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Dynamic performance and control accuracy of a novel proportional valve with a switching technology-controlled pilot stage

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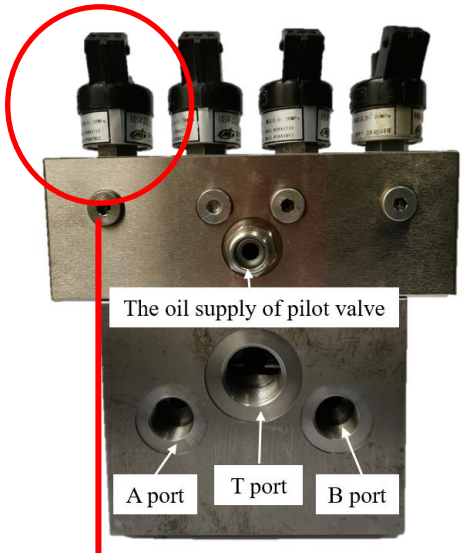
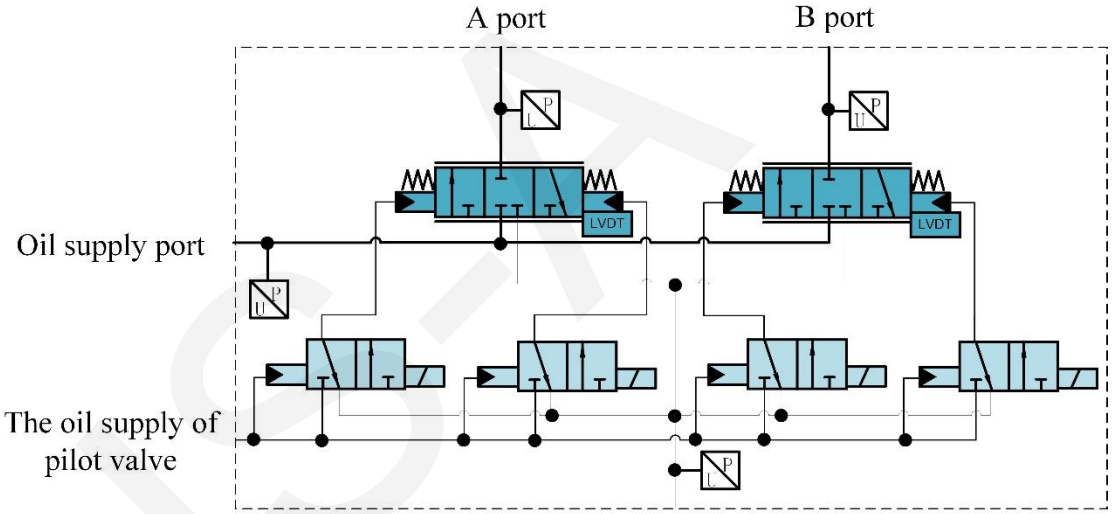
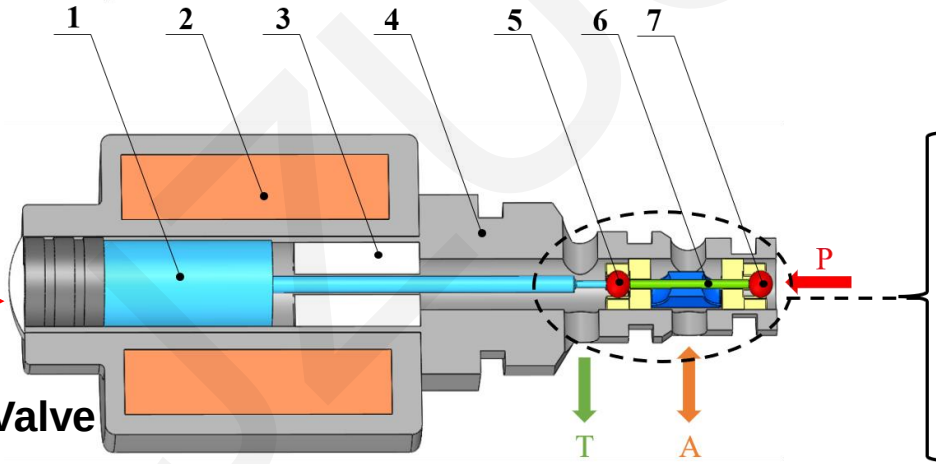
The structure of the two-stage hydraulic valve

