Engineering Failure Analysis 45 (2014) 41–48

Contents lists available at ScienceDirect

Engineering Failure Analysis

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

Analysis of pipe conveyor belt damaged by thermal wear

Gabriel Fedorko [a,*], Vieroslav Molnar [a], Miroslav Dovica [b], Teodor Toth [b], Melichar Kopas [b]

[a] Faculty of Mining, Ecology, Process Control and Geotechnology, Technical University of Kosice, Park Komenskeho 14, 042 00 Kosice, Slovak Republic
[b] Faculty of Mechanical Engineering, Technical University of Kosice, Letna 9, 042 00 Kosice, Slovak Republic

ARTICLE INFO

Article history:
Received 3 April 2014
Received in revised form 16 May 2014
Accepted 25 June 2014
Available online 5 July 2014

Keywords:
Conveyor belt
Damage
Metro-tomography
Thermal degradation
Analysis

ABSTRACT

The conveyor belts are applied for transportation of a wide spectrum of materials with various technical parameters. An influence of these parameters determines durability as well as damage level of the conveyor belt. The temperature of transported material is one of the relevant criteria with a significant impact on the damaging process of the conveyor belt. An increased degradation of the conveyor belt construction can be caused due to a heat influence. In this article there are analysed several selected samples of the conveyor belt, which was used for transport of a roasted ore with the temperature 120 °C. The small failures occurred initially during a current operation of this conveyor belt and these failures led consequently to the development of severe cracks after a longer operational time. Application of a non-destructive diagnostic method enables to consider a next operation possibility of the belt as well as to obtain more detailed information about this type of damaging process.

1. Introduction

The belt conveyors seem to be the primary transportation technology specified for mining of materials in many countries. These conveyors are able to transport various kinds of the bulk materials [1]. Application of a suitable conveyor belt is a necessary initial condition, which is required for a correct functioning of any transport system equipped with the belt conveyors, taking into consideration the real operational situation. The dynamical characteristics of the belt conveyor are determined by the mechanical properties of the belt predominately [1].

The conveyor belt is subjected to a process of gradual wearing and degradation. The most common case of the conveyor belt damage is a puncture caused by falling of a sharp material [2]. Another typical example of the conveyor belt damage is a destruction of joining among the individual construction layers inside the conveyor belt. Lihua [3] analysed two typical failure forms of roller and conveyor belt and described the maintenance methods for prevention and elimination of failures in order to ensure a normal operation of the belt conveyor. Sarkat et al. elaborated studies concerning adhesion between the rubber and fabric as well as between the rubber and rubber inside a heat resistant conveyor belt [4]. Information about the stress-deformation conditions is knowledge, which is substantial for analysis of the given technical problem. Czaplicka performed an analysis of stress relaxation processes in conveyor belts [5]. It is possible to apply the experimental and theoretical methods based on the simulation experiments performed in the framework of this analysis. Hastie and Wypych created an experimental validation of a particle flow through conveyor transfer hoods via continuum using the discrete element methods [6]. Blazej and Hardygora dealt with a simulation of shear stresses in multiply belt splices [7]. A suitable method

* Corresponding author. Tel.: +421 6023147.
E-mail address: gabriel.fedorko@tuke.sk (G. Fedorko).

http://dx.doi.org/10.1016/j.engfailanal.2014.06.016
1350-6307/

for prediction of the fatigue strength in multiplies splices of the belt conveyors studied Hardygora in [8]. Mazurkiewicz [9] presented and analysed the laboratory test results and industrial measurements for conveyor-belt joint strength from the point of view of the aging impact on the conveyor-belt joint durability and reliability. The main purpose of this extensive research was to obtain the strength parameters of the conveyor-belt joints during different periods of use as well as to compare the laboratory tests results with the long-term measurements that were performed on the working conditions. Mazurkiewicz [10] describes a step-by-step procedure for creation of a knowledge base of the functional properties of the multi-ply rubber conveyor belts. The results of these laboratory studies were used for a verification of numerical model, which was developed for a typical conveyor belt adhesive joint, which is manufactured from several rubber materials with the different properties [10].

