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Stratification of off-gases in stored wood pellets



F. Yazdanpanah^{a,*}, S. Sokhansanj^{a,b}, C.J. Lim^a, A. Lau^a, X. Bi^a, S. Melin^{a,c}

^a Chemical and Biological Engineering Department, University of British Columbia, Vancouver, BC V6T 1Z3, Canada

^b Environmental Sciences Division, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

^c Delta Research Corporation, Delta, Canada

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ABSTRACT

Wood pellets emit gases such as CO, CO₂ and CH₄ during storage especially under high temperature conditions. This study investigates the stratification of the evolved gases in a sealed storage container of 1.2 m diameter and 4.6 m height. The data recorded include the concentration of off-gasses (CO₂, CO and CH₄), temperature and relative humidity profiles in vertical and horizontal directions. The results obtained clearly show high concentration of gases as well as fast depletion of oxygen. The emitted gases showed to have higher emission factor compared to work done with white wood pellets in small scale. Some stratification was observed for CO₂ and CH₄ over the first days of storage. However for CO the stratification was much clear and related to high uptake of CO by wood pellets over time.

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1. Introduction

Wood pellets are compacted ground wood having a diameter of 6 mm, about 12–20 mm long with a moisture content of 6–8% (w.b.). After they are manufactured, wood pellets are stored in silos at the production sites, shipping ports, and at the users' facilities. Most pellets produced in British Columbia, Canada, are exported via ocean vessels. The ocean voyage to Europe through Panama Canal lasts 30–40 days. A number of studies showed that biomass decomposes chemically and biologically and emits CO, CO₂ and CH₄ [1,2] over time. Evolution of these gases along with consequential depletion of O₂ within closed spaces make the unventilated storage environments toxic. A number of incidences of injuries and even fatalities have occurred as a result of exposure to this environment.

When organic matters are stored at room temperature, they emit small amounts of carbon monoxide and the emission rate increases with temperature [3]. Researchers have mentioned CO as the main component being emitted from storage of wood pellets and emission of other compounds such as methanol, formic acid and aldehydes are much lower than CO [4]. High temperature conditions can aggravate gas emissions due to microbial growth on pellets, chemical oxidation of lipids in the pellet and hydrothermal migration of moisture between pellets. Emissions of CO₂, CH₄ and N₂O from stored wood pellets and wood chips