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An investigation into the swash plate vibration and pressure pulsation of piston pumps based on full fluid-structure interactions

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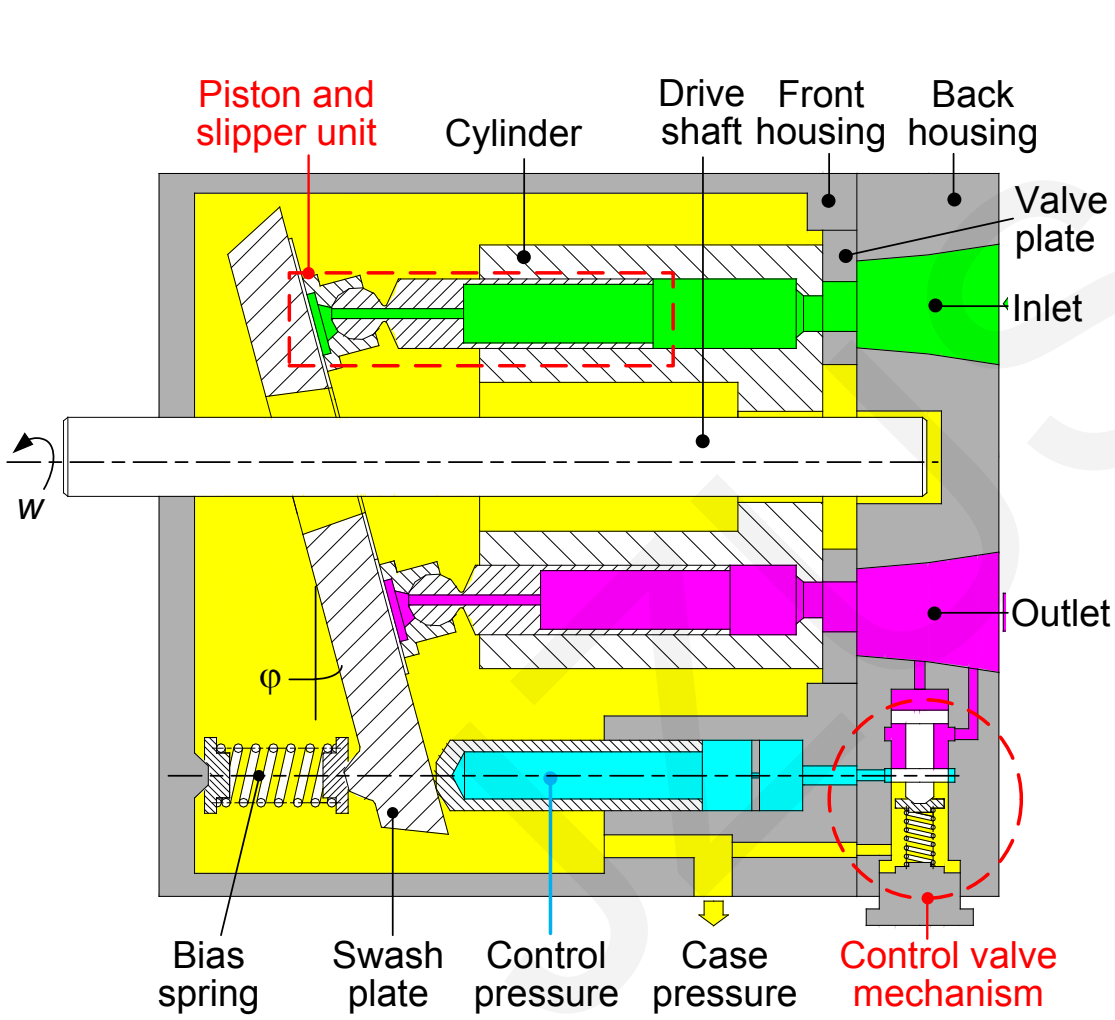
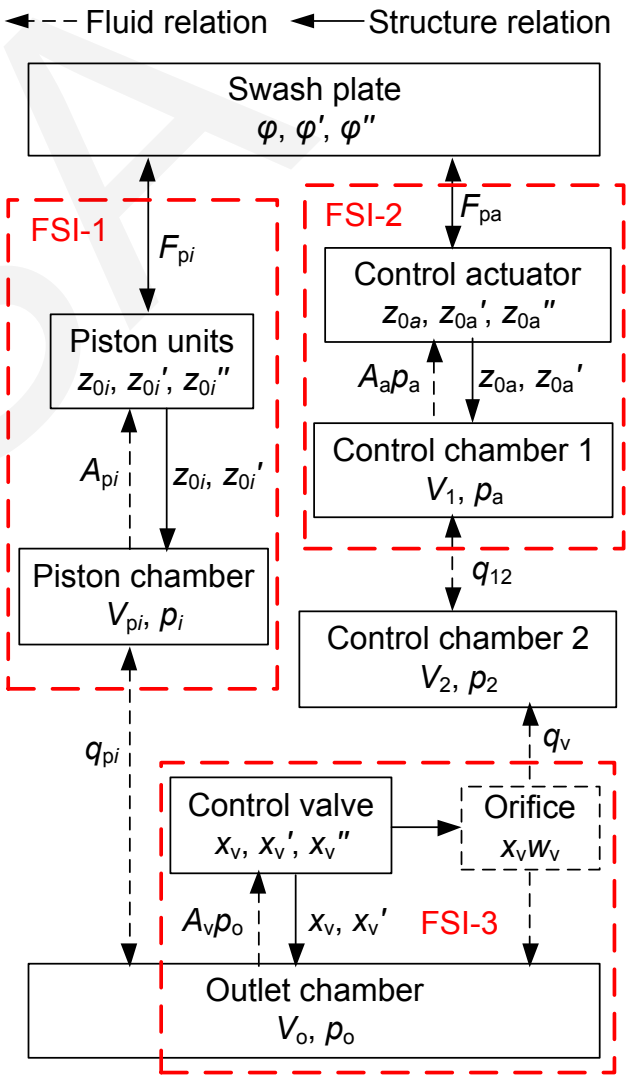
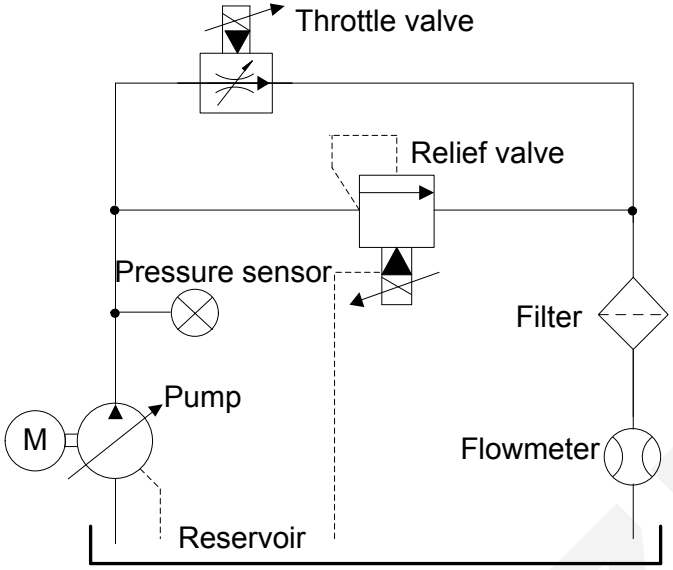
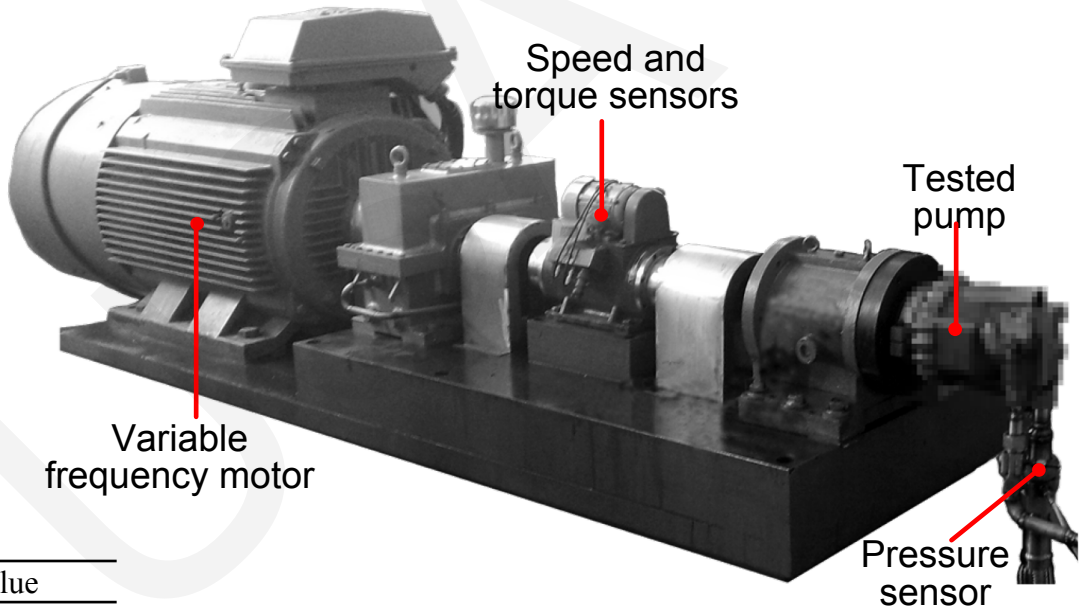
Theoretical Models





