Adaptive Feedforward Based Control Strategy for Attenuation of Periodic Tension Oscillations in Roll-to-Roll Manufacturing

Article

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Abstract

Periodic oscillations in the tension signal are frequently observed in roll-to-roll manufacturing due to the presence of many rotating elements which are often non-ideal, such as out-of-round material or eccentric rolls. In certain situations the amplitude of the oscillations is large enough to affect normal operation of the web line. The proportional-integral-derivative (PID) feedback control algorithms that are commonly used for tension regulation do not have the dynamic complexity to compensate for such periodic disturbances. In this paper we investigate a two-degree-of-freedom controller which has two control actions, feedback and feedforward. The feedforward part is adaptive and is designed to provide control actions to compensate for periodic oscillations. Several issues must be considered when designing a control algorithm for the attenuation of periodic oscillations. First, since the control algorithm is executed in real-time using a real-time system which may have restrictions on the sampling period, the complexity of the algorithm must be such that the control action can be computed in a time period that is less than the sampling period, and the sampling period for most systems is typically in the range of tens of milliseconds. Second, it is desirable to have a feedforward algorithm that can be implemented in parallel with an existing feedback control scheme for tension and speed regulation without the need to retune and redesign the existing scheme. Further, it is desirable to have an algorithm that is understandable to practicing engineers who may have limited or no advanced controls background other than an undergraduate course in control systems. Considering the aforementioned issues, an adaptive feedforward (AFF) algorithm that can work in parallel to an existing feedback control systems is developed for control of web tension and to attenuate periodic oscillations. The essential ingredient of the AFF algorithm is the estimation of amplitude and phase of the periodic oscillations based on which a feedforward compensating control action is generated. The action of the AFF algorithm is such that retuning or redesign of the existing feedback controller is not required. Several different configurations of the AFF for different scenarios in terms of where to apply the feedforward action in the

control system are investigated. Extensive experiments are conducted on a large web platform with different scenarios and by transporting two different web materials at various speeds. Results from these experiments are presented and discussed. Experimental results show the effectiveness of the proposed AFF algorithm to attenuate tension oscillations.