西安交通大學
XI'AN JIAOTONG UNIVERSITY

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2016 Purdue Conferences
Compressor Engineering
Refrigeration and Air Conditioning
High Performance Buildings

Study of Valve Motion in Reciprocating Refrigerator Compressors Based on the 3-D Fluid-Structure Interaction Model

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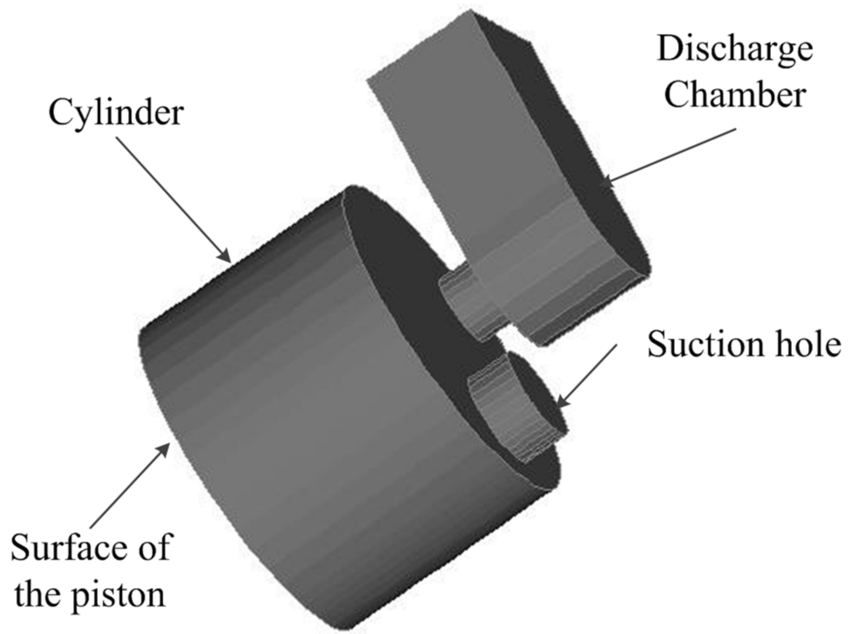
contents

1. Introduction

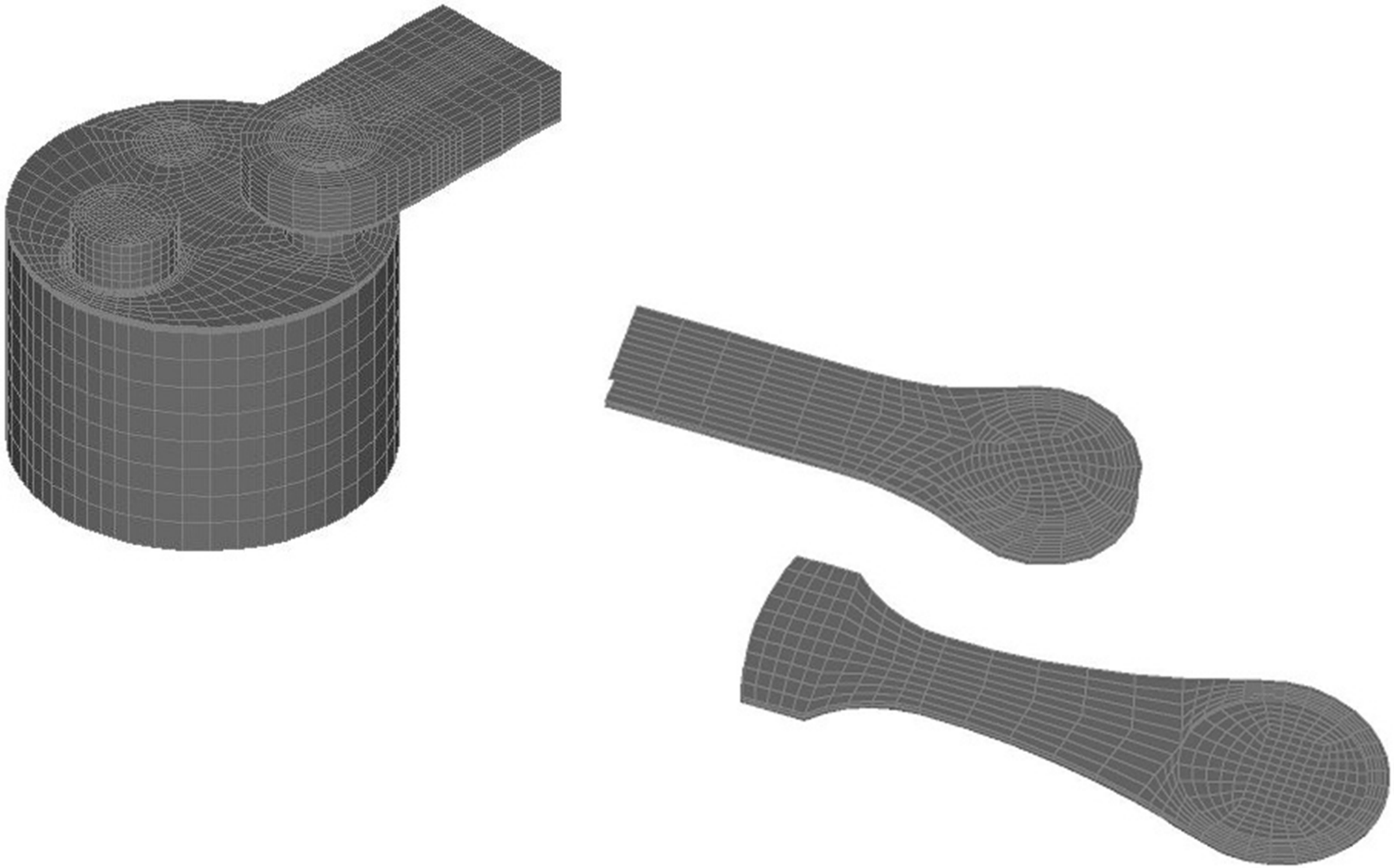
- The valves in a reciprocating compressor are main factor affecting the efficiency, reliability and noise
- Existing parameter model and one-dimensional method fails to predict the detail of the motion and deformation of the valve.
- 3-D fluid-structure interaction model is thus necessary

2. 3-D Fluid-Structure Interaction Model



Parameters	Value
Diameter of the cylinder/mm	31
Stroke/mm	24
Diameter of the suction valve hole/mm	8.2
Diameter of the discharge valve hole/mm	5.6