Test Rig and Parameters

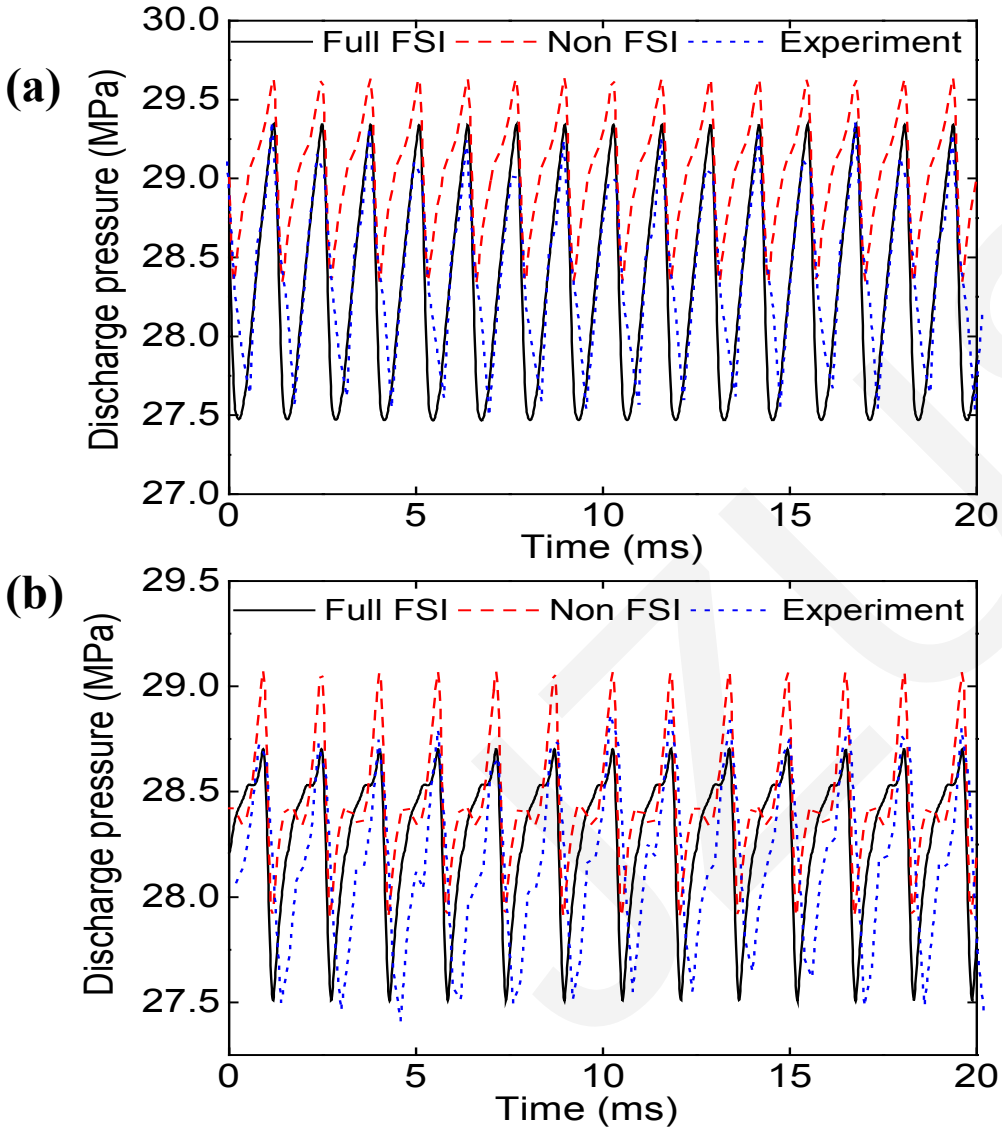


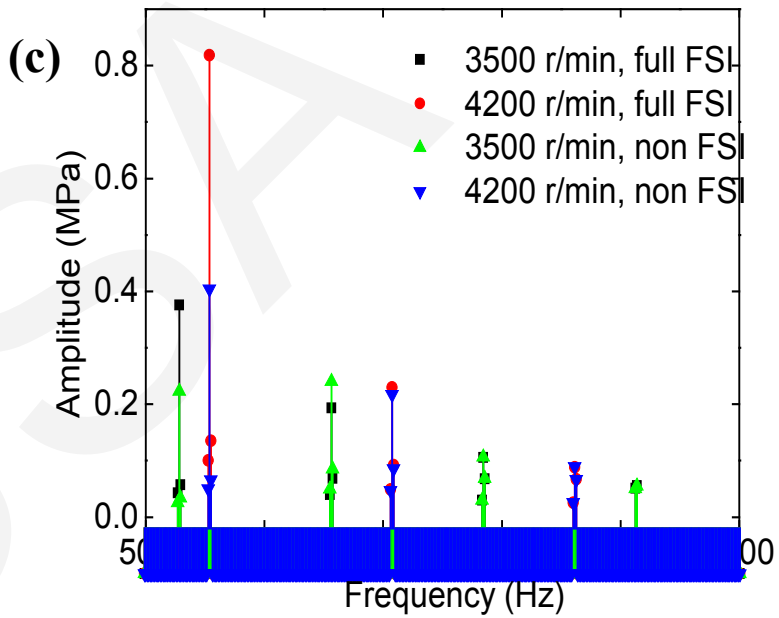


Parameter	Value
Pump	
Discharge pressure, p_o (MPa)	28
Rated speed range (r/min)	3000–4500
Piston diameter, d_p (mm)	19
Piston rotation radius, r_{pc} (mm)	45
Valve diameter, d_v (mm)	4.0
Valve spring stiffness, k_v (N/mm)	110
Valve spool mass, m_v (g)	5.5
Bias spring stiffness, k_b (N/mm)	17.0
Swash plate moment of inertia, J_s (kg·m^2)	0.0046

Parameter	Value
Test rig	
Inlet pressure (MPa)	0.5
Oil density, ρ (kg/m^3)	900
Oil bulk modulus, K (MPa)	1100
Oil temperature (° C)	40–50
Oil kinematic viscosity, v (m^2/s)	1.5×10^{-5}
Sampling frequency (Hz)	5000

