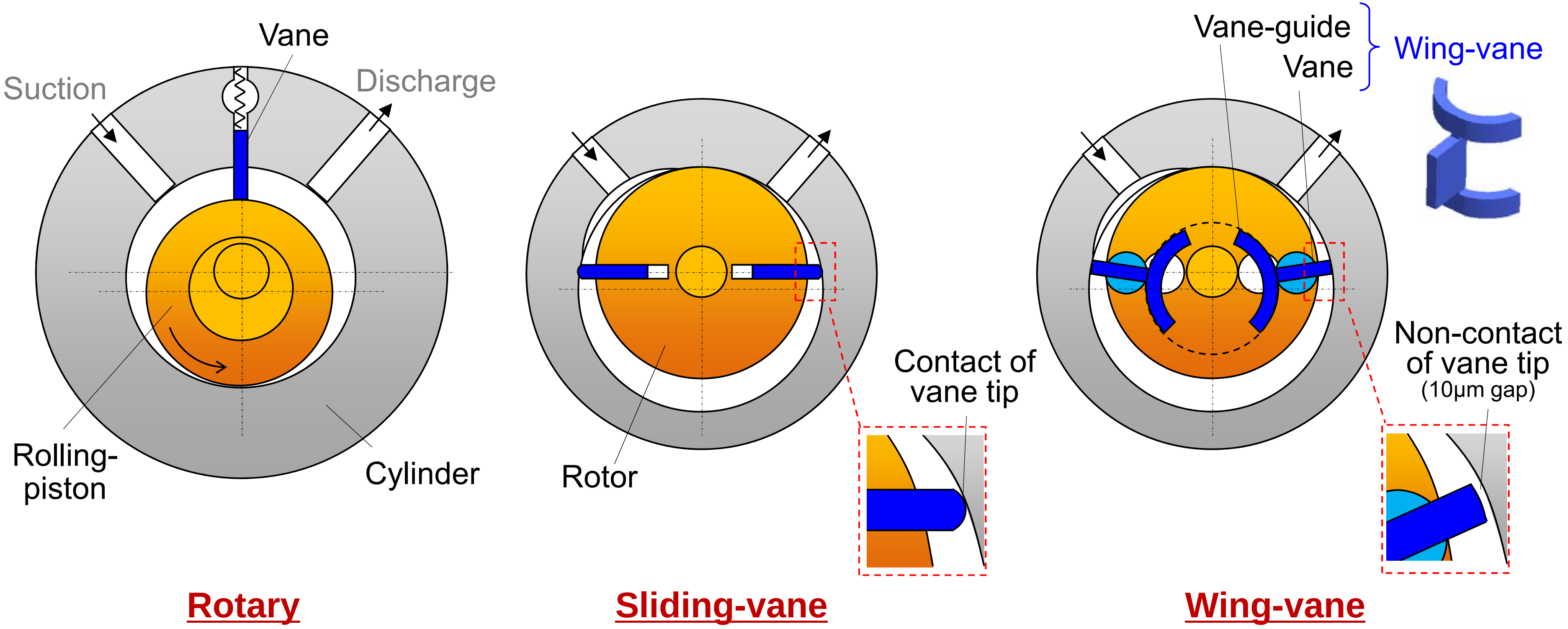
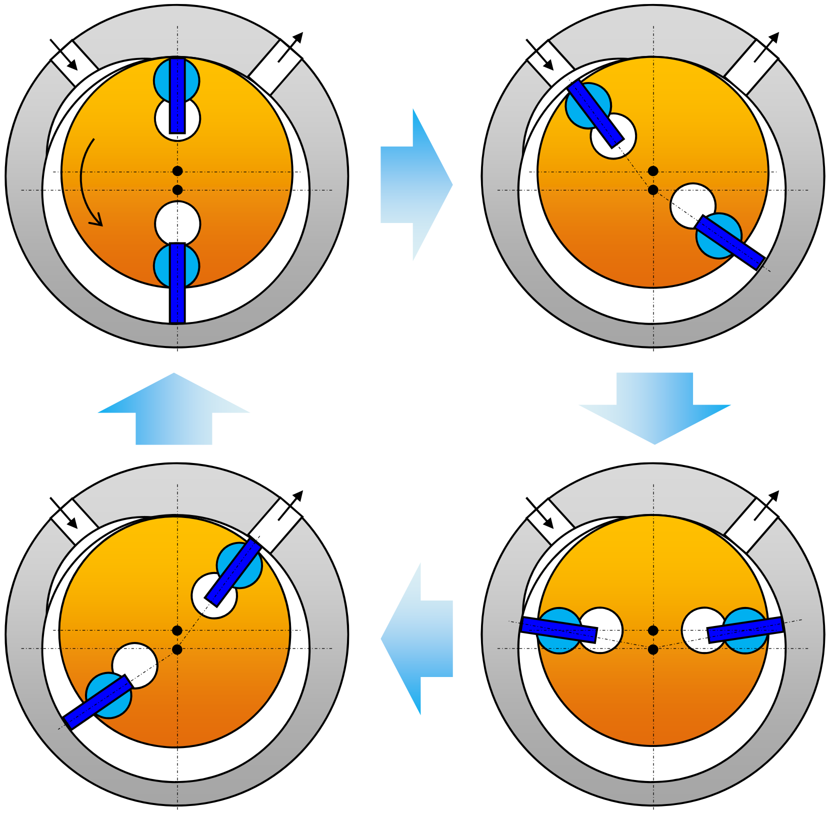


