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Dynamic Behaviour of Valves with Pneumatic Chambers for Reciprocating Compressors (1st Report, Calculations)

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TITLE : Dynamic Behaviour of Valves with Pneumatic Chambers for Reciprocating Compressors (1 st Report, Calculations)[*1]

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ABSTRACT :

Valves with pneumatic chambers for reciprocating compressors are known as "damped valves" (ref; Fig.1 and Fig.2). These are capable of reducing hard impact force on the valve seat and valve stopper, which is one of the causes of damage to the valve plates and valve springs. Because of merits like this, damped valves are widely used. However, the specifications of the damped valves have been empirically decided, and their dynamic behaviour has not been examined in detail in a theoretical study.

This paper describes the dynamic behaviour of valves with pneumatic chambers for reciprocating compressors. The characteristics of the dynamic behaviour of the damped valves were clarified by calculating nowly deribed governing equations of valves dynamics, including the characteristics of the pneumatic chambers. The equations of pressure fluctuation at both sides of the valves are based on Costagliola's[1] processes, which applied one-dimensional compressible flow in a nozzle. Futhermore, we derived the following term and equations;

(1) the term for pre load of the valve spring.
(2) the equation of gas pressure fluctuation in pneumatic chambers.
(3) the equation of gas pressure fluctuation which can be also applied when pressure pulsations exist on the discharge side or suction side.
(4) the equation of gas pressure fluctuation when the gas flows backward.

*1 Valve Dynamics, Reciprocating Compressor
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The valve behaviour was calculated by using the Runge-Kutta-Gill method, and studied by changing variables such as the volume of the pneumatic chambers, the clearance between the pneumatic chamber and the valve plate, compressor speed, gas density, the stiffness of the valve spring, and the valve lift.

From the calculated results, the following become apparent;

(1) the volume of the pneumatic chambers and the clearance between the pneumatic chamber and the valve plate have a large influence on the impact speed of the valve (ref; Fig.3, Fig.4, Table 1 and Table 2).

(2) the valves tend to close later for a higher compressor speed and to oscillate at a larger amplitude for a lower density of gas, such as hydrogen. Therefore, the valve specifications, such as the stiffness of the valve spring and the valve lift, must be carefully chosen.

This method has wide application, since the dynamic behaviour of valves without pneumatic chambers can be also calculated.

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1) Costagliola, M., Trans. ASME, J. Appl. Mech., (1950), 17, No.4, 415

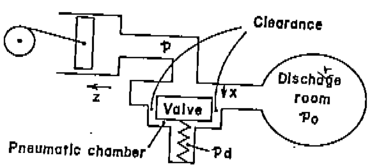

Fig. 1 Discharge valve

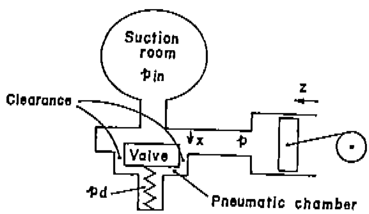

Fig. 2 Suction valve

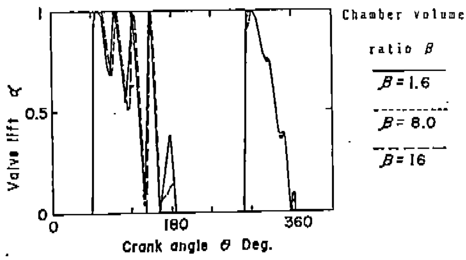

Fig. 3 Valve displacements
(influence of chamber volume)

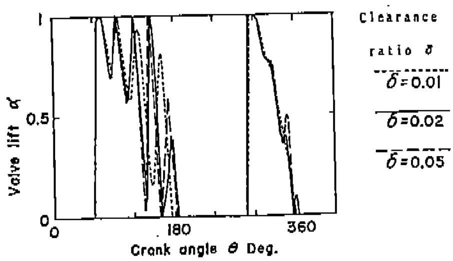

Fig. 4 Valve displacements
(influence of clearance)

Table 2 Impact speed of valves
(influence of clearance)

Clearance ratio δ	Impact speed cm／s	
	Dis. valve	Suc. valve
0.01	85.8	82.3
0.02	145.4	131.6
0.05	215.3	166.9

Table 1 Impact speed of valves
(influence of chamber volume)

Chamber volume ratio β	Impact speed cm／s	
	Dis. valve	Suc. valve
1.6	145.4	131.6
8	169.9	151.5
16	189.8	171.6