2. 1 Mesh

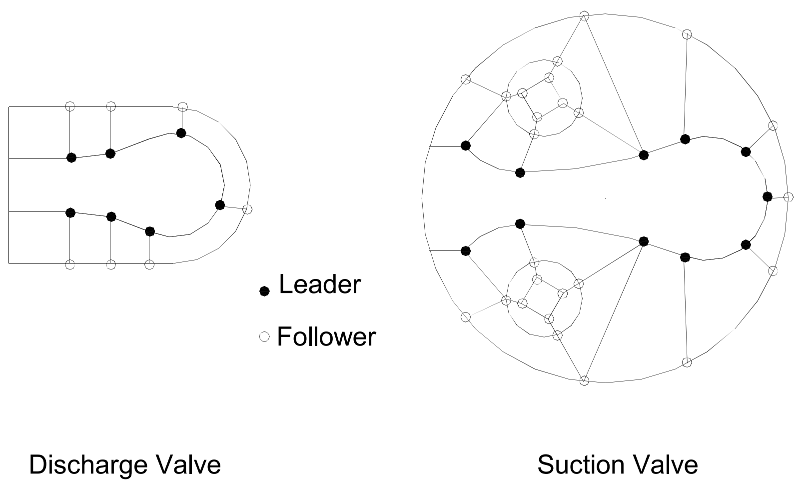


2.2 Boundary Conditions

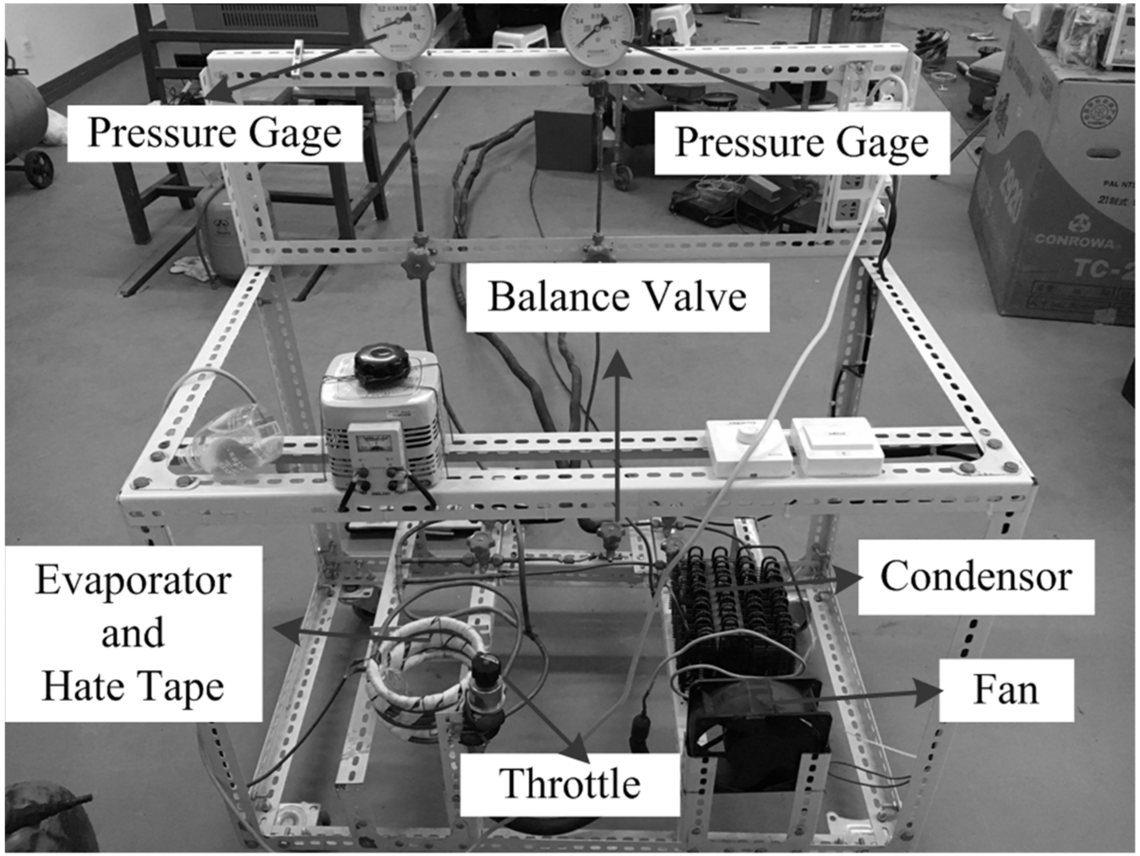
- The motion equation of the Eccentric installed piston

$$x = R[(1-\cos\alpha) + \frac{\lambda}{4}(1-\cos 2\alpha) - \lambda\eta\sin\alpha + \frac{\lambda^2\eta^2}{2(1+\lambda)}]$$