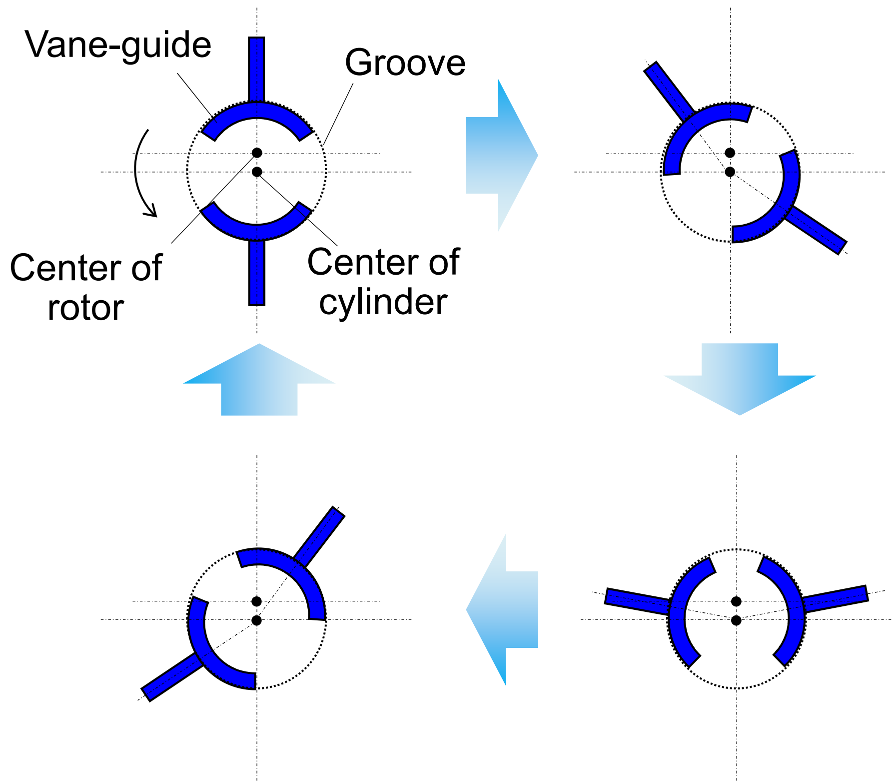
Fig.2 Horizontal cross-sectional view of compression mechanisms

3. OPERATING PRINCIPLE

- The vane rotates around the center of the cylinder.
- It is possible to keep the gap between the vane tip and the cylinder.



