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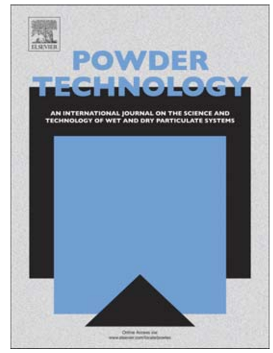

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Healthy speed control of belt conveyors on conveying bulk materials

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Abstract

Belt conveyors play an important role in the dry bulk material handling process. Speed control is a promising method of reducing the power consumption of belt conveyors. However, inappropriate transient operations might cause risks like material spillage away from the belt conveyor. The unexpected risks limit the applicability of speed control. Current studies on speed control mainly focus on designing energy models of belt conveyors or building control algorithms of variable speed drives, while rare researchers take into account the risks in transient operations and the dynamic performance of belt conveyors under speed control. The paper proposes an Estimation-Calculation-Optimization (ECO) method to determine the minimum speed adjustment time to ensure healthy transient operations. The ECO method is composed of three steps and takes both risks in transient operations and the conveyor dynamics into account. In the Estimation step, an estimator is built to approximate the permitted maximum acceleration by treating the belt as a rigid body. Taking the belt's visco-elastic property into account, the Calculation step computes the conveyor dynamics by using a finite-element-method. With respect to the risks in transient operations, the Optimization step improves the conveyor's dynamic behaviors and optimizes the speed adjustment time. A case of a long belt conveyor system is studied and the ECO method is applied. The secant method is also used to improve the optimization efficiency. According to the experimental results, the ECO method is successfully used to determine the minimum speed adjustment time to ensure healthy transient operations, including both the accelerating and the decelerating operations. With the suggested adjustment time, unexpected risks are avoided and the belt conveyor shows an appropriate dynamic behavior. Accordingly, the ECO method ensures healthy transient operations and improves the applicability of speed control with the consideration of the potential risks and the conveyor dynamics.

Keywords: belt conveyor, speed control, risks, conveyor dynamics, ECO method

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