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Charcoal production in a continuous operation retort. Experimental data processing

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Abstract

The charcoal industry has recently regained the spotlight along with other renewable resources, not from its previous ill repute as a cause of deforestation but as one of the tools for climate change mitigation. In this paper a study with an experimental evaluation of a charcoal production technology is carried out in an industrial facility. The investigated technology is a state-of-the-art continuous operation automated retort which is comprised of a monitoring system continuously registering process characteristic temperatures. The raw material, biomass, passes through three different stages in the retort - biomass heating and drying, biomass carbonization, and charcoal cooling. These process sections are described and analyzed according to the relevant temperatures. The obtained data is processed using Statgraphics Centurion Statistical data analysis tool. This study draws attention to the importance of a scientific approach to charcoal production with optimized process parameters directing the charcoal industry towards the increase of production sustainability.

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Keywords: pyrolysis; temperature; biochar; free fall reactor; statistical analysis

1. Introduction

The traditional charcoal markets include the metallurgical industry, activated coal in medical use, filtrating and purification applications, as a barbecue fuel, and, in developing countries, as a household fuel [1]. Further on, through a pyrolysis process biochar can be obtained. Biochar is defined as char that can be used as a soil

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amendment, thus enhancing soil fertility, as well as trapping atmospheric carbon in the ground [2]. This shows the versatile application of this renewable material, and also the possibility to substitute a share of fossil material use in energy and material industries, as well as mitigate climate change. A comprehensive overview of the pyrolysis process, different feedstock, technologies, including economic aspects is discussed in a paper by Jahirul et al. [3].

Batch-type kilns are the technology that was developed centuries ago to produce one of the first charcoal fuels. The production method with different variations has mostly been used up until the present. The introduction of pyrolysis gas recirculation in the pyrolysis chamber, thus supplying the heat that is necessary for the pyrolysis process without using a part of the input material for this purpose, and lowering the pyrolysis gas emissions into the atmosphere is one of the most important updates of the technology. The next step that has been taken is transitioning from batch-type production to continuous production. Continuous charcoal production retorts are a comparatively new technology. Continuous retorts have enhanced productivity by taking up the same space, but using it continuously for charcoal production. In the batch-type kilns the input material is in turn heated and carbonized, and then the charcoal is left to cool for some time. In the continuous retorts the input material is inserted from above and falls out from the bottom into the cooling chamber, and is automatically conveyed to package and storage locations. The process is highly automated, thus significantly increasing the possibility for process control.

Charcoal production in a continuous production retort with the Lambiotte carbonization system is studied in this paper. The temperature monitoring data is obtained and analyzed to describe the internal processes of the retort. The results can be used in process mathematical modelling, and in calculations for the energy balance estimation.

Nomenclature

T1	effluent pyrolysis gas temperature, °C
T2	gas temperature before the drying zone, °C
T3	hot pyrolysis gas temperature, °C
T4	temperature of the cooled pyrolysis gas, °C
T5	air supply temperature, °C
T6	temperature in the carbonization zone upper layer, °C
T7	temperature in the carbonization zone bottom layer, °C

2. Methodology

2.1. Industrial experiment

The industrial experiment takes place during the process of the facility's environmental performance evaluation. The environmental performance results are discussed in the study by Kļaviņa [4]. The experiment takes place at a real-life industrial charcoal production retort with the process of continuous carbonization of cellulosic materials initially patented by Auguste Lambiotte in 1942 [5].

The permit for polluting activities needed for the duration of the experiment is arranged beforehand. The period of experimentation is 23 days. Charcoal is produced from a mix of birch and alder firewood. During the course of the experiment, the initial stage consisted of the preparation of the input material – cleaving of wood logs, and drying the first input portions. The retort was started and worked around-the-clock, the only exception being for servicing. Likewise, the input material drying was continued throughout the experiment. The technology requires regular feed material, and a symmetrical material distribution in the retort for the best results. It is essential to ensure that the input material moisture content does not exceed 25 %.

A schematic representation of the retort is illustrated in Fig. 1. The scheme describes the retort by dividing it into three zones in the charcoal production process – drying zone, carbonization zone, and the cooling zone. These three zones are indeterminate, as the input material is inserted from the top with a skip conveyor, and moves from one zone to the next by free gravitational pull. The retort is 16.3 m high, with the volume of 600 m^3, and has the estimated production of 2,000 tons of charcoal per year [6].