Overall operation

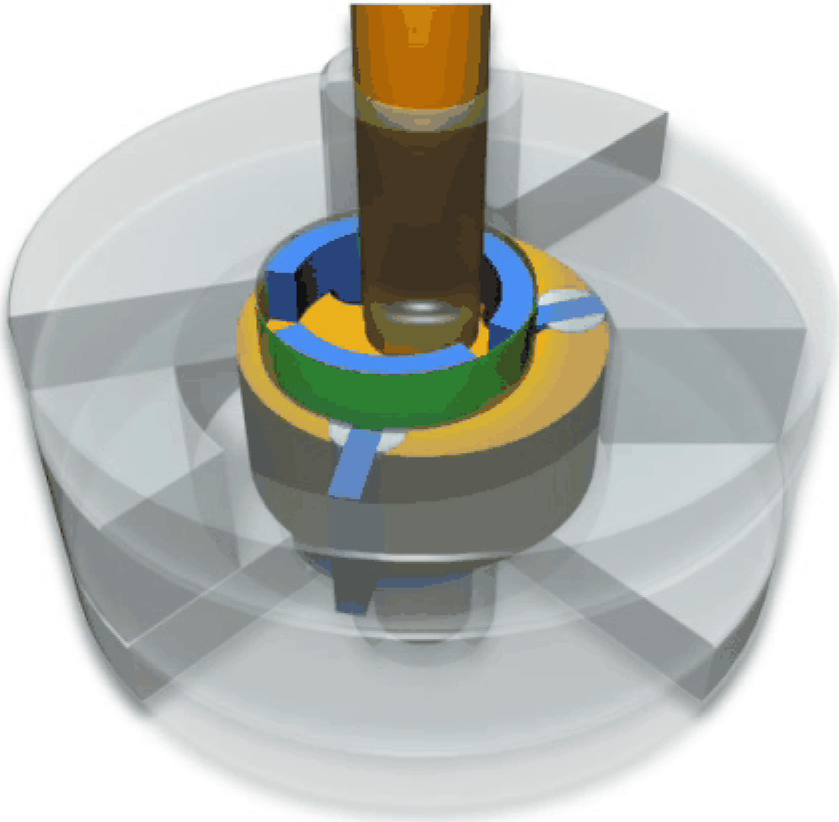


Vane and vane-guide operation

Fig.3 Compression process of the wing-vane compressor

3. OPERATING PRINCIPLE

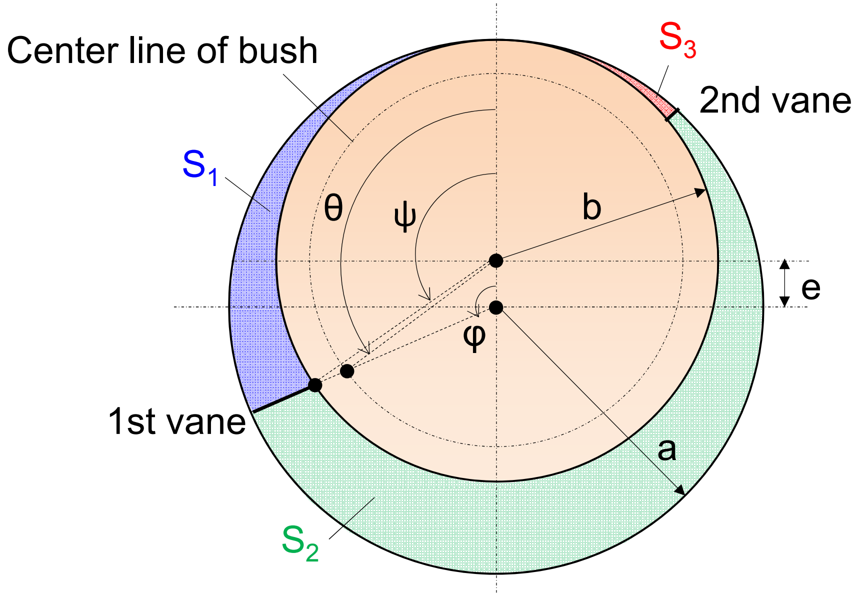
ウィングベーン圧縮機の構造



Animation of operating principle

4. CHARACTERIZATION

(1) Compression chamber volume change



$$S_1 = A(\theta)$$
$$S_2 = A(\theta + \pi) - A(\theta)$$
$$S_3 = \pi(a^2 - b^2) - A(\theta + \pi)$$
$$A(\theta) = \frac{a^2\phi}{2} - \frac{b^2\varphi}{2} - \frac{be\sin(\varphi)}{2}$$

