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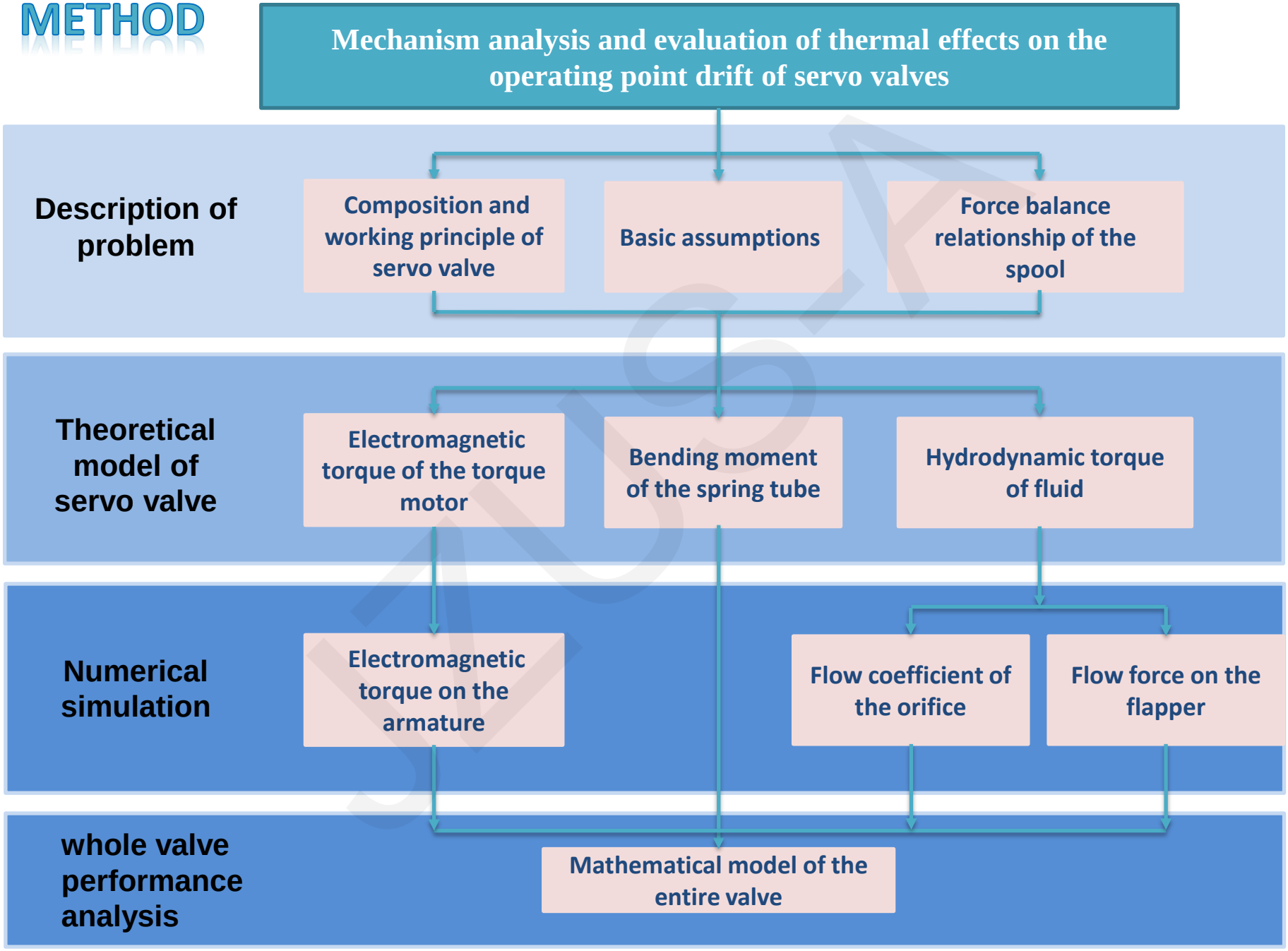
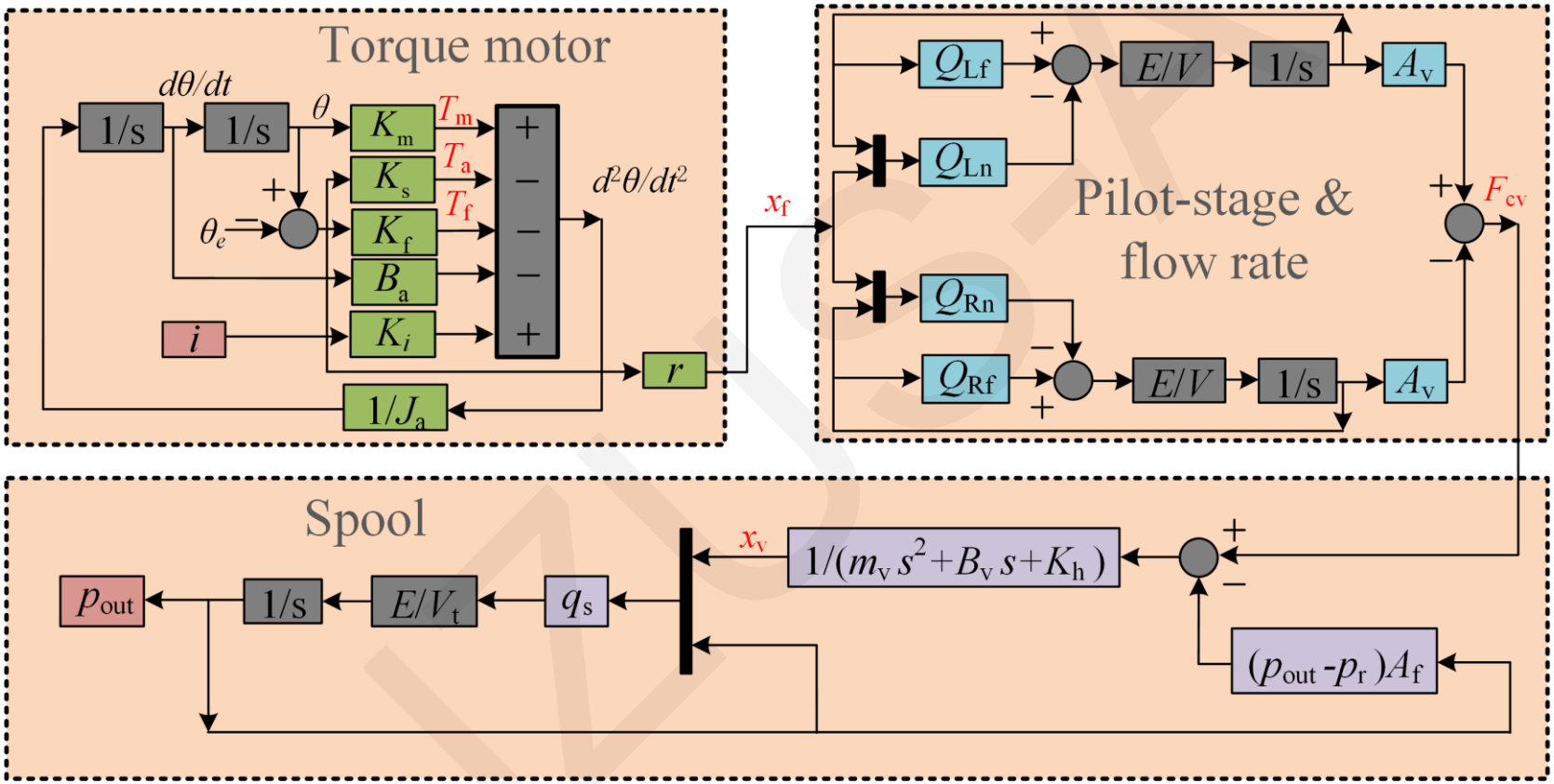
Mechanism analysis and evaluation of thermal effects on the operating point drift of servo valves