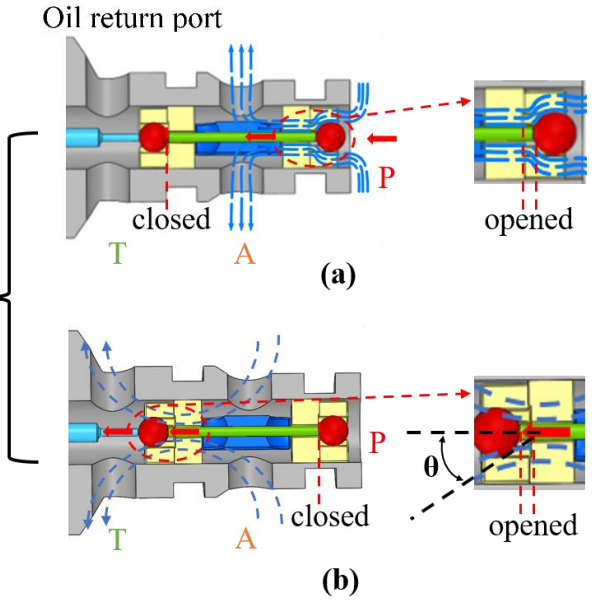






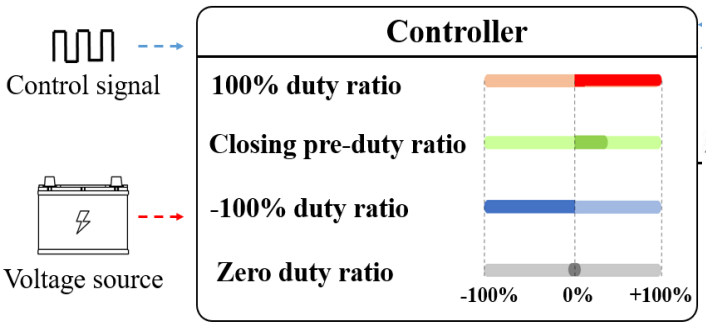
High Speed on/off Valve (HSV)

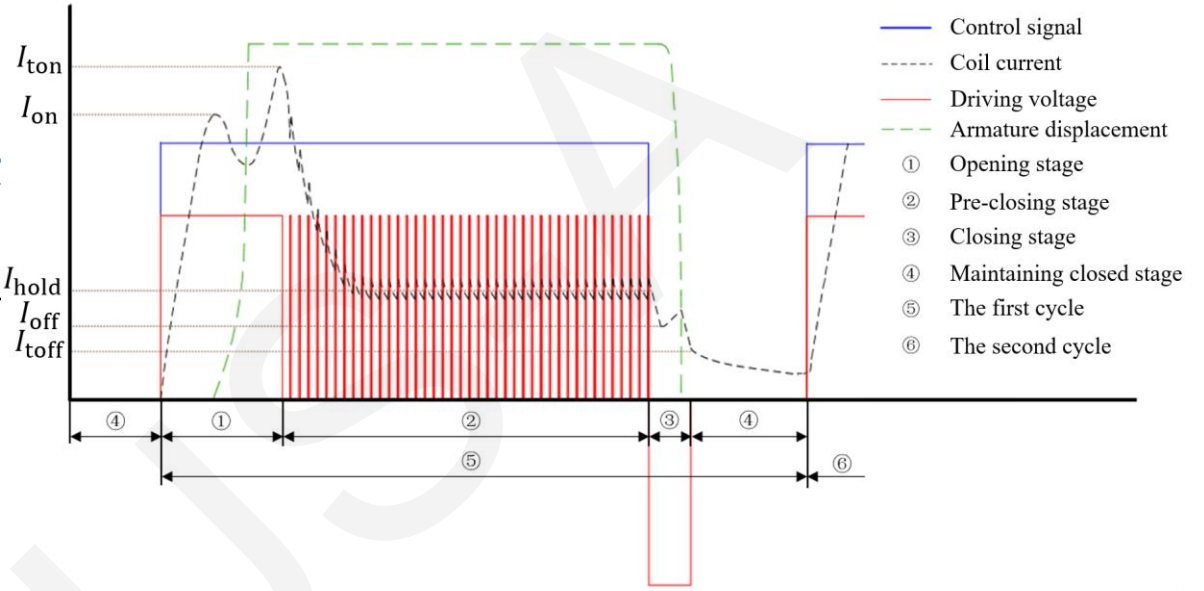
1. Armature, 2. Coil, 3.Pole Shoe, 4.Valve Housing,
5. Returning Ball, 6. Separating Pin, 7. Supply Ball