Fig.4 Calculation model of volume change in compression chamber

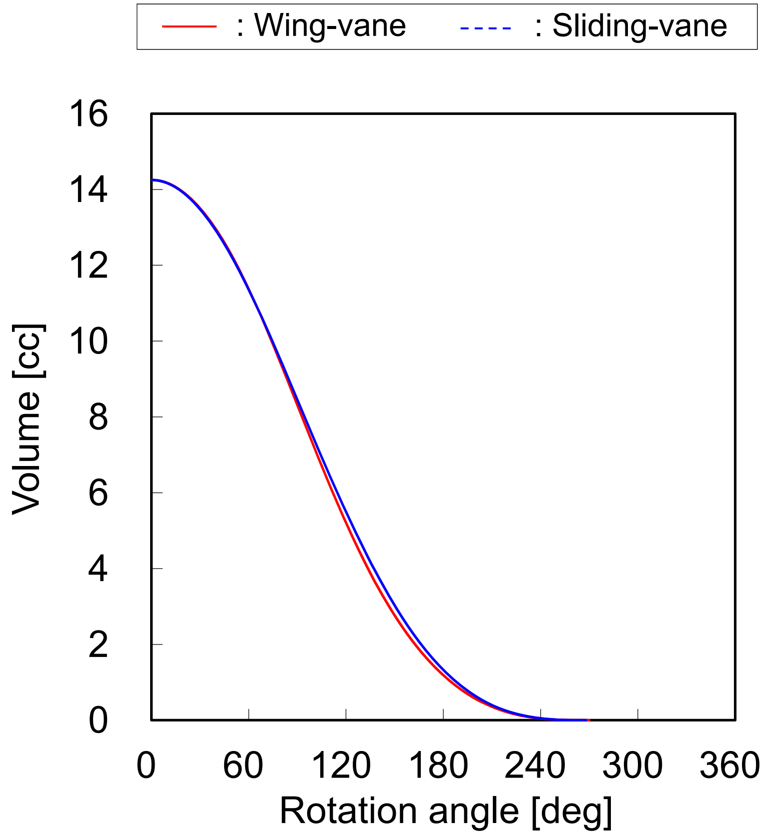
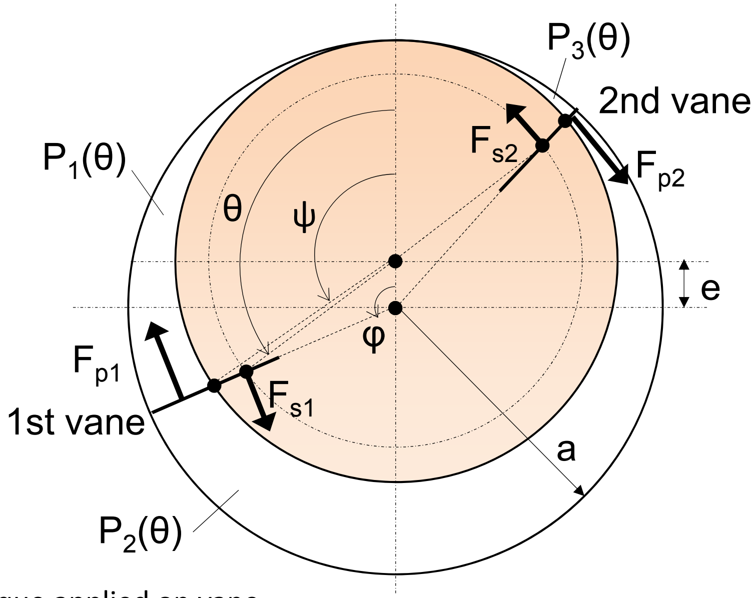


