Measurement 112 (2017) 47–52

Contents lists available at ScienceDirect

Measurement

journal homepage: www.elsevier.com/locate/measurement

Examination of the process of damaging the top covering layer of a conveyor belt applying the FEM

Daniela Marasová[a], Ľubomír Ambriško[a,*], Miriam Andrejiová[b], Anna Grinčová[c]

[a] Faculty of Mining, Ecology, Process Control and Geotechnology, Technical University of Košice, Letná 9, 042 00 Košice, Slovak Republic
[b] Faculty of Mechanical Engineering, Technical University of Košice, Letná 9, 042 00 Košice, Slovak Republic
[c] Faculty of Electrical Engineering and Informatics, Technical University of Košice, Letná 9, 042 00 Košice, Slovak Republic

ARTICLE INFO

Keywords:
Conveyor belt
Covering layer
Modelling
Regression models

ABSTRACT

Damage to the conveyor belt structure is in many cases caused by the impact of the material on the chutes. The impact energy is initially absorbed by the covering layer. As a result, stress and strain conditions develop in the covering layer. The research presented in this article is focused on the modelling of the conveyor belt covering layer damage induced by the dynamic force, applying the force method. The force method is based on the selection of intensity and direction of the developed dynamic force. The modelling facilitates monitoring of its course, sizes of deformations, and intensity of stress developed in the covering layer. The output of the model is the determination of the covering layer damage limit condition in which the conveyor belt is disrupted.

1. Introduction

Belt conveyor is the most economical solution for the long-distance transportation of bulk materials [1–3] at high rates. It is a complex system of mechanical and electrical components [1], widely applied in areas such as mining, coal, ports, chemical industry, electric power, metallurgy, architecture, and food supplies [4]. A conveyor belt is an important element used for carrying and traction. Belt properties greatly affect the functions of the system. It is thus necessary to model and simulate a belt and analyse its dynamic properties.

Much attention has recently been paid to mathematical modelling and simulation. Taraba [5] modelled the stress and strain conditions in a steel-cord conveyor belt caused by the impact of the dynamic force. Marasová modelled the conveyor belt resistance to puncture [6]. Bindzár modelled the static and dynamic stress of conveyor belt while applying the Finite Element Method (FEM) [7]. Gondek in his papers [8–10] deals with the modelling of the stress-strain statuses in conveyor belts while applying the force method and the deformation method, including the experimental identification of input material data. The issues regarding the conveyor belt modelling include also the belt joining, attracting the attention as well. The paper [11] identified the stress, distribution thereof along the entire joint length, the place and the value of the highest concentration, as well as determination of the relationship between the stress and particular mechanical properties of the conveyor belt carcass. Song [12] built the mechanical and mathematical models of a belt unit, a drive unit, and a take-up unit. By combining those unit models, the dynamic equation of the whole conveyor system was built. According to the examples, Shi [13,14] analysed the dynamic properties during the start, free stoppage, abnormal loads, belt rupture, emergency stoppage, and lose power in starting, simulated dynamic curves, developed dynamic analysis algorithm that control the starting and the stopping processes and optimal methods. As for a conveyor as an elastic continuum, Wang [15] built a mechanical belt model with inertia, elastic, damping distribution, simulated dynamic properties of changing load starting. Nuttall [16] presented a simplified approach to modelling the rolling contact phenomena that occur at the surface of a wheel-driven rubber belt. Fiset [17] presents a model of a rigid cylinder rolling on a curved viscoelastic surface represented by Maxwell elements to analyse the friction due to hysteresis and the relationship between the traction and the slip in a wheel-driven belt conveyor system.

In the last decade, the issues regarding rubber materials, modelling thereof, and modelling of their behaviour in various structures and conditions, have been extensively studied; however, as Diani [18] pointed out, sufficiently accurate modelling of rubber behaviour still remains an open question. As natural rubber is a specific material, its properties are usually rather varied and depend on its composition and the contents of special ingredients [19].

The objective of the article is the analysis of deformations and stresses induced by the dynamic force in the covering layer of a conveyor belt (CB), developed in real conditions (mining transportation of the sharp-edge material consisting of large pieces) at the material's

* Corresponding author.
E-mail address: lubomir.ambrisko@tuke.sk (Ľ. Ambriško).

http://dx.doi.org/10.1016/j.measurement.2017.08.016
Received 24 September 2015; Received in revised form 25 June 2017; Accepted 9 August 2017
Available online 10 August 2017
0263-2241/ © 2017 Elsevier Ltd. All rights reserved.

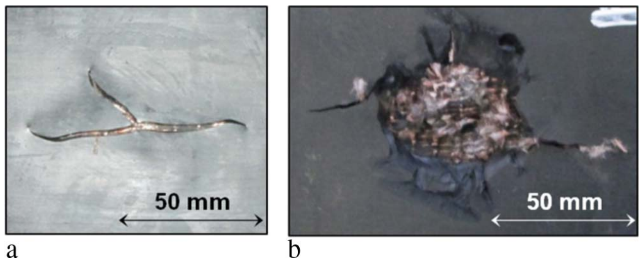

Fig. 1. Conveyor belt covering layer damages (a, b).

impact onto a CB, particularly on the chutes, and causes the damage thereto. Intensity of stress-strain statuses in the cover layer depends on the specific weight and shape of the impacting material. The research may be carried out using 3 impactor types. A pyramidal impactor represents a sharp-edge raw ore, a conical impactor simulates raw ore consisting of pieces with irregular shapes and sharp edges, and a spherical impactor represents raw ore without sharp edges, i.e. soft light rocks. In the case of the covering layer disruption, transverse and lengthwise cracks are formed (Fig. 1a); at some places, certain part of the carcass becomes even exposed and protrudes into the zone of the covering layer and the disruption thereof (Fig. 1b) which can lead to the loss of a CB's function [20–22]. The conveyor belt resistance to punctures is one of the most important criteria for the evaluation of their operational durability [26].