Development of the advanced digital controller

HSV controller



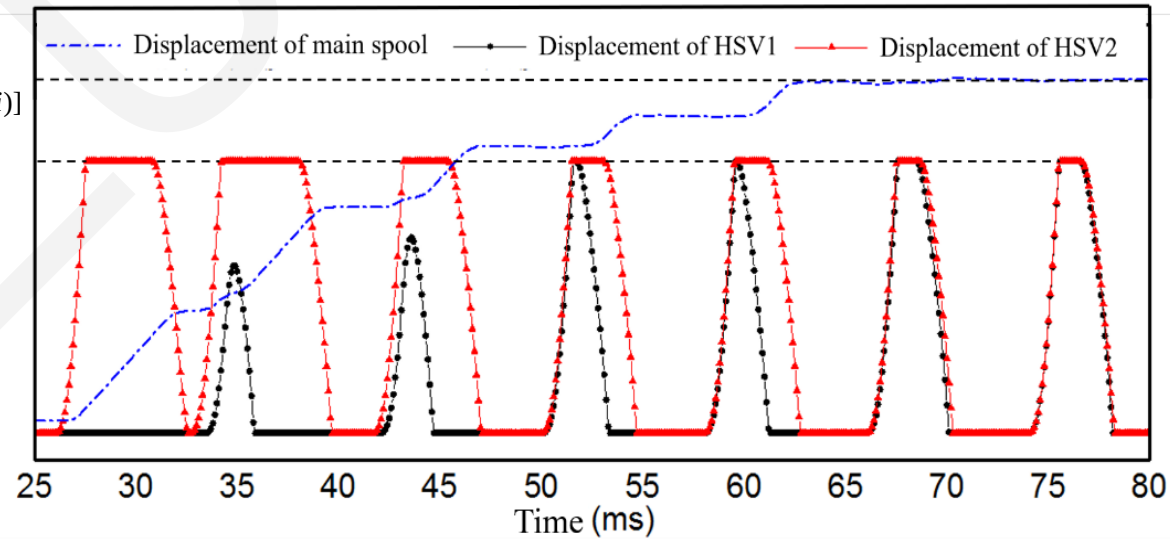


Main spool controller

$$\alpha_1 = 0.5 - \{k_p e_d(k) + k_i \sum_{i=0}^{k} [e_d(i)] + k_d [e_d(k) - e_d(k-1)]\}$$

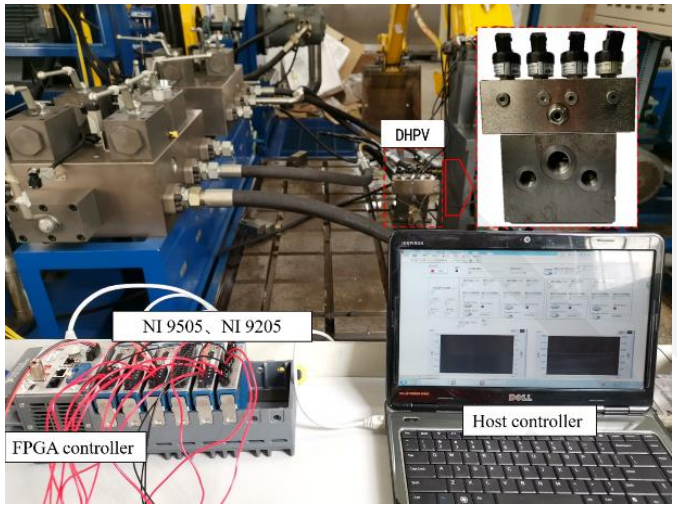
$$\alpha_2 = 0.5 + k_p e_d(k) + k_i \sum_{i=0}^{k} [e_d(i)] + k_d [e_d(k) - e_d(k-1)]$$

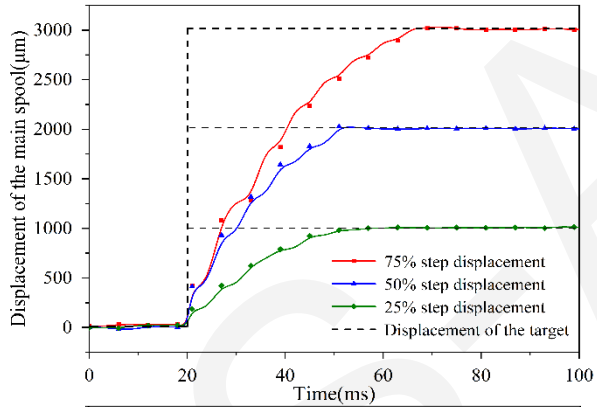
|e| (μm)	k_p	ki	k_d
[0,150]	400	120	5
(150,400]	550-|e|	150-0.2|e|	0
>400	150	70	0