Fig.5 Characteristics with respect to rotation angle

4. CHARACTERIZATION

(2) Torque and rotor load

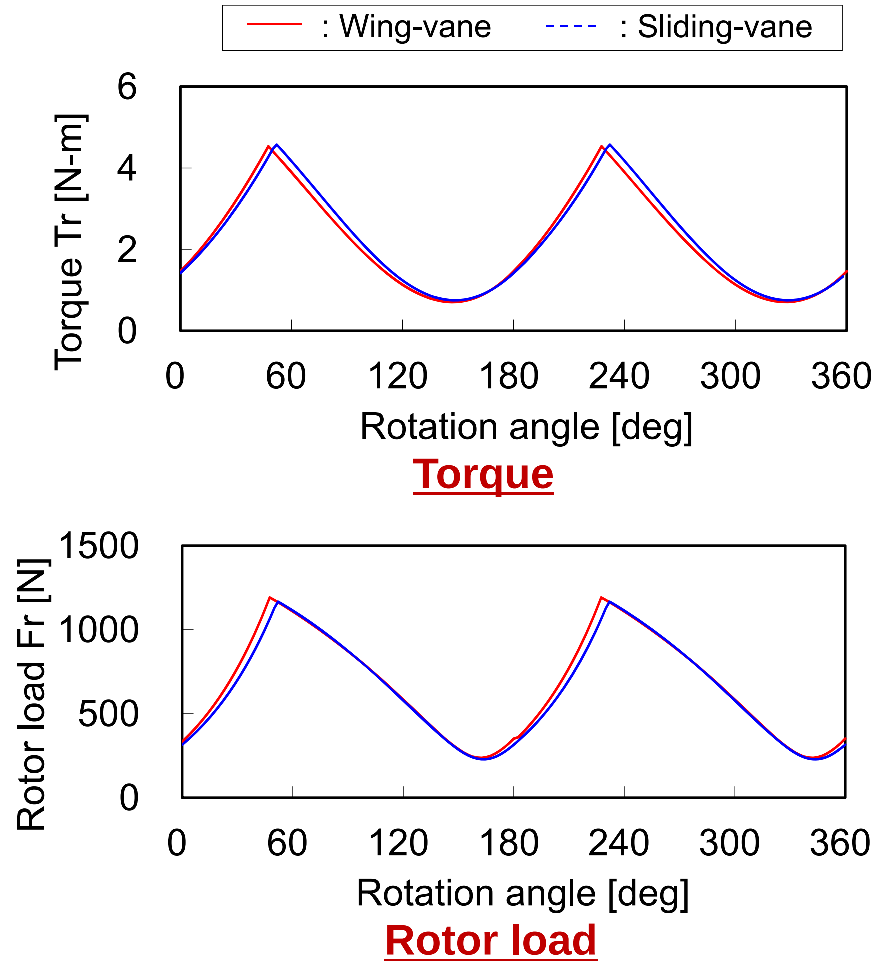


T_r : Torque applied on vane,
F_r : Total Load applied on rotor
F_e : Gas load applied on rotor
F_s : Gas load applied on bush from vane

$$T_r = F_{p1}\{a - \frac{L(\theta)}{2} - e\cos(\phi)\} + F_{p2}\{a - \frac{L(\theta+\pi)}{2} - e\cos(\phi+\pi)\}$$

$$F_r = \sqrt{(F_{ex}+F_{sx})^2 + (F_{ey}+F_{sy})^2}$$

Fig.6 Calculation model of the torque and the rotor load characteristics

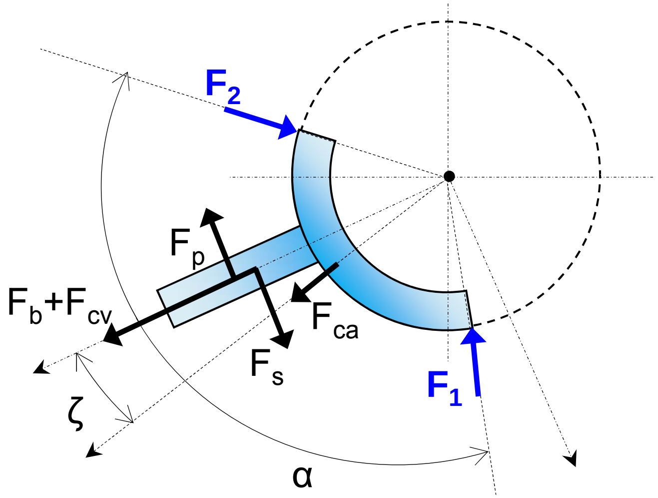


*calculated under specific operating conditions
(Evaporation temperature 52℃, Condensation temperature 5℃)