- Leader-follower condition of the valve

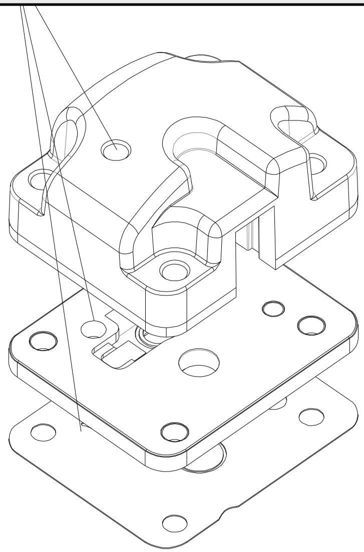


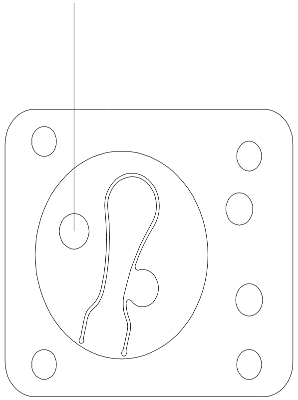
3. EXPERIMENTS



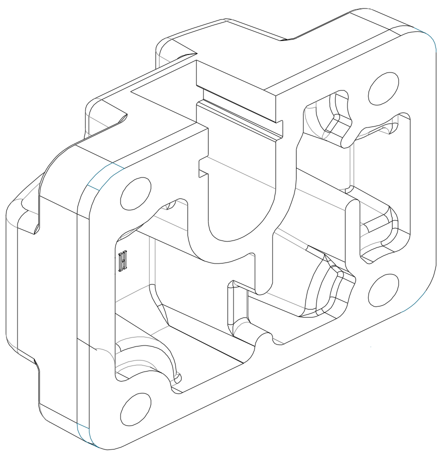
3.1 Installation of the pressure sensor

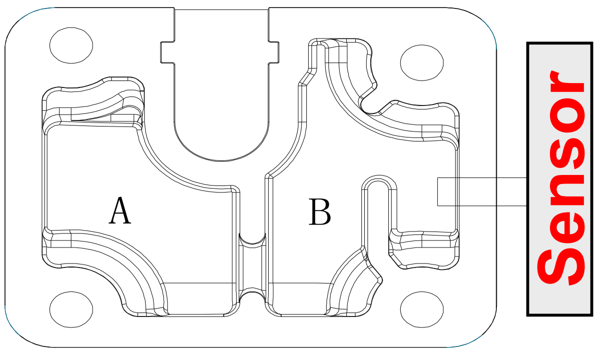
Pressure sensor hole



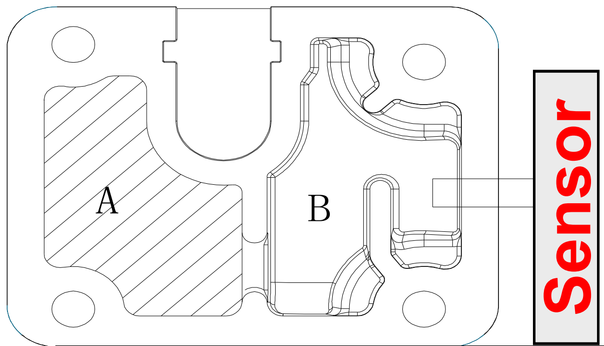


3.2 Testing the Installation of the pressure sensor



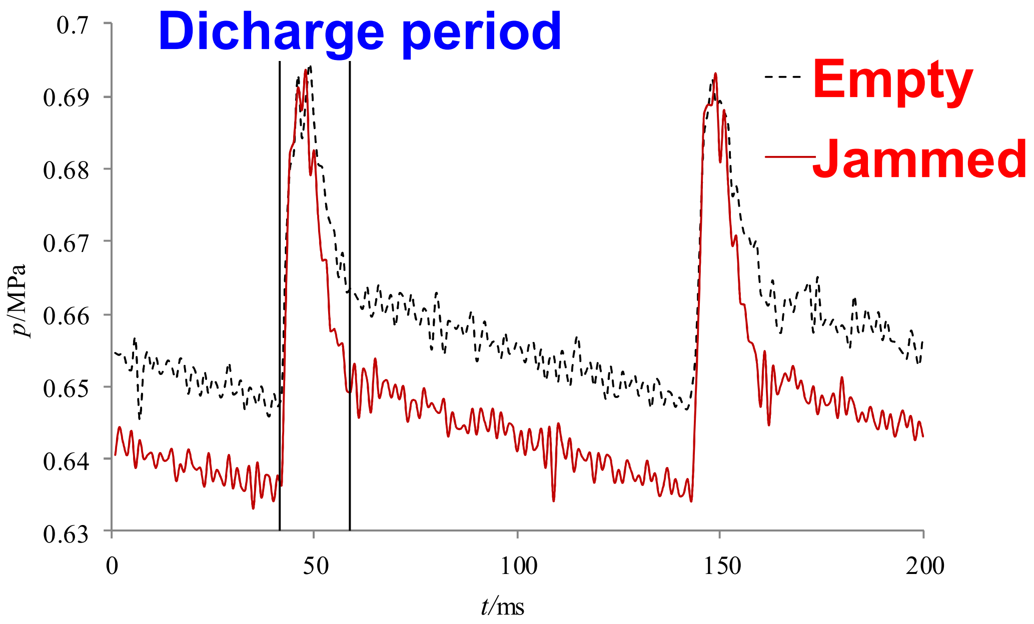


Empty Discharge chamber



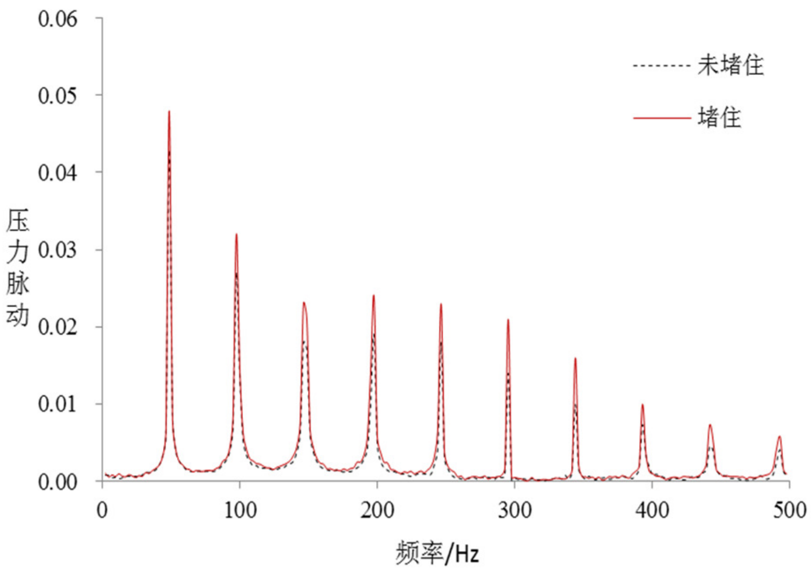
Jammed Discharge chamber

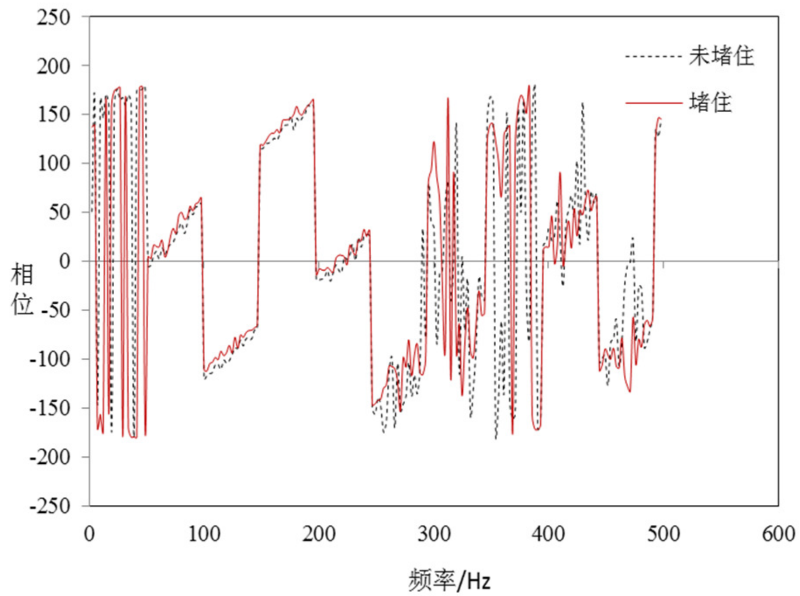
3.3 Pressure in Discharge chamber



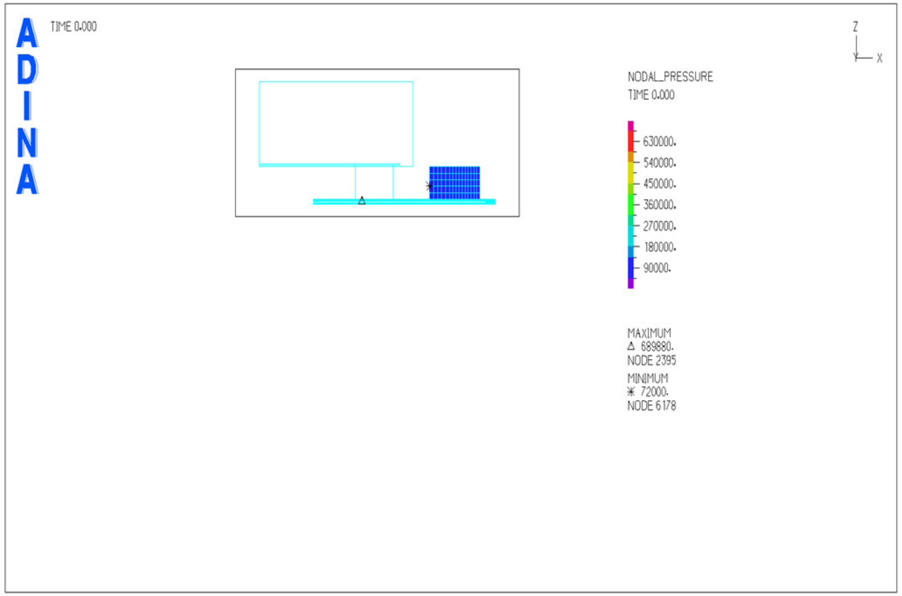
3.3 Pressure in Discharge chamber

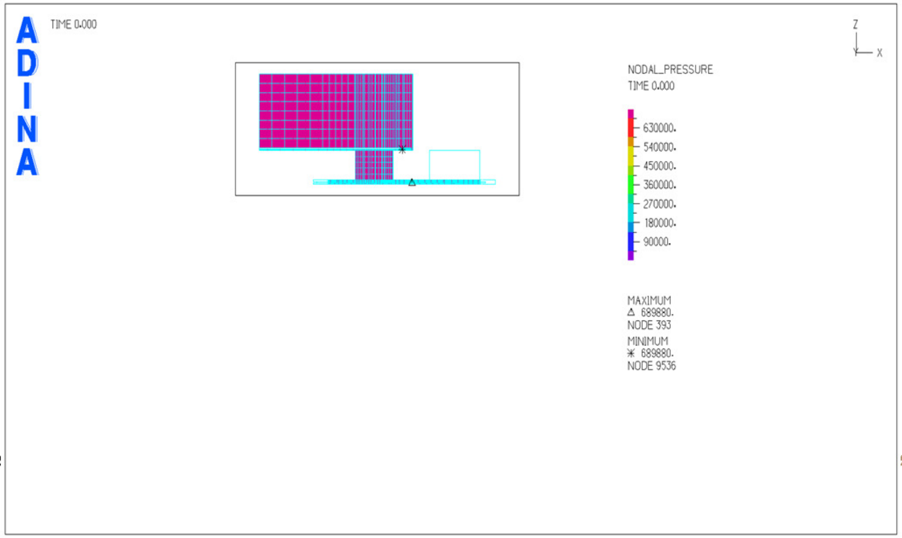
- pressure amplitude-frequency, phase-frequency characteristic analysis

