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Dynamic mass measurement in checkweighers using a discrete time-variant low-pass filter

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ABSTRACT

Conveyor belt type checkweighers are complex mechanical systems consisting of a weighing sensor (strain gauge load cell, electrodynamically compensated load cell), packages (of different shapes, made of different materials) and a transport system (motors, gears, rollers). Disturbances generated by the vibrating parts of such a system are reflected in the signal power spectra in a form of strong spectral peaks, located usually in the lower frequency range. Such low frequency components overlap in the frequency domain with the useful signal and it is very difficult to eliminate them. The conventional way of suppressing disturbances is via low-pass filtering of the signal obtained from the load cell. However, if the speed of the conveyor belt is high, the response of the applied filter may not settle fast enough to enable accurate weighing of objects in motion, i.e., without stopping them on the weighing conveyor. Since attempts to overcome this problem using classical linear time-invariant low-pass filtering fail for high belt speeds, the paper presents and verifies experimentally a new approach, based on time-variant low-pass filtering. It is shown that, when properly tuned, the proposed time-variant filter fulfills the measurement accuracy requirements for a wide range of operating conditions.

1. Introduction

In industrial fields it is often necessary to weigh objects in motion, without stopping them on the weighing platform. Fast weighing, i.e., weighing in a time that is much shorter than the settling time of the measuring instrument, is one of the basic challenges in the field of dynamic mass measurement [1]. Dynamic weighing systems are usually used to check quantities of pre-packaged products. In this group of applications the conveyor belt type checkweighers play an increasingly important role [2].

Checkweighers belong to a group of automatic catchweighing instruments [3]. They are mostly a part of production lines and are integrated into a load transport system. During normal operation the transported products are moved sequentially along the weighing conveyor and weighed on-the-fly without any intervention of an operator, as it is schematically depicted in Fig. 1. The main source of disturbances corrupting the measurement signal, reflected in the signal power spectra in a form of well-emphasized spectral peaks (located usually in the lower frequency range, from several up to tens of Hz) are mechanical

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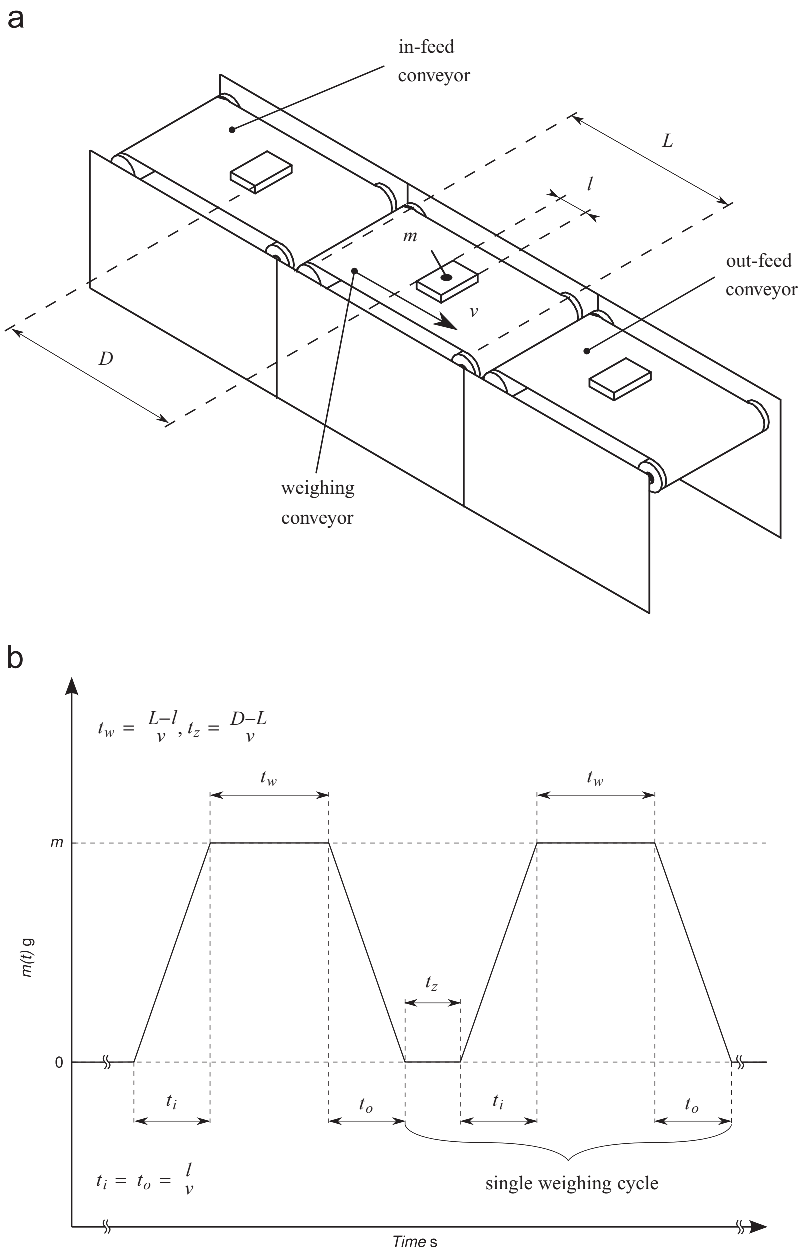

Fig. 1. A conveyor belt type checkweigher and its weighing cycle. L is the length of the weighing conveyor, l and m denote respectively the active length and the mass of the weighed object, D is the distance between two consecutive objects, and v denotes the belt speed. (a) A conveyor belt type checkweigher. (b) Weighing cycle of a conveyor belt type checkweigher.

vibrations [4–9]. The disturbance spectrum varies with the conveyor belt speed and the mass of the weighed object. Moreover, such low frequency components overlap in the frequency domain with the useful signal and it is practically impossible to eliminate them completely. For this reason some more advanced noise attenuation techniques must be used [10,16].

The paper solves the above-mentioned problem by proposing and verifying experimentally a linear time-variant low-pass filtering technique. The new solution is compared with the identification-based approach proposed earlier in the literature [11,12] and with the classical filtering approach incorporating time-invariant low-pass filters.

2. Problem formulation

Suppose that to eliminate disturbances, one performs linear low-pass filtering of the measured signal. Narrowing the filter passband decreases the influence of disturbances and increases the measurement accuracy. However, bandwidth limitation is always achieved at the expense of increasing the settling time of a filter. In extreme cases the duration of the