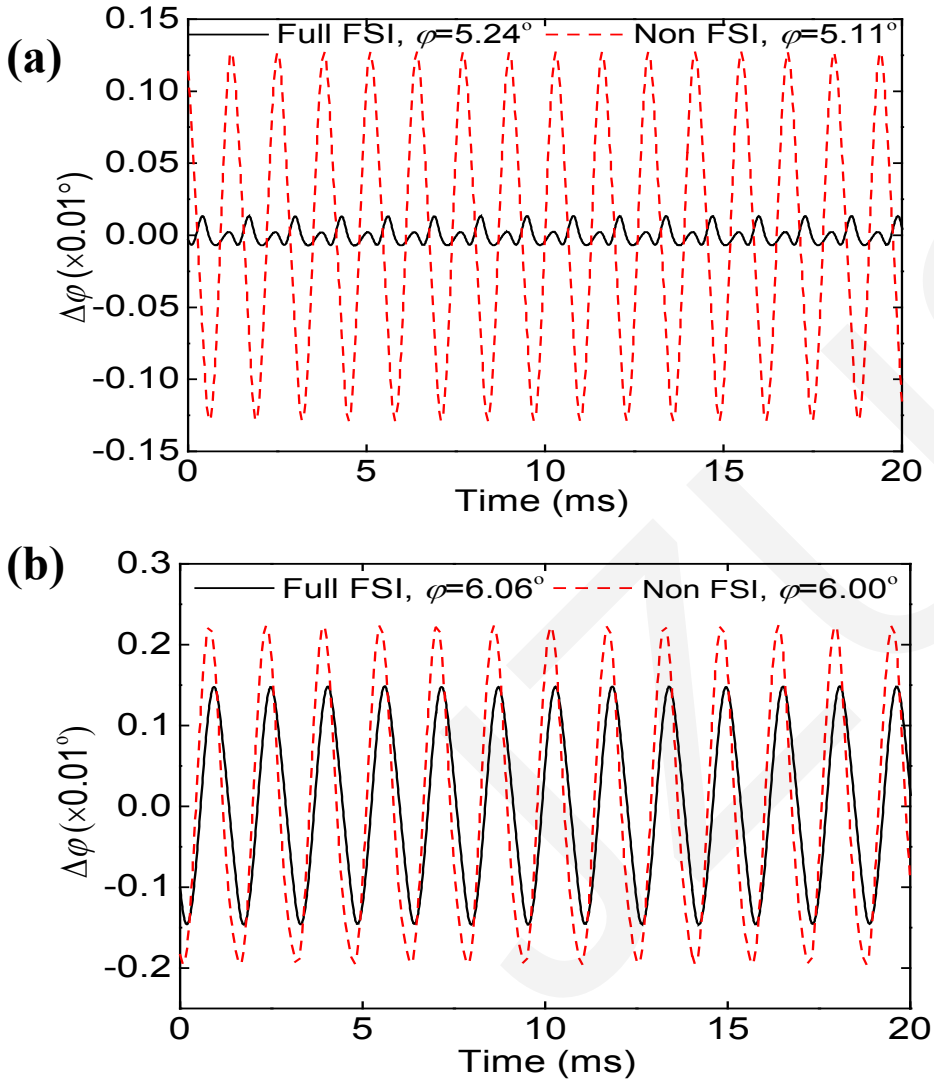
Results and Discussion

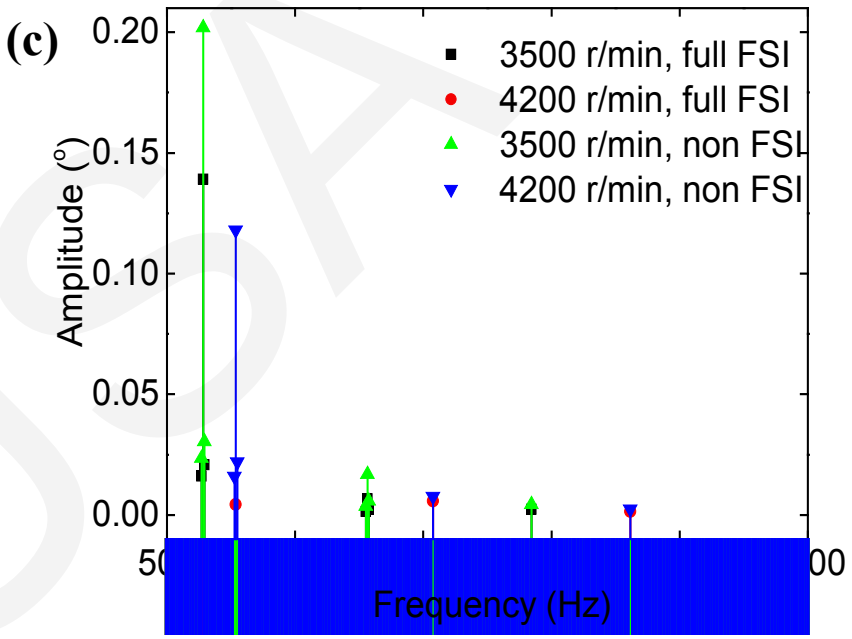




(a) The discharge pressure pulsation at 4200 r/min; (b) The discharge pressure pulsation at 3500 r/min; (c) The spectrum graph of the discharge pressure pulsation