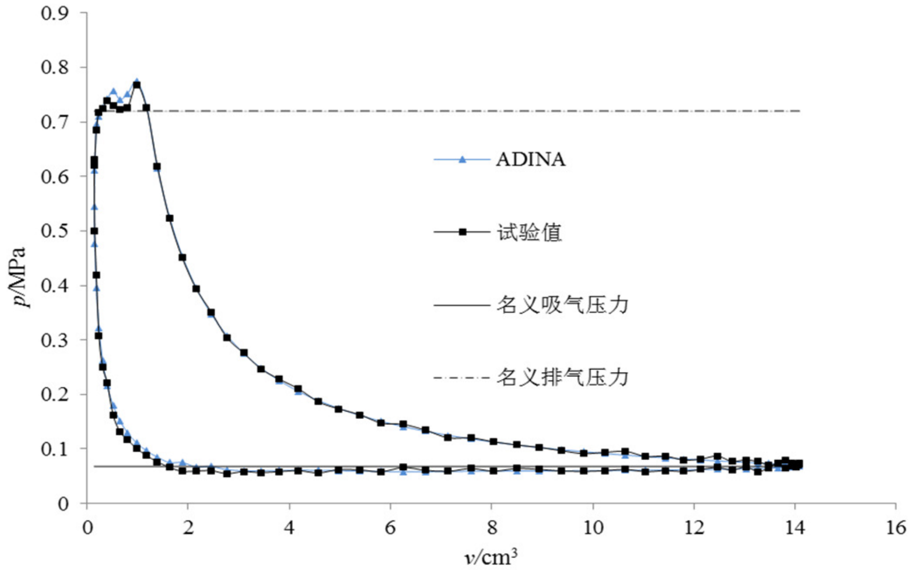




● 实验与模拟结果对比（P-V图）

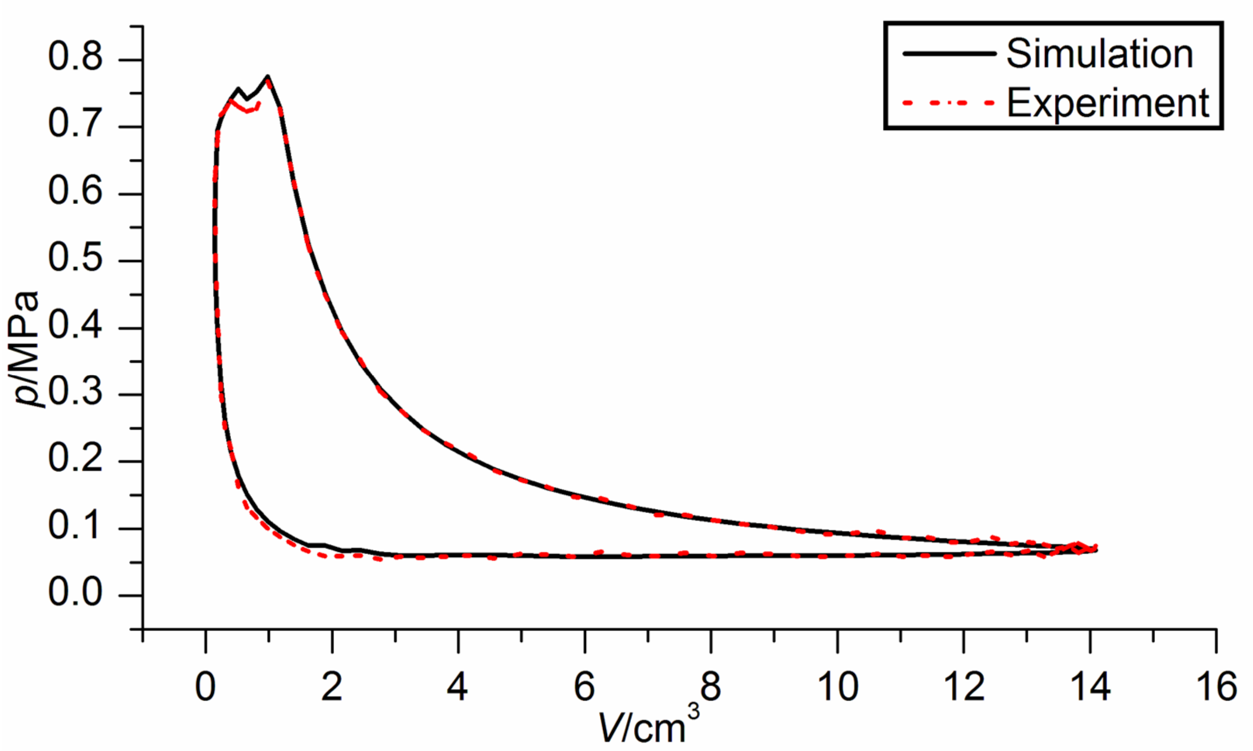




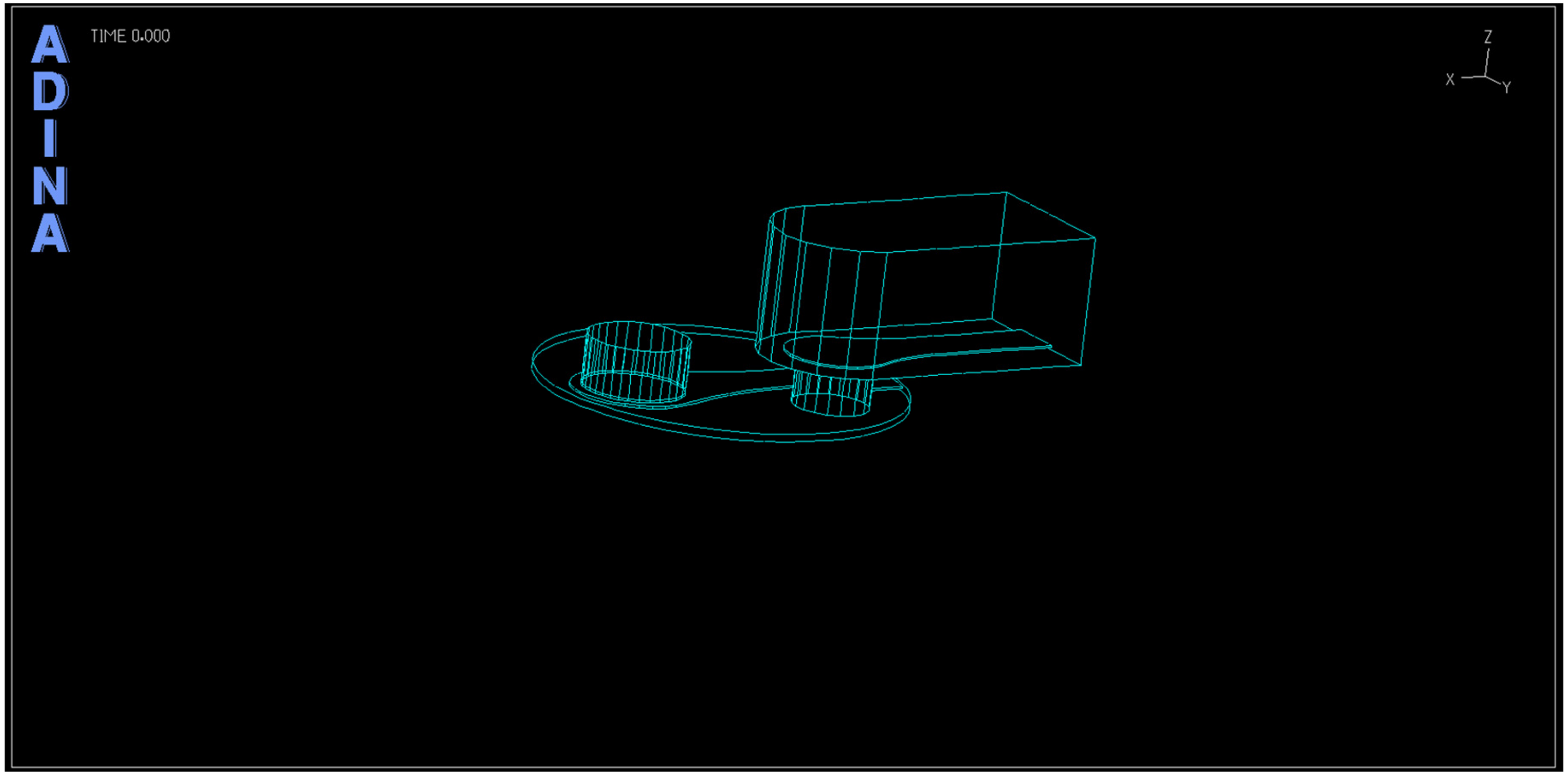


