Development of Scroll Compressor for 16HP VRF System

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1. Introduction
   1.1. VRF System Line-up
   1.2. Problem for Expanding Stroke Volume
2. Improvement for Expanding Stroke Volume
   2.1. Our Scroll Compressor
   2.2. Keeping Oil Circulation Technology
   2.3. “Nano-grinding” Machining
   2.4. New Oil Supply Structure
   2.5. Performance for 16HP System
3. Conclusion
1. Introduction

1.1. VRF System Line-up

Usage example

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Limit of 1 comp.  →  Multiple compressors
1. Introduction

1.1. VRF System Line-up

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- Usage of multiple compressors has some problem
  - Complicate controlling circuit and each compressors
  - Difficult to reduce cost
## 1. Introduction

### 1.1. VRF System Line-up

#### Usage example

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**Expanding Stroke Volume**
### 1. Introduction

#### 1.1. VRF System Line-up

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*Expanding Stroke Volume*

*Our compressor can cover up to 16HP with one compressor*
1. Introduction

1.2. Problem for Expanding Stroke Volume

(1) Difficult to keep reliability at the shaft and the bearing for expanding stroke volume

2.2. “Nano-grinding” Machining

(2) Difficult to keep oil circulation because of expanding stroke volume

2.3. Keeping Oil Circulation Technology

(3) Need to operate at wide range by 1 compressor. (Not only high capacity operation but also low capacity operation)

2.4. New Oil Supply Structure
2. Improvement for Expanding Stroke Volume

2.1. Our Scroll Compressor

Compression chamber

Compliance Structure

Motor section

Gas flow
2. Improvement for Expanding Stroke Volume

2.1. Our Scroll Compressor

- **Compliance Structure**
- **Compression chamber**
- **Motor section**
- **Gas flow**

- Pm1
- Pm2
2. Improvement for Expanding Stroke Volume

2.1. Our Scroll Compressor

- Compression chamber
- Compliance Structure
- Motor section
- Gas flow

Sealed by Contact Force by Pm1 ⇒ Minimize Leak loss
2. Improvement for Expanding Stroke Volume

2.1. Our Scroll Compressor

Compression chamber

Compliance Structure

Motor section

Gas flow

Thrust Cancel Force by Pm2

⇒ Minimize Thrust friction loss
2. Improvement for Expanding Stroke Volume

2.2. “Nano-grinding” Machining

Crankshaft is forced by gas compression load.

Load on Crank Shaft

- Compression chamber
- Crankshaft

Load increases 30% by Vst expansion

Comparison between 10HP model and New 16HP model.
2. Improvement for Expanding Stroke Volume

2.2. “Nano-grinding” Machining

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**Surface Roughness**
- **Conventional**: Load concentrates on projection.
- **Nano-grinding**: Load doesn’t concentrate by projection removal.

**Load Concentration**
- Load concentrates on projection.
- Load doesn’t concentrate by projection removal.
2. Improvement for Expanding Stroke Volume

2.2. “Nano-grinding” Machining

Effect for reliability against load

Improvement of critical load against bearing scuff by 50% can cover increase of load on Crankshaft by 30%
2. Improvement for Expanding Stroke Volume

2.3. Keeping Oil Circulation Technology

- Conventional Structure
- Mechanical Section
- Stator
- Rotor
- Gas Flow Analysis
- Balance Weight
2.3. Keeping Oil Circulation Technology

- Conventional Structure
- Mechanical Section
  - Stator
  - Rotor
- Flow velocity is very high
- Balance Weight

Gas Flow Analysis

Gas flow
2.3. Keeping Oil Circulation Technology

Conventional Structure

Mechanical Section
- Stator
- Rotor

Flow velocity is very high

Balance Weight

Oil is agitated by Balance Weight

Gas flow

Improvement for Expanding Stroke Volume
2. Improvement for Expanding Stroke Volume

2.3. Keeping Oil Circulation Technology

- New Structure
- Mechanical Section
  - Stator
  - Rotor
- Balance Weight
- Additional Cup

Gas Flow Analysis

[Diagram showing flow analysis with vectors and velocity scale]
2.3. Keeping Oil Circulation Technology

- New Structure
- Mechanical Section
  - Stator
  - Rotor
  - Balance Weight
- Flow velocity become low
- Additional Cup
- Gas Flow Analysis

Oil is agitated by Balance Weight. Flow velocity become low.
2. Improvement for Expanding Stroke Volume

2.3. Keeping Oil Circulation Technology

- New Structure
- Mechanical Section
  - Stator
  - Rotor
- Balance Weight
- Flow velocity become low
- Additional Cup
- Oil can be kept

Gas Flow Analysis

Oil is agitated by Balance Weight.
Flow velocity become low.
Oil can be kept.
2. Improvement for Expanding Stroke Volume

2.3. Keeping Oil Circulation Technology

Effect for Reduction of Oil Circulation

At the Compressor Starting

- Without Oil circulation
- With Oil circulation (Reduction ratio)

At Rated Operation

- Without Oil circulation
- With Oil circulation (Reduction ratio)

Keeping oil level technology is effective to oil circulation
2. Improvement for Expanding Stroke Volume

2.4. New Oil Supply Structure

Conventional Structure
2. Improvement for Expanding Stroke Volume

2.4. New Oil Supply Structure

Conventional Structure

Pm2 is controlled by spring force

\[ Pm2 = Ps + \alpha \]  \( (\alpha : \text{Spring Force}) \)
2. Improvement for Expanding Stroke Volume

2.4. New Oil Supply Structure

Conventional Structure

Oil is supplied by $\Delta P$

$\Delta P = P_d - P_{m2}$
2.4. New Oil Supply Structure

Conventional Structure

Allowable Operating Area

This limitation is decided by $\Delta P = P_d - P_{m2}$
2. Improvement for Expanding Stroke Volume

2.4. New Oil Supply Structure

New Structure

Intermittent opening hole was added
2. Improvement for Expanding Stroke Volume

2.4. New Oil Supply Structure

Effect for oil supply with new structure

Allowable operating area can be expanded by New Oil Supply Structure
2. Improvement for Expanding Stroke Volume

2.5. Performance for 16HP system

- Inverter 1comp.
- Constant 1comp.

Efficiency

Cooling Capacity [HP]

- 55%
- 65%
- 75%
2. Improvement for Expanding Stroke Volume

2.5. Performance for 16HP system

Our compressor 1comp.:
- High efficiency
- Cover up to 16HP

![Graph showing efficiency versus cooling capacity for different compressor types.](image-url)
3. Conclusion

New compressor which can cover up to 16HP by 1 compressor was developed and anxious points against reliability was solved as below countermeasure.

1. By simulation of the gas and the oil flow in the compressor, optimal structure for keeping oil level in the compressor was designed and this structure can keep oil at actual operation.

2. By introduction of “Nano-grinding” machining technology, load limitation against bearing scuff is improved by 50% and durability of lubrication was kept.

3. By new oil supply structure, it could achieve lubrication reliability in lower pressure difference operation.