2. Material and methods

Mathematical modelling is currently a very progressive research method focused on the CB damage process. For the purpose of analysing the effects of an object's impact on a conveyor belt, induced by the dynamic force F (Fig. 2), only the vertical component F_y of this force will be analysed, because the vertical component is the only component causing the damage to a conveyor belt cover layer. The horizontal component of the F force affects only the partial wearing of the cover layer, due to acceleration by the friction contact between the transported material and the belt and acceleration by the shape contact between the transported material and the belt.

The stress and strain condition in a conveyor belt covering layer is induced by the dynamic point force. This condition is solved by a 2D model which models the point dynamic force F developed on the line along the entire CB width and in the plane of a vertical cross-section crossing the longitudinal axis of the top covering layer of the conveyor belt (Fig. 2). While applying the Finite Element Method (FEM), the rubber segment compression was simulated, as this segment represents the top covering layer of a conveyor belt. The modelled covering layer was placed on a rubber pad. Modelling in the ANSYS software was carried as shown in the scheme presented in Fig. 3.

Modelling the damage to a conveyor belt covering layer with a textile carcass, loaded by the dynamic point force, was carried out as follows:

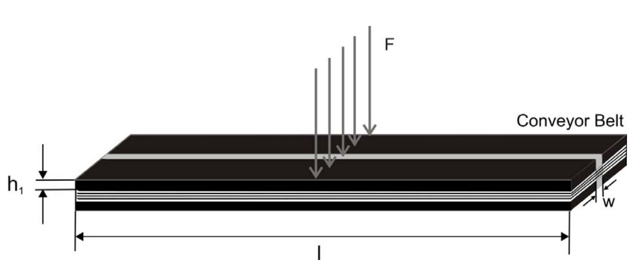

Fig. 2. Conveyor belt stress caused by the dynamic force *F*.

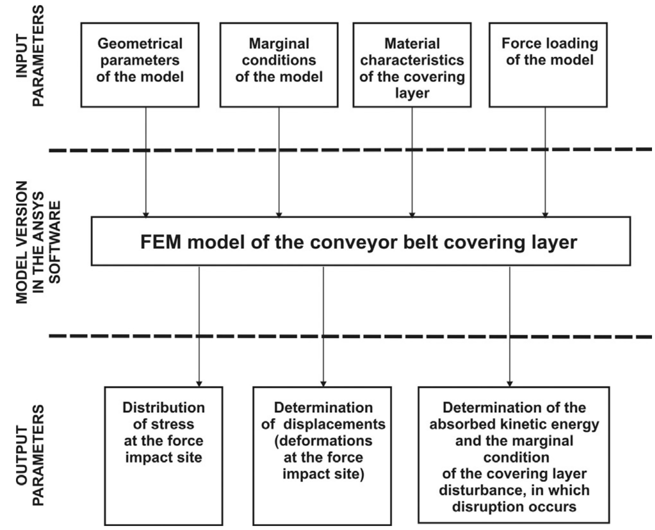

Fig. 3. Procedure of the covering layer damage modelling.

2.1. *Determination of geometrical parameters of the model*

A 2D model of the conveyor belt covering layer (Fig. 4) is defined by the following geometrical parameters:

modelling length $l = 60$ mm,
covering layer thickness $h_1 = 2$ mm,
rubber pad thickness $h_2 = 6$ mm,
modelling width $w = 1$ mm.

2.2. *Division of the covering layer model into the finite number of elements*

Number of elements is 480 and the size of a single element is 1×1 mm (Fig. 4).

2.3. *Determination of marginal conditions of the model*

The model was supported in its lower part along the entire modelling length to avoid the displacement of is nodal points in the direction of the y axis. All nodes on the left and right edges of the model are prevented against the displacement in the direction of the x axis. All nodes on the top edge of the model are arranged in pairs and have the same displacement in the direction of the y axis. Marginal conditions of the problem were specified in the shape of the required compression $U_y = 2$ mm.

2.4. *Determination of the intensity of the dynamic force impacting the model's covering layer*

The model was loaded by the point force F_y impacting in the central part of the model within the range of 50–400 N with the 50 N increments.

2.5. *Determination of material characteristics of a conveyor belt covering layer*

The modelling and the design of hyperelastic materials, including rubber, require the selection of an appropriate function of the deformation energy and the exact determination of material constants for these functions. The HYPER56 element was selected as the material for the top covering layer and the pad. HYPER56 is used for the 2-D modelling of solid hyperelastic structures. The mixed *U-P* (displacement-pressure) formulation allows the element matrices to be formed using mixed variation principles with the pressure introduced to

Download English Version:

https://daneshyari.com/en/article/5006424

Download Persian Version:

https://daneshyari.com/article/5006424

Daneshyari.com