

Abstract

Modeling and control of 3D-elastic ship-mounted cranes with a circular cross section elastic boom had been developed. The developed model contains three kinematic inputs (the luff and slew angles of the boom together with the length of the payload hosting cable) to control the elastic vibrations of the boom and the pendulation of the payload. Two kinds of disturbances are considered; the sea waves which act on the ship and the wind force which act directly on the payload. The developed nonlinear model of the crane is expanded about the current operating point which varies with the luff and slew angles and the length of the payload cable using Taylor series. The result is a linear time-variant model for the crane under consideration.

Simulation results for the linearized model show that the disturbances considered cause the payload to oscillate in the in-plane and in the out-of-plane. Consequently, the linear model is used to design the control system of the crane. The coefficient matrices of this linear model are calculated at the current (instantaneous) operating point, which varies with the luff and slew angles and the length of the payload cable, therefore, a variable-model problem is created and accordingly a variable-gain observer and a variable-gain controller are designed to cover the operation of the crane for all possible operating points in the working space of the crane.

The switching between these gains takes place automatically according to the output of a region finder, which uses the measurements of the luff and slew angles and the length of the payload cable to detect the current operating region. Extended-observer is used to estimate the states and unknown disturbances; this guarantees that the estimated states converge to their true values even though a nonzero disturbance force acts on the payload. The controller uses the estimated states and the measured pendulation distances of the elastic boom in both in-plane and out-of-plane, and the measured in-plane and out-of-plane pendulation angles of the payload cable to create the required damping and to reduce the effect of the disturbances on the ship. Stability and performance robustness of the system are ensured for the total working space and

also for the expected range of the payload mass. Simulation results show that the observer can estimate the states and the disturbances very well and the controller can reduce the payload pendulations significantly.