Fig.7 Characteristics with respect to rotation angle

4. CHARACTERIZATION

(3) Vane load

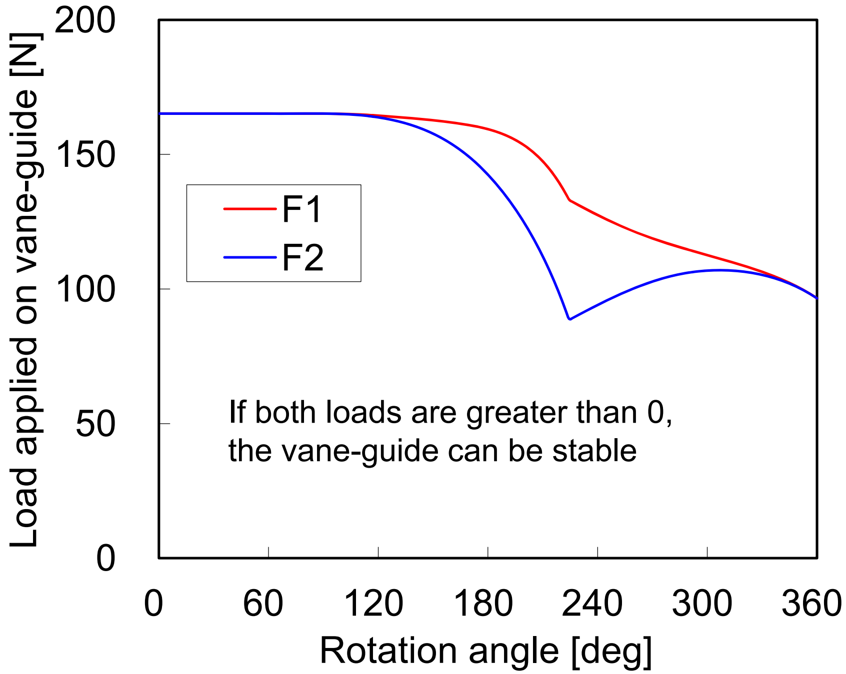


F_p : Load applied on the vane from the pressure difference (side),
F_b : Load applied on the vane from the pressure difference (back/ tip),
F_s : Load applied on the bush,
F_{cv} : Centrifugal force applied on the vane,
F_{ca} : Centrifugal force applied on the vane-guide,

$$F_1 = \frac{\{2F_{ca} + (F_b + F_{cv})\cos(\zeta) + (F_s - F_p)\sin(\zeta)\}\sin(\alpha/2) + \{(F_s - F_p)\cos(\zeta) - (F_b + F_{cv})\sin(\zeta)\}\cos(\alpha/2)}{2\sin(\alpha)}$$

$$F_2 = \frac{\{2F_{ca} + (F_b + F_{cv})\cos(\zeta) + (F_s - F_p)\sin(\zeta)\}\sin(\alpha/2) - \{(F_s - F_p)\cos(\zeta) - (F_b + F_{cv})\sin(\zeta)\}\cos(\alpha/2)}{2\sin(\alpha)}$$

Fig.8 Calculation model of the stability of the vane-guide



Load applied on vane-guide

*Under specific operating conditions
(evaporation temperature 52°C, condensation temperature 5°C)

Fig.9 Characteristics with respect to rotation angle

5. CONCLUSIONS

■ A new "wing-vane compressor" which has no contact between the vane and cylinder has been developed to prevent an increase in size without performance degradation.

■ The characteristics of the compression process, torque, and rotor load, are almost the same as the sliding-vane type.

■ Lubrication of the newly added vane-guide is important to ensure reliability.

Next Presentation

Part 2:
Lubrication Characteristic of The Partial Arc Guide Bearing

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