Kinematics Simulation Analysis of Engine Automatic Docking System Employing AMESim and Matlab Simulink

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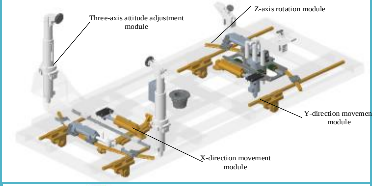
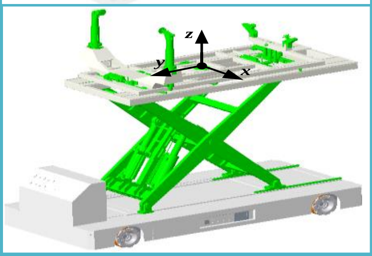




Abstract: The current posture adjustment and docking of various engine models typically rely on rigid tooling for support and locking, with the position and posture of the engine being confirmed and adjusted manually. Such docking methods often come with issues such as intense labor, low assembly efficiency, and lengthy assembly cycles. To address these problems, this paper takes the common aircraft engine as the research object and builds an automatic engine docking system. In the AMESim software, a theoretical model of Diverter-regulated cylinder position control is established. Parameters are adjusted based on different working condition parameter scenarios, and the variation curves of parameters such as pressure and flow rate over time under different working conditions are measured to analyze the actual operating status of the system. In the Simulink software, the Diverter-regulated cylinder position control system is reestablished. Sensitivity is used to analyze the Diverter-regulated cylinder unit, and the first-order sensitivity equation and the first-order sensitivity matrix are established. The values of each state variable of the system are extracted in real time using the simulation platform to obtain the sensitivity of the system to each parameter and obtain the optimal solution for each parameter, ensuring the high-precision response of each adjusting leg. The high-precision automatic mounting of the engine is achieved through numerical simulation.

The servo valve will be selected and approximately equivalent to a second-order oscillation link. The transfer function of the spool displacement and the input voltage of the servo amplifier board is.

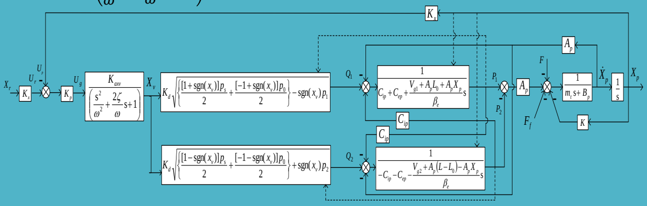
$$\frac{X_v}{U_l} = \frac{K_{axv}}{\left(\frac{V^2}{\omega^2} + \frac{2\zeta}{\omega}s + 1\right)}$$

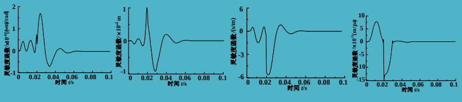
First-order matrix sensitivity.

$$l(x, u, \alpha, t) = 0$$

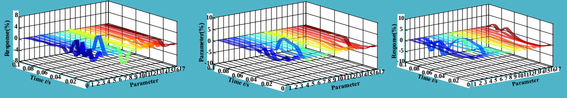
First-order trajectory sensitivity

$$\Delta x_1 = -V_\alpha \cdot \Delta\alpha + R_n(\alpha) = \sum_{i=1}^{16} \beta_{1w}^{i} \cdot \Delta\alpha_i + R_n(\alpha)$$

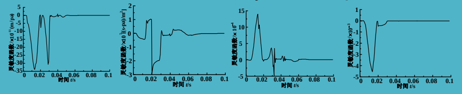




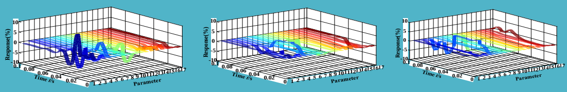
First-order matrix sensitivity−V_1、V_2、V_3、V_4



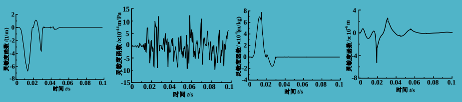
When loading 800N and stepping 2 mm/5mm/10mm



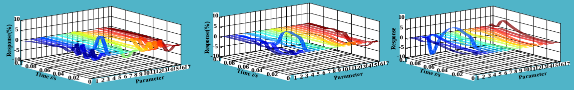
First-order matrix sensitivity−V_5、V_6、V_7、V_8



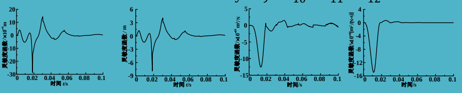
When loading 800N and stepping 2 mm/5mm/10mm



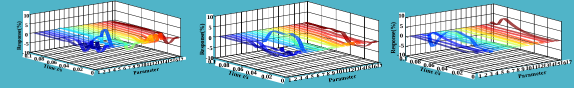
First-order matrix sensitivity−V_9、V_{10}、V_{11}、V_{12}



When loading 20000N and stepping 2 mm/5mm/10mm



First-order matrix sensitivity−V_{13}、V_{14}、V_{15}、V_{16}



When loading 20000N and stepping 2 mm/5mm/10mm

Conclusion

(1) For the hydraulic system of the product assembly vehicle, a Diverter-regulated cylinder model is established in AMESim and MATLAB/simulink software, and the first-order trajectory sensitivity theory and first-order matrix sensitivity theory are introduced for simulation analysis.

(2) Through simulation, the action law of the position control characteristics of the Diverter-regulated cylinder system on the 17 parameters in the system model is analyzed, and the main and secondary influencing parameters that affect the system output characteristics under nine working conditions are obtained. The simulation model of the Diverter-regulated cylinder position control system is given. Under nine typical working conditions of displacement step response, the maximum value of system output change caused by parameter changes within the system sampling time and the sum of the absolute values of system output change caused by parameter changes are taken as the measurement indicators of two parameters.

(3) The Diverter-regulated cylinder unit uses first-order trajectory sensitivity and first-order matrix sensitivity simulation analysis to study the first-order sensitivity of the 17 parameters in the system model, and obtains the main and secondary influencing parameters that affect the system output characteristics under nine working conditions. The simulation model is given. The two system control characteristics to each parameter are solved. Taking the maximum value of system output change caused by parameter changes within the system sampling time and the sum of the absolute values of system output change caused by parameter changes as the two parameter sensitivity measurement indicators, the sensitivity measurement indicator column charts with a 10% parameter change are given and analyzed, laying a foundation for high-precision control of the system.