It is possible to apply various methods in order to perform an experimental research of the conveyor belts. Zimroz and Król [11] used the non-destructive testing techniques for evaluation of the conveyor belt condition. Tests of the wear behaviour of the conveyor belts performed Wolper and Hager [12]. The wearing process of the conveyor belts is characterised by the almost evenly distributed abrasion of the covers as well as by a local damage, such as tears, nicks in the cover, penetration of the belt and longitudinal slitting [12]. Fiset and Dussault [13] compared the wear resistance of a low carbon steel and polyester matrix composites containing hard particles. For all tests, the loss of weight converted into the loss of volume, was used to determine wear resistance. Langebrake et al. [14] dealt with a non-destructive testing of the steel-cord conveyor belts. Fedorko et al. [15] studied failure analysis of a textile-rubber conveyor belt damaged by a dynamic wear. The main purpose of this paper is to demonstrate a change of physical and mechanical properties of the dynamically damaged conveyor belts and to analyse inner structure of the conveyor belt carcass by means of a non-destructive analytic method. Michalik and Zajac [16] used the Computer Integrated System for the automated measuring of strength in the conveyor belt arranged in the pipe conveyor.

Another very frequently occurrence of the conveyor belt damage is a degradation influence of the heat factor. This damage occurs due to a high temperature of the transported material or as a result of a high ambient temperature. Rubber is a material, which is very sensitive to the temperature influences [17]. The effects of thermal elastic fluctuations in the rubbery materials studied Xing et al. [18]. Thermal degradation of a municipal plastic waste for production of fuel-like hydrocarbons investigated Miskolczi et al. [19]. Research trends in the degradation of butyl rubber described Dubey et al. [20]. (Sheng) Chen et al. [21] constructed the test rig to study the friction and noise behaviour of rubber belt with interfacial ice film under low temperatures.

The problem of rubber degradation in conveyor belts is a very important question, because the conveyor belt incorporates a lot amount of rubber, which is an expensive base material [22]. Dobrota [22] published a theoretical study oriented to a simulation of the joining between the metal cord insertion and the rubber matrix and he obtained a relationship for calculation of a degradation degree of the connection between the metal cord insertion and the rubber matrix. You-fu and Fan-sheng [23] developed a new full two-dimensional semi-analytical method based on Maxwell model in order to simulate rigorously and efficiently and to solve the indentation rolling resistance of conveyor belts. Xie et al. studied the conveyor belt materials with regard to the heat-resistant performance characteristics [24]. A determination of temperature distribution in the conveyor belt as well as on the upper and lower surfaces of a roto-cure system analysed Sadraei et al. [25].

The non-destructive testing (NDT) of the conveyor belt has become a common practice throughout the world [26]. The non-destructive testing of the steel-cord conveyor belts realised Langebrake [27]. A thermal damage of the conveyor belt can be investigated by means of the non-destructive methods based on the computed metro-tomography. The metro-tomography is a very progressive method, which is suitable for performing of the conveyor belt analysis [28]. In the work of Fedorko et al. [29] there is applied the computed metro-tomography method for analysis of the conveyor belt damage after impact of a sharp material. This method enables to investigate the thermal degradation process of the conveyor belt taking into consideration also changes in the belt inner structure. Ákos [30] dealt with problems of exploration using optical measuring method in detail. Williams et al. [31] investigated the feasibility of using an array of non-invasive tomographic sensors around a moving conveyor belt carrying solid particulates.

One of relevant problem areas concerning the rubber-textile conveyor belt, which is suitable for application of the non-destructive testing, is a research of technical damage of the conveyor belts focused on occurrence and extension of cracks on the belt surface. This research question is neglected considerably in the in the up to now published scientific works, in spite of a fact that such kind of investigation can be very helpful for understanding of an influence of the thermal degradation processes in the belt surface layers with regard to the overall durability of the conveyor belt and its inner structure. It is also important to answer a question whether there are accumulated material particles in the surface structure cracks of the conveyor belt.

2. Material and methods

2.1. Problem formulation

A thermal degradation of the conveyor belt is a very unfavourable situation, because during this damaging process the small failures are occurring on the belt surface first, however the final consequence of this occurrence is a fundamental integrity destruction of the upper and bottom covering layer (top cover and bottom cover) of the conveyor belt. The main purpose