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Energy and exergy balance methodology. Wood chip dryer

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Abstract

Drying is widely used in a variety of thermal energy applications ranging from food drying to wood drying. Utilization of high amount of energy in the drying industry makes drying one of the most energy-intensive operations in pellet production. Thermodynamic analysis has appeared to be an essential tool for system design, analysis and optimization of thermal systems. The aim of current paper is to make an algorithm to evaluate wood chip drying process energy and exergy efficiency. Energy and exergy efficiency evaluation consist of the drying process energy and exergy balance analysis.

On the basis of the results of the study it can be concluded that under the given assumptions drying process energy efficiency varies between 22.69 % and 10.25 % but the exergy efficiency varies between 16.47 % to 0.7 %. Decrease of drying air mass flow increases the energy and exergy efficiency. This is because less heat is required to heat drying smaller air mass flow. Decreasing drying air humidity ratio of air before dryer, increases energy and exergy efficiency. This is because the drying air with smaller humidity ratio content are able to attract more moisture from the drying product.

Keywords: exergy; energy; balance; drying process; wood chips

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1. Introduction

Drying is widely used in a variety of thermal energy applications ranging from food drying to wood drying. Utilization of high amount of energy in the drying industry makes drying one of the most energy-intensive operations in pellet production [1, 2].

Drying generally used to remove moisture or liquid from a wet solid by converting this moisture into gaseous state. In most drying operations, water is the liquid evaporated and air normally employed as purge gas [3].

During the past decade, thermodynamic analysis has appeared to be an essential tool for system design, analysis and optimization of thermal systems [4−8]. Energy balance is traditional approach to evaluate various energy conversion processes in which forms of energy are changing: mechanical energy, internal energy, electromagnetic energy, chemical energy, nuclear energy, etc. There are also a number of energy analysis methods known, such as statistical analysis, input-output flow analysis and process analysis. Energy balance allows to calculate heat losses, but does not provide information on how optimally transform energy. This can be done by exergy analysis, because the second law of thermodynamics determines that all the entire energy input of system can`t be converted to useful work. Exergy analysis method is a new instrument, which can be used to improve energy production and conversion. Exergy is defined as the maximum amount of work to be able to take by system in relation to the ambient temperature [9, 10].

Nowadays exergy analysis is an effective method to perform an objective evaluation of energy conversion processes in heating systems. Comparing the energy balance composition, based on the first law of thermodynamics, during exergy analysis the first as well as the second law of thermodynamics are used [11, 12].

Exergy is not subject to a conservation law, rather exergy is consumed or destroyed, due to irreversibilities in any process. It is a measure of the potential of a stream to cause change, as consequence of not being completely stable relative to the reference environment. For this reason, the state of the reference environment, or the reference state, must be specified completely [13, 14].

In this study wood chips drying process is investigated with a perspective of energy and exergy analyses. Energy and exergy analyses conducted on drying process in order to improve the operating conditions and system efficiency.

2. Methodology

2.1. Algorithm for calculation

Algorithm consists of 5 modules:

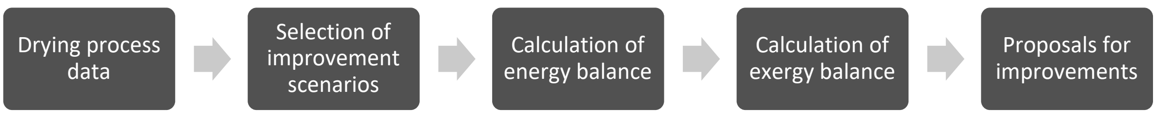

Fig. 1. Algorithm of methodology.

In the first block of algorithm the drying process data are identified, which with the help of energy and exergy balance are analysed. In the next block the improvement scenarios will be analysed using energy and exergy balance, for example, impact of the outside air temperature on drying efficiency. Further on energy and exergy balance calculations are made by using data from previous blocks. Results of calculation are analysed and presented visually. Formulating conclusions of the results take place in the last block.

Assumptions:

- Drying air temperature is constant 80 °C;
- Moisture of wet product is constant 55 %;
- Drying material flow rate does not exceed 1 t/h;
- Heat exchanger for drying air heating does not exceed 480 kW.