Noise Reduction for Oil Pump System of Linear Compressor

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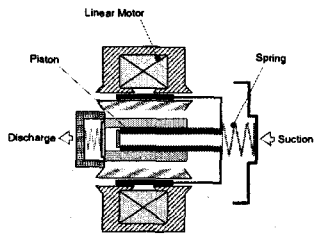
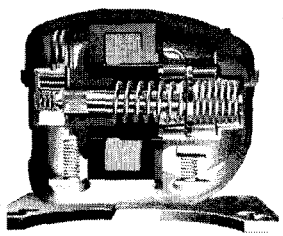
LG Electronics / Digital Appliance Lab.

Linear Compressor의 개요





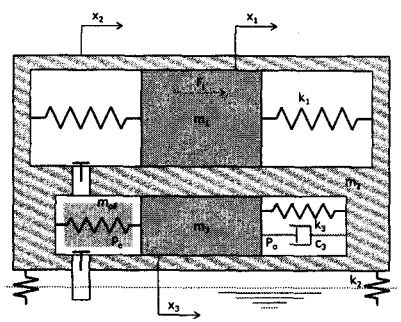
Characteristics

- Simple Configuration
- High Efficiency
- Easy to Use Various Refrigerant

Technology

- Free Piston Mechanism
- Oscillating Linear Motor
- Piston Stroke Control (sensorless)

Oil Pump System



[Linear Comp의 단순화 model]

Oil Pump System

Linear Comp의 단순화 model의 동역학적 운동 방정식은,

$$m_1\ddot{x}_1 + k_1(x_1 - x_2) = F_r \quad (1)$$

$$m_2\ddot{x}_2 + c_3(\dot{x}_2 - \dot{x}_3) + k_3(x_2 - x_3) = F_r \quad (2)$$

$$m_3\ddot{x}_3 + c_3(\dot{x}_3 - \dot{x}_2) + k_3(x_3 - x_2) = -A_3(P_c - P_o) \quad (3)$$

오일 공급에 영향을 주는 상대변위를 본체진동과 오일피스톤의 변위차이로 표시하면,

$$x = x_3 - x_2 \qquad m_3\ddot{x} + c_3\dot{x} + k_3x = -m_3\ddot{x}_2 - A_3(P_c - P_o)$$

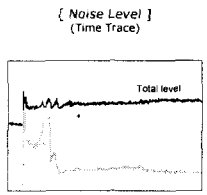
여기서,

$$c_3 = \mu\frac{\pi D_3 L_{oil\_piston}}{c_{p\_oil}} \qquad A_3(P_c - P_o) = m_{oil}\ddot{x}$$

오일피스톤의 변위가 조화가진 운동을 한다고 가정하면, $x = Xe^{i\omega_n t}$

$$X(\omega_n) = \frac{m_3\omega_n^2 X_2}{(m_3 + m_{oil})(\omega_n^2 - \omega_e^2 + jc_3\omega_n/(m_3 + m_{oil}))} = \frac{m_3}{m_3 + m_{oil}}\frac{1}{\sqrt{(r^2-1)^2 + (2\zeta r)^2}}X_2$$

Oil 소음 현상



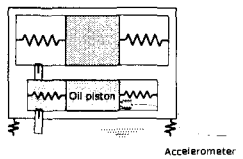
Oil을 통한 전달음

Oil contact
교반 소음

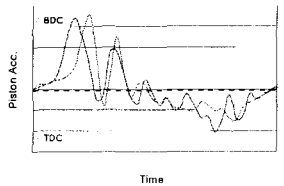
Oil path 유동음

Oil flow
cavitation 소음

Oil Piston의 거동 측정

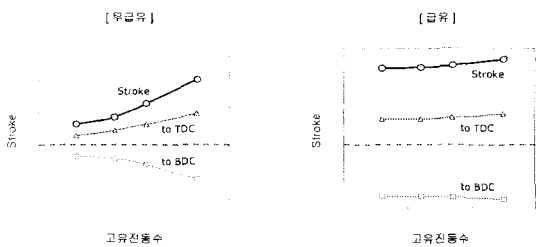


[Oil piston 거동측정 방법]



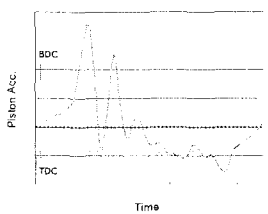
[운전중 Oil piston 거동]

Oil Piston의 거동 측정

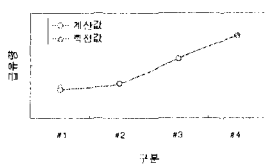


[급유 상태별 Oil piston 거동]

Oil Pump의 급유량 예측

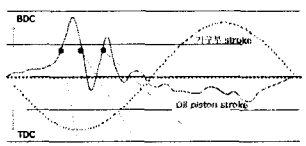


[유효 급유 형정]



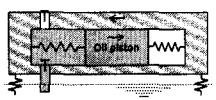
[급유량 예측]

Oil Pump의 Mechanism

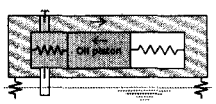


Backward force	piston & oil 관성력	d/valve 복원력	d/valve & spring 복원력
Forward force	s/valve & spring 복원력	Spring 복원력	piston & oil 관성력
Piston 거동	흡입	급유(토출)	흡입

흡입 과정



급유 과정



[Oil 흡입 및 급유 과정]

Oil 소음의 개선

Linear compressor의 oil system에서 소음에 영향을 미치는 인자를 분석하여 소음을 개선함.

1) Oil contact을 줄이는 설계가 필요함.

2) Oil path의 유로저항을 줄이는 설계가 필요함.

3) Oil의 유속을 줄이는 설계가 필요함.

4) 위에서 검토된 인자들을 종합적으로 적용한 결과 소음 수준 저감 효과를 얻음.