Key words: Servo valve; Operating point drift; Mathematical model; Numerical analysis; Thermal effect

METHOD


Mechanism analysis and evaluation of thermal effects on the operating point drift of servo valves
Description of problem
Composition and working principle of servo valve
Basic assumptions
Force balance relationship of the spool
Theoretical model of servo valve
Electromagnetic torque of the torque motor
Bending moment of the spring tube
Hydrodynamic torque of fluid
Numerical simulation
Electromagnetic torque on the armature
Flow coefficient of the orifice
Flow force on the flapper
whole valve performance analysis
Mathematical model of the entire valve



A modular block diagram of the whole valve performance analysis.

RESULTS AND CONLUSIONS

- (1)The thermal effect will affect the electromagnetic torque of the torque motor and the bending torque of the spring tube by changing the structural parameters. In addition, the matching relationship of the structure and the difference in the characteristics of the fluid will affect the flow force acting on the flapper.

- (2)Through the numerical simulation of each stage, the expression of the fitting relationship between input, output and temperature was obtained. The influence of temperature on the electromagnetic torque output by the torque motor is about 5%, and its changing trend with temperature is relatively linear. The change trend of the discharge coefficient is more complicated, and the influence of temperature on the discharge coefficient of the nozzle is about 2% at most. Temperature will not only change the fluid characteristics, but also have a significant impact on the pressure difference and structural coordination. In addition, the difference of the above factors will also affect the flow force, which will be reduced to about 60% of the normal temperature.

- (3)(3)According to the working principle of the servo valve, a mathematical model of the whole valve was established. On this basis, the influence of the thermal effect on the drift of the operating point was evaluated. When the deviation angle reaches ±1°, within the range of 40–50 °C, the tangent slope of the displacement deviation reaches 1.44×10-5 m/°C, and the tangent slope of the pressure deviation within this range can reach 1.14×103 Pa/°C. An increase in temperature will gradually reduce the slope of the tangent. In the range of 110–120 °C, the above values will be reduced to 1.25×10-6 m/°C and 110 Pa/°C, respectively. Therefore, we conclude that the deviation angle of the armature-flapper is an important factor affecting the drift of the operating point.

- In conclusion, the mechanism of the working point drift of servo valves under thermal effects is related to the structural and fluid characteristics. The deviation angle between components generated during the process of machining or assembly will directly lead to the working point drift. Moreover, the direction of the deviation angle will affect the drift direction of the operating point and the output amplitude.