

Modeling of Mold Oscillation

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Mold oscillation system at NUCOR





Simplified mock-up



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Data from mock-up



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- The desired position for the actuator is chosen to be a sine wave of frequency 4.8 Hz (half the resonance frequency)
- PI controller is used to achieve this
- Actuator displacement signal looks almost perfect
- But large distortion (deviation from sinusoidal profile) in the mold end

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Metals Processing Simulation Lab



- Actuator displacement looks sinusoidal, this can be misleading
- Via Fourier transform we obtain the frequency content of the signal
- As expected there is a large peak (2.6mm) at 4.8 Hz, but there is also a small peak (0.07mm) close to 9.6 Hz

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Amplification of signal at resonant frequency



- Exciting the mockup at resonance frequency is unsafe
- Instead excite the Timoshenko beam model at 9.6 Hz
- From previous work, the beam model was able to capture the resonance frequency of the actual system quite well.
- 0.7mm-amplitude displacement sine-wave is observed (10 times amplification of resonance signal), which is a serious alteration of mold displacement



Hydraulic actuator nonidealities







Proposed controller design approach



- Develop linearized model of valve/actuator and mold
- Design a controller for the linearized model which is sufficiently robust to account for modeling uncertainties
- Design this robust controller to give linear behavior for nonlinear valve.
- Design repetitive controller around linearized model-robust controller structure that focuses on removing signals near resonant frequency

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