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Analysis of Picked up Fraction Changes on the Process of Manual Waste Sorting

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Abstract

The problem of proper organization of waste management systems is becoming more and more significant these days. In Poland, regulations requiring municipalities to achieve by 2020, 50% recovery of weight fractions such as paper, metal, plastic and glass are the main factor contributing to the need to undertake new activities in the field of waste management. Waste processing takes place in complex technical systems. Modern waste processing systems are characterized by low efficiency. Currently, it is estimated that the efficiency of installations dealing with the sorting of waste does not exceed 35%. In 2015, the authors of the article carried out waste morphology in the city of Wrocław (only selectively collected waste). On its basis, the authors established that fractions suitable for re-use accounted for 77% of the total weight of waste sent to processing plants. Despite the significant development of systems for automatic identification and sorting of waste in recent years, systems using mainly human labour are still very common. The main goal of this article is to analyse the impact of changes in the type of waste picked up on consecutive workstations on the value of indicators used to evaluate the process of manual waste sorting.

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1. Introduction

The problem of proper organization of the waste management systems is becoming more and more significant nowadays. In Poland, regulations forcing municipalities to achieve by 2020, 50% recovery of weight fractions such as paper, metal, plastic and glass are the main factors contributing to the need of undertaking new activities in the field of waste management.

A waste management system consists of: collection and transport, processing and treatment and, finally, storage and disposal (Bilitewski, 2010; Chowdhury, 2009; Finnveden *et al.*, 2006). Waste processing takes place in complex technical systems. Modern waste processing systems are unfortunately characterized by low efficiency. Currently, it is estimated that the efficiency of installations dealing with the sorting of municipal waste does not exceed 35%. In 2015, the authors of the article carried out waste morphology in the city of Wroclaw (only selectively collected waste). On the basis of this research, the authors established that fractions suitable for re-use accounted for 77% of the total weight of waste sent to processing plants. Despite the observed significant development of systems due to automatic identification and waste sorting, systems using mainly human labour are still very common.

The main goal of this article is to analyse the impact of changes in the type of waste picked up at consecutive workstations on the value of indicators used to evaluate the process of manual waste sorting. The authors have developed a simulation model of a sorting line. It takes into account the variability of the size of the waste stream moving through the sorting line and the volatility of employee productivity during the 8-hour shift. Waste stream volatility has been modelled on the basis of studies conducted in one of the Wroclaw sorting plants owned by WPO ALBA S.A. Changes in employee productivity are more broadly described in (Kozlowski, 1998). The analysis of the sorting line and individual workstations was performed on the basis of a multi-criteria method described in more detail in (Giel *et al.*, 2016). The method is based on evaluation criteria such as efficiency of the line, total capacity achieved by the employees and the volatility of the performance of individual workstations. On the basis of this assessment method, it is possible to determine the status of the tested system. As a result, it is possible to identify the weak points of the system and identify the actions that need to be taken into account in order to improve the system

In the literature, there are four main groups of assessments for waste processing systems:

- safety (impact of harmful substances on the health of installation workers) (Kozajda *et al.*, 2009; Krajewski *et al.*, 2011);
- impact on the environment (LCA models) (Gentil, 2010; Pressley *et al.*, 2015);
- economic factors (models for comparing investment in terms of economic efficiency) (Cimpan *et al.*, 2016);
- operational measurements (productivity, efficiency, capacity).

The method used in this article is a part of the last shown group. It includes methods for dealing with the overall assessment systems (Hryb, 2013). The methods described in the literature are based mainly on a single evaluation criterion.

Further work assumes the development of an algorithm, which will allow for an improvement of the process of manual waste sorting by amending the other parameters of the process line (e.g. the number of waste fractions selected from the stream on each workstation). The algorithm will use computer simulation to analyse the process and the evaluation of parameter values, which will make it possible to indicate the directions improvement.

2. Description of the real system

2.1. Waste flow

The data used in the article were collected during research that was conducted in a WPO ALBA S.A. recycling centre. The research involved sampling the weight of the waste stream in a given period of time. The waste stream was described with probability distribution. In order to verify the distribution, the Kolmogorov test was carried out (significance level $\gamma = 0.95$). The test confirmed the correctness of distribution fitting.

The waste mass flow was described by the following equation:

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