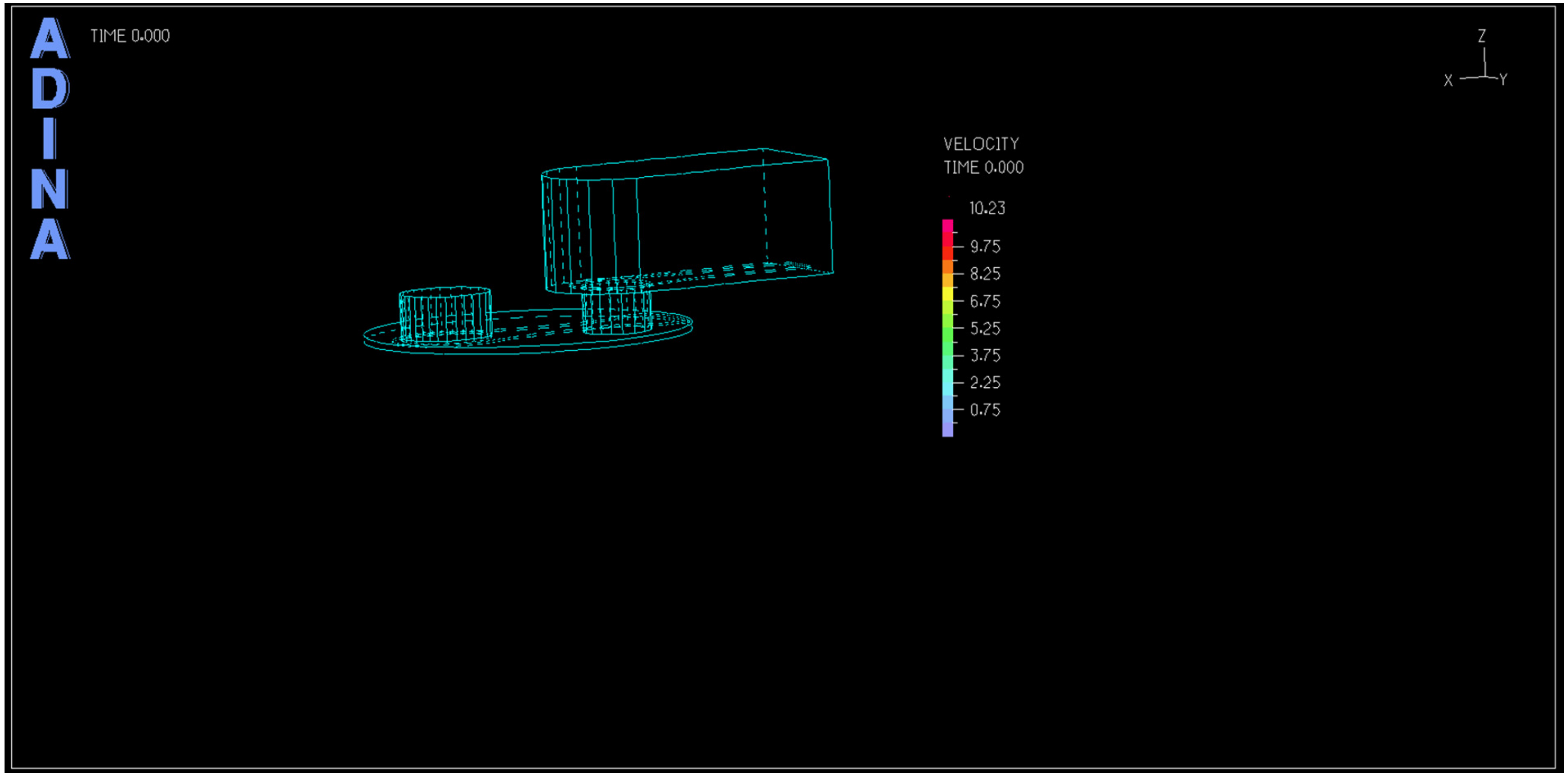
气体阻力损失	实验值	模拟值
进气阻力损失/MPa	0.013	0.010
排气阻力损失/MPa	0.054	0.063
指示功率/W	114.8	112.6