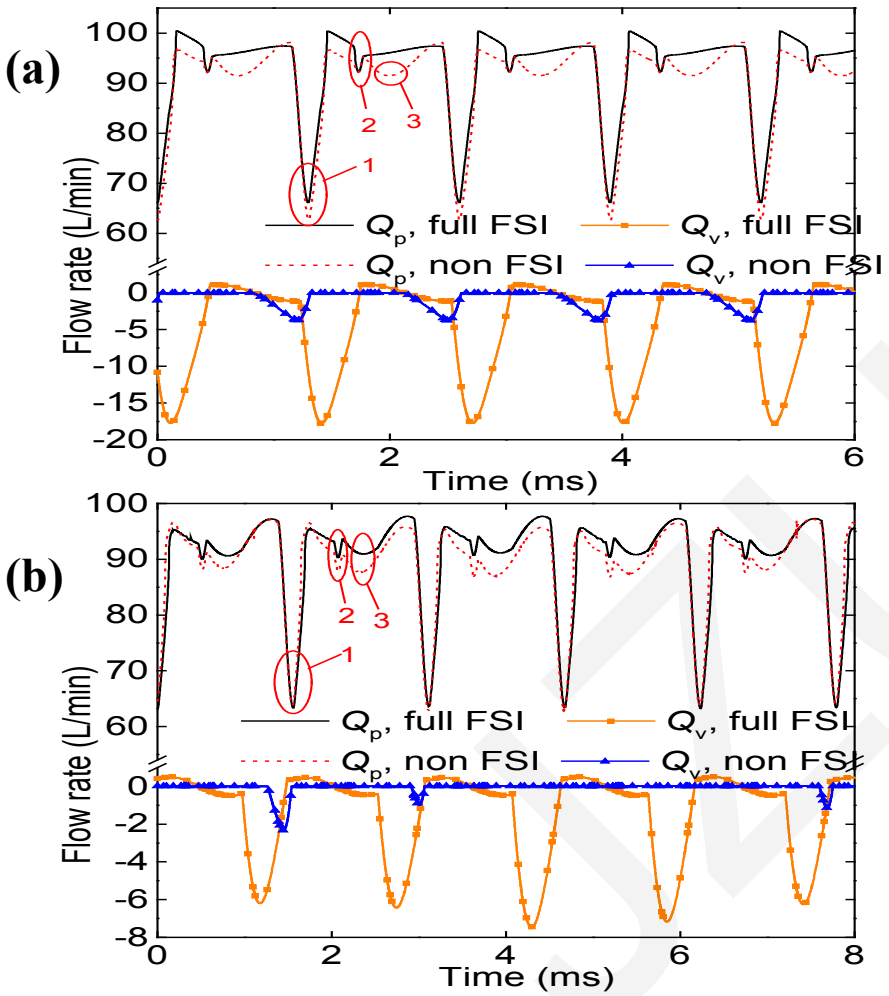
Results and Discussion



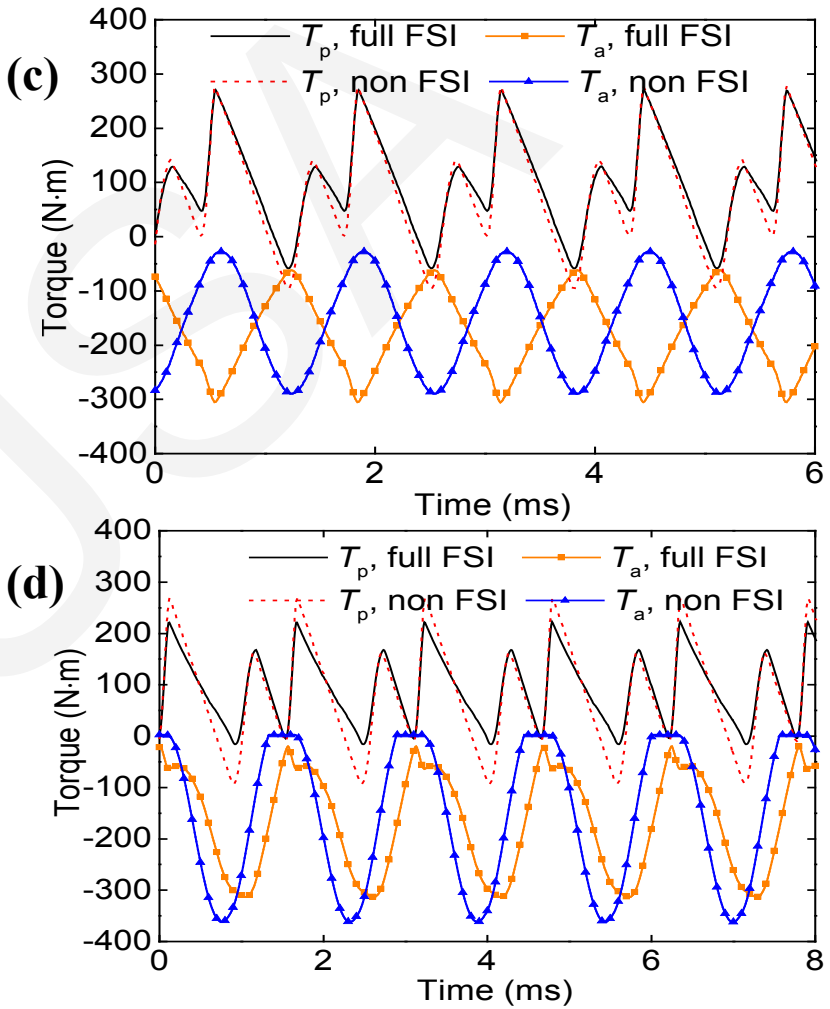


(a) The angle of the swash plate at 4200 r/min; (b) The angle of the swash plate at 3500 r/min; (c) The spectrum graph of the swash plate angle

Results and Discussion



Flow rate of the outlet chamber at the rotation speed of 4200 r/min (a) and 3500 r/min (b)



Torques on the swash plate at the rotation speed of 4200 r/min (c) and 3500 r/min (d)

Conclusions

- The full FSIs model is much more accurate in predicting the vibration of the swash plate and the pulsation of the discharge pressure than the non FSIs model.
- The swash plate vibration is strongly influenced by the pressure pulsation through the control actuator mechanism (FSI-2) and the control valve mechanism (FSI-3). The discharge pressure pulsation is mostly dictated by the kinematic relations of the piston slipper-shoe units (FSI-1), and is almost isolated from the swash plate vibration.