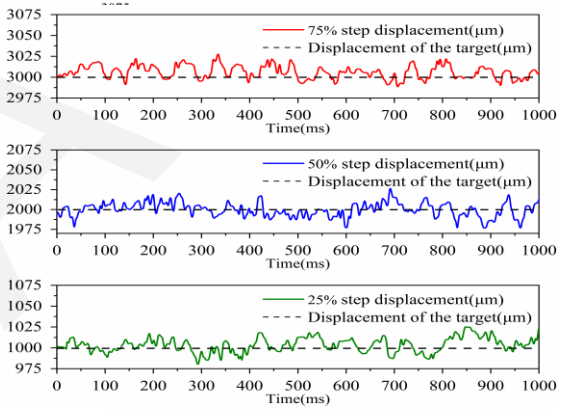


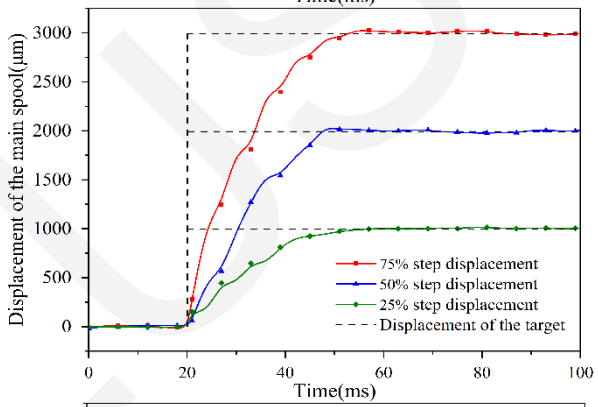
Experiment analysis

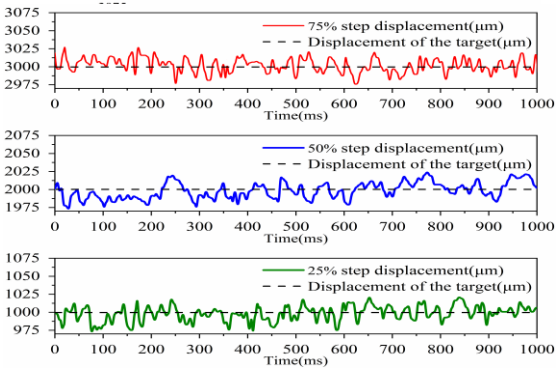
- The scheme of switching pilot technology proposed in this paper is shown to be **feasible** through theoretical analysis and experimental verification.

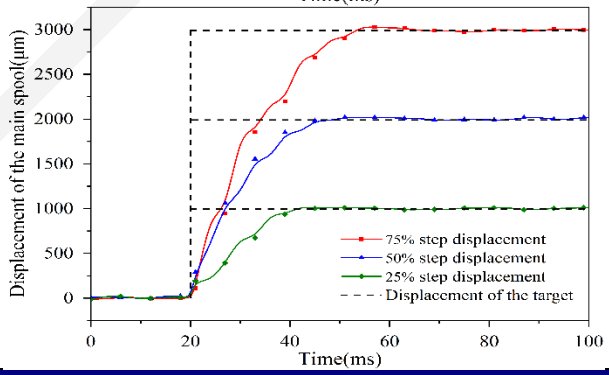


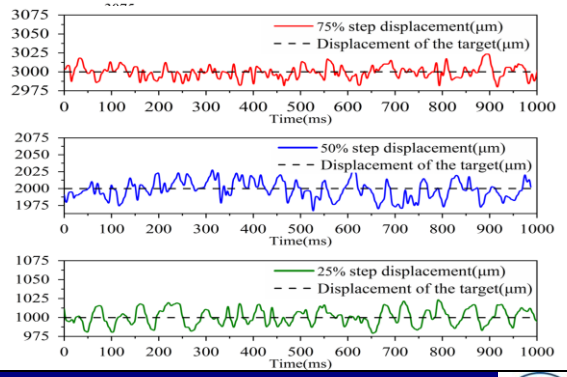












Conclusions

- As the oil supply pressure of the pilot stage increases, the flow gain is improved so that the dynamic response performance can be optimized by **21.5%**. However, it will cause a larger steady-state error.

- Increasing the frequency of the pilot stage will reduce the output oil volume in each switching cycle, so that the flow ripple in the control chamber can be reduced, and the steady-state error can be controlled within **20μm**, which meets the high precision control requirements of the flow.

- Switching pilot technology showed rapid dynamic performance and stable static characteristics, proving that it has a **huge potential** for application.

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