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A Comparative Study on the Cost-effective Belt Conveyors for Bulk Material Handling

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Abstract

Among the various types of belt conveyors, the multi-drive technology has gained worldwide popularity in recent years because of the cost saving opportunities as a result of the possible reduction of the belt weight. Until recently, however, limited knowledge on the cost-effective design of such conveyor systems was reported in the literature. Following the findings of a novel contribution on this matter, this paper presents a comparative numerical study for the identification of the most advantageous belt conveyor design for a specific bulk material handling application. Three types of belt conveyor are compared: the single drive belt conveyor, the single-tandem drive belt conveyor and the multi-drive belt conveyor. Subject to the assumption made and the manufacturers supplied information, the study shows that the implementation of the most cost-effective multi-drive conveyor will result in equivalent annual cost savings of about 63,120 \$(USD) and 29,475 \$(USD) over the cheapest single drive and single-tandem drive contenders, respectively. Other economic and environmental spin-off effects are also evaluated in the paper.

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Keywords: Multi-drive belt conveyor; energy optimization; optimal design; component sizing; life cycle cost; environmental footprint.

1. Introduction

Nowadays, belt conveyors represent a substantial proportion in the bulk material handling industry because of their high efficiency of transportation over short and medium distances [1]. Despite this renowned, however, conveyor systems are regularly subject to low economic performance due to either oversizing or inadequate operation [1, 2].

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While the majority of previous contributions focused on improving operational performance of belt conveyors [1, 3, 4, 5, 6], the possibility to address the problem downstream from the design stage was also investigated in the literature [7, 8]. The latter, however, was limited to the cost-effective design of conveyor systems powered by a unique drive unit.

Over the past few decades, the multi-drive technology has gained worldwide popularity as an effective method of achieving high performance through the possible use of lighter belts [9]. The literature study showed that limited knowledge was, until recently, available on the economic design of multi-drive belt conveyors. As a contribution to bridge this gap, an optimization method for the cost-effective design of multi-drive conveyor systems was recently introduced by the authors [10, 11]. In order to further confirm the benefits induced by the proposed design approach, this paper reports a numerical study on the optimal belt conveyor solution for the cost-effective transport of a bulk material. The resulting optimal designs of three types of conveyor layouts, namely, the single drive belt conveyor, the single-tandem drive belt conveyor and the multi-drive belt conveyor, are compared in this study.

2. Cost-effective design of belt conveyors

2.1. Conveyor systems description

Fig. 1(a) displays a typical layout of an uphill single drive belt conveyor intended to transfer a bulk material of density ρ over a transport distance L with a lifting height H. In this system, the pulling force is applied to the belt by the drive unit situated at the head pulley, which consists of a unique drive pulley mounted on the output shaft of the motor-gearbox assembly. In order to withstand the pulling force entirely concentrated at a single point, belts with high rated breaking strength of the belt related to belt width, noted by k_N, are required for this layout, with the consequence of an increased motor load.

The typical uphill single-tandem drive belt conveyor is shown in Fig. 1(b). In this case, the unique drive unit positioned near the head pulley is composed of two drive pulleys mounted in tandem, each driven by a dedicated motor-gearbox assembly. By sharing the pulling force between two different points, belts with relatively low values of k_N can be considered.

The layout of the modern uphill multi-drive belt conveyor is shown in Fig. 2, where the introduction of one or more drive units along the carry side of the system gives the opportunity to reduce further the belt weight. While the illustration presents a multi-drive conveyor system composed of three intermediate drive units on the carry side and a fourth drive unit positioned on the return side, the more general design will comprise of $N+1$ drive units, N of which are distributed on the carry side as intermediate drive units.

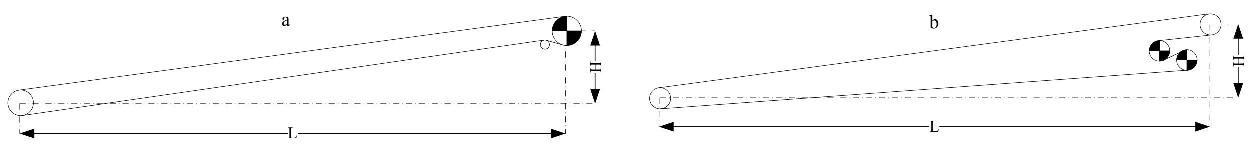

Fig. 1. (a) Single drive belt conveyor layout; (b) Single-tandem drive belt conveyor layout.

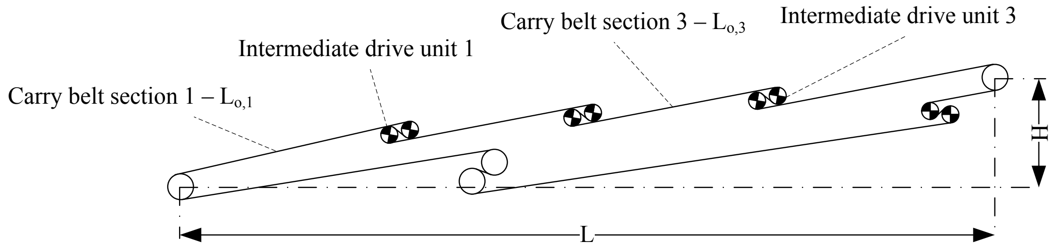

Fig. 2. Multi-drive belt conveyor layout (adapted from [9])

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