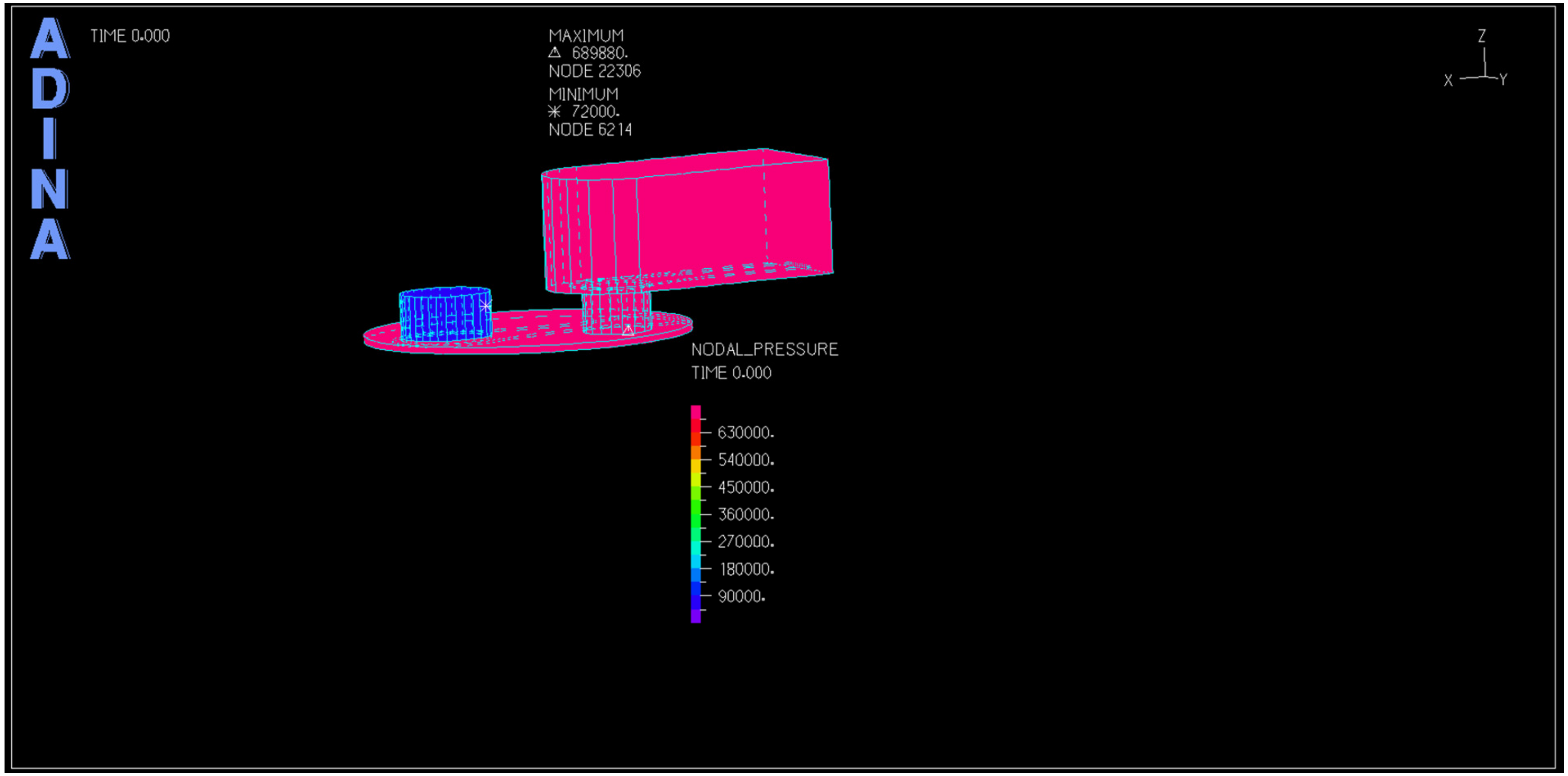
3.5 EXPERIMENTS RESULTS



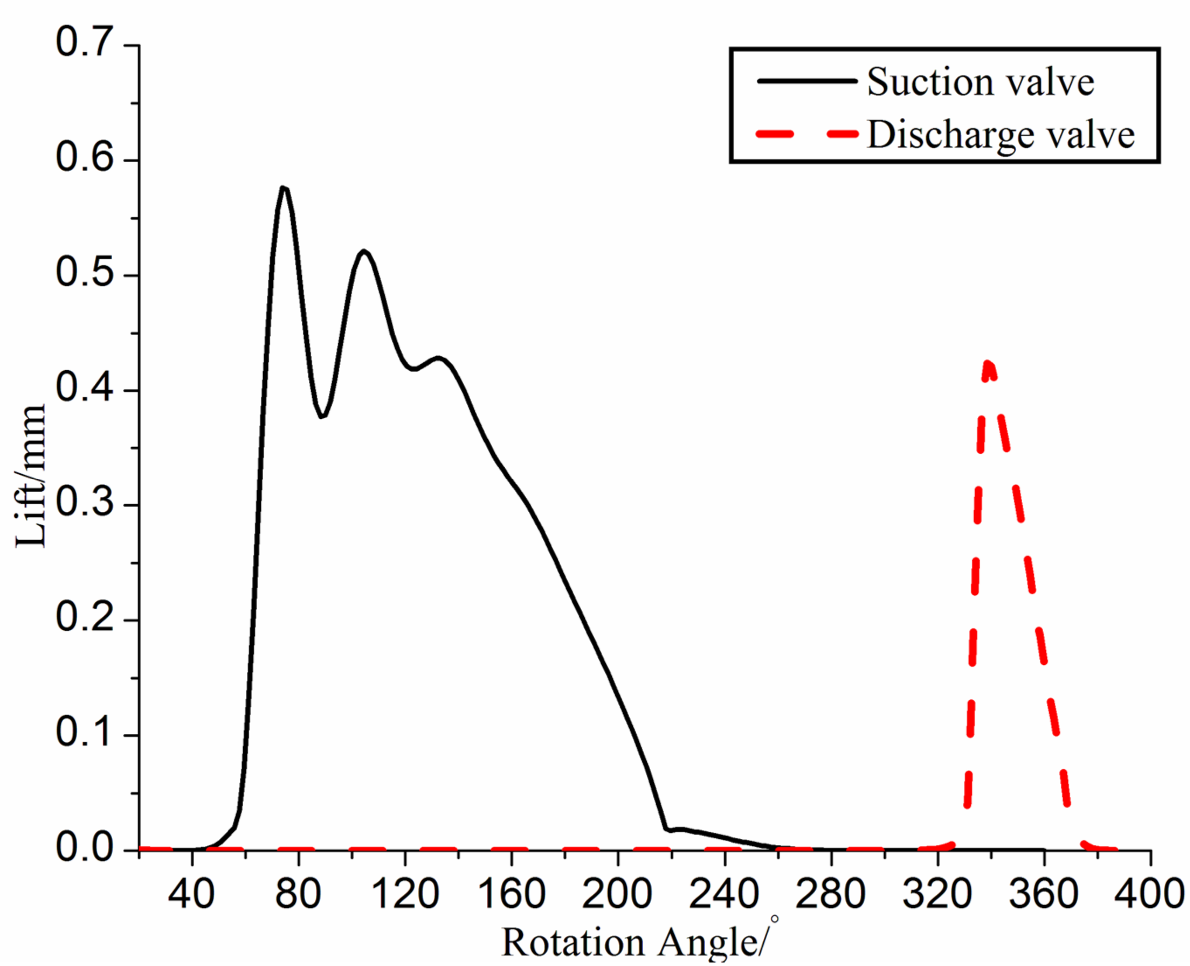
4 Simulation results of the valve motion




ADINA
TIME 0.000
Z
X
Y
VELOCITY
TIME 0.000
10.23
9.75
8.25
6.75
5.25
3.75
2.25
0.75

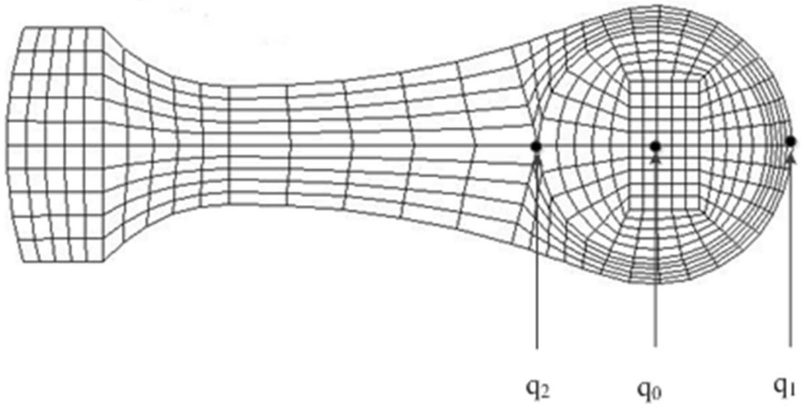

ADINA
TIME 0.000
MAXIMUM
△ 689880.
NODE 22306
MINIMUM
✳ 72000.
NODE 6214
Z
X
Y
NODAL_PRESSURE
TIME 0.000
630000.
540000.
450000.
360000.
270000.
180000.
90000.

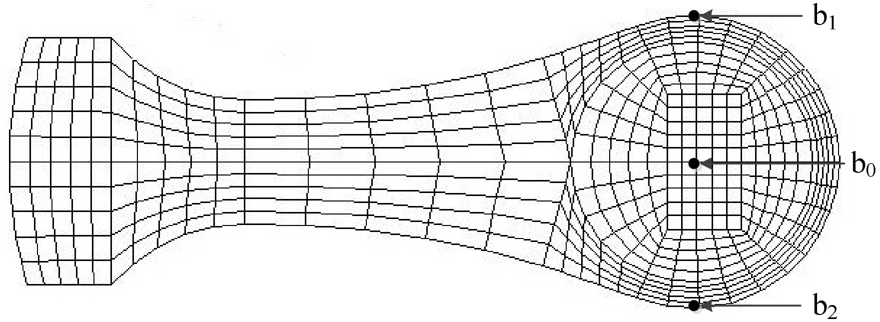
4 Simulation results of the valve motion

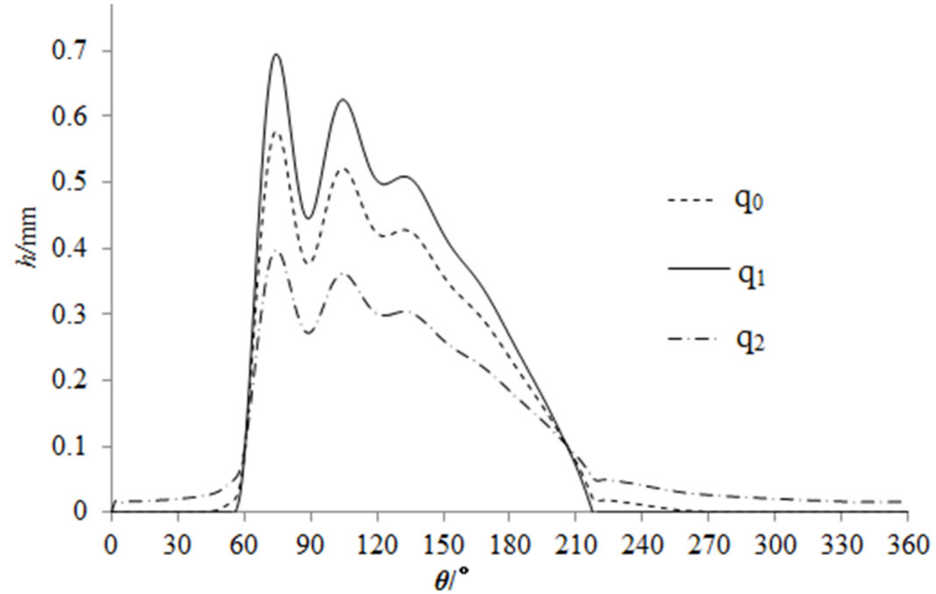


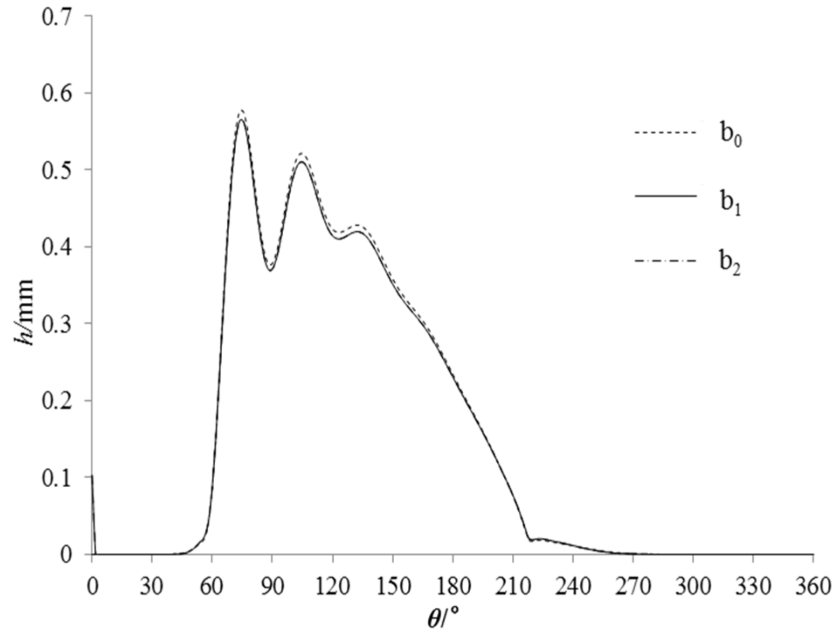
4.1 Motion of the suction valve

17:14

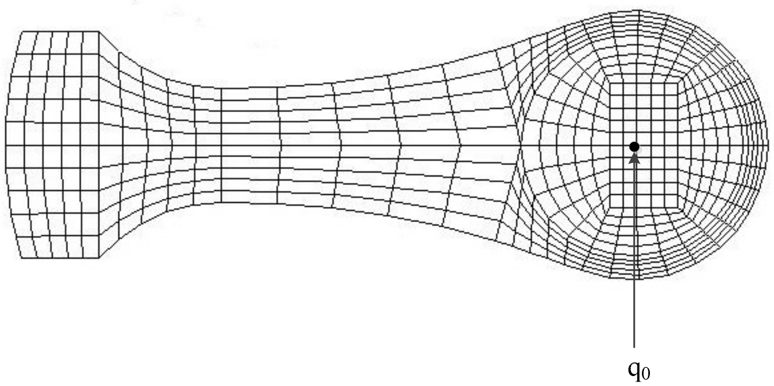


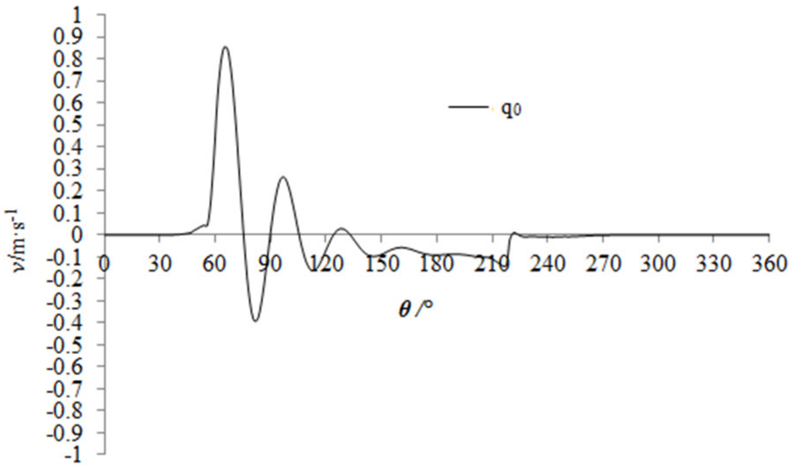






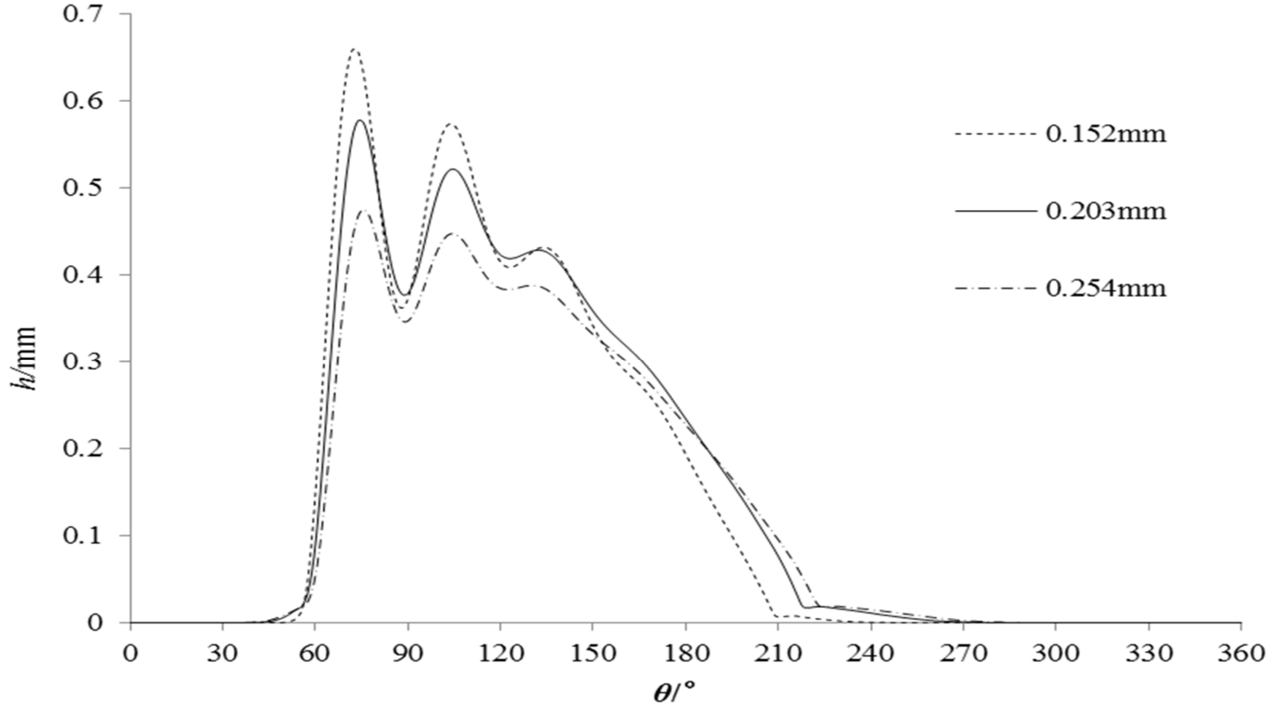
4.1 Motion of the suction valve





- Highest valve velocity is 0.85m/s。
- Valve impact velocity of the valve seat is0.2 m/s
- Valve motion frequency 250Hz。

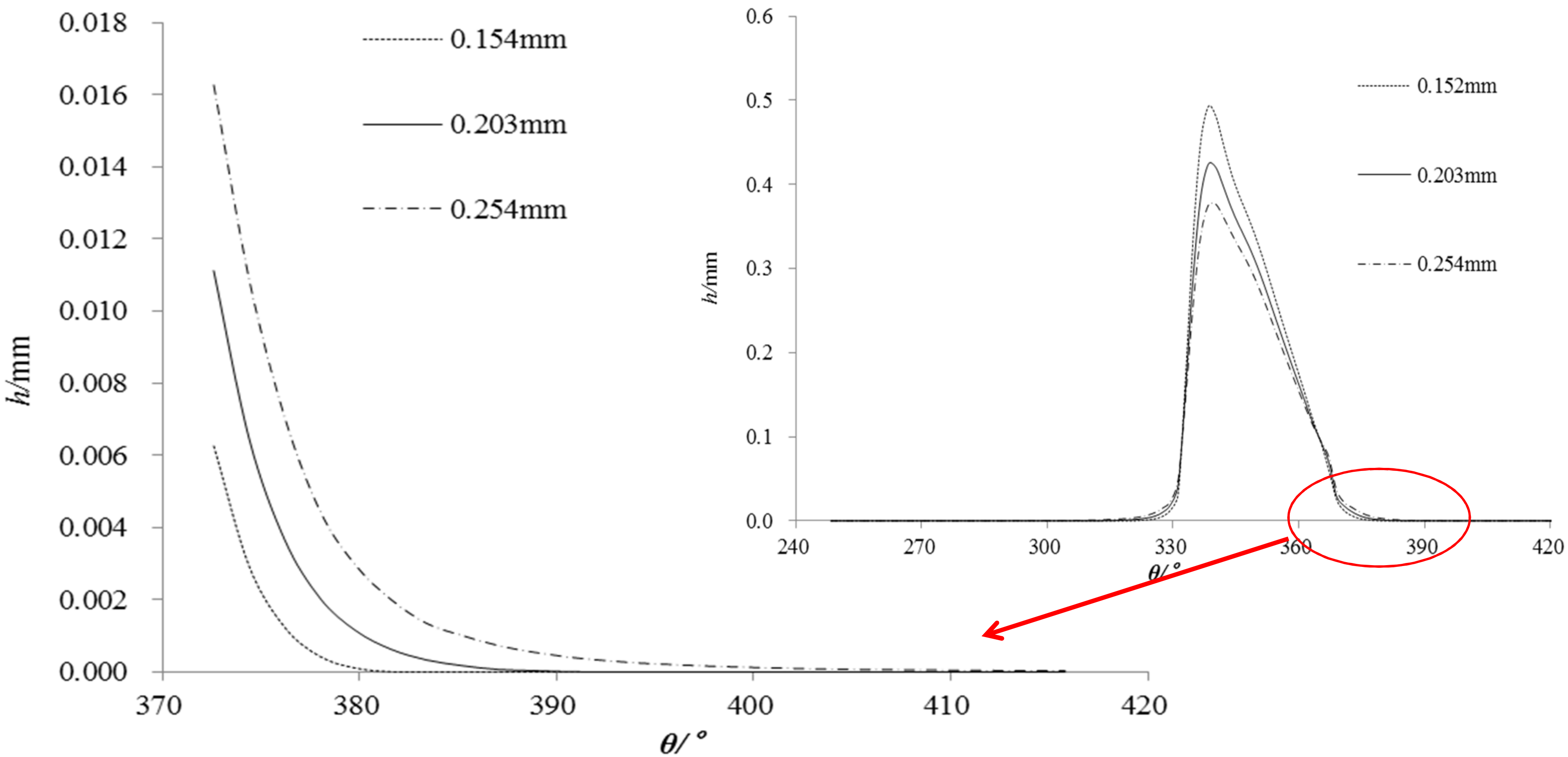
4.2 Motion of the suction valve with different thickness



- Opening angle are almost same;
- Thinner valve plate results in higher Lift, and small closure angle
- The closure angle is bigger for thick valve(more serious delayed effect)

Valve plate thickness /mm	0.152	0.203	0.254
Closure angle /°	203.4	214.2	219.6

4.3 Motion of the discharge valve



Valve thickness/mm	0.152	0.203	0.254
Closure angle /°	379.8	387.0	408.6

4.4 Reasons for the delayed closure

- The pressure difference acting on the valve plate is higher, which preventing the closing
- It is resulted by the smaller gas flow area during the suction and discharge process

5. Conclusions

- A three dimensional fluid-structure interaction model of small refrigerator reciprocating compressor was established, and validated by experiments
- Simulation of the valve motion showed that:
- increased thickness of the valve could result in increased delay of its closure.
- The lower lift of the thicker valve results in lower flow area, which leads to higher pressure difference preventing the valve closure.
- It is conflict to traditional prediction that thicker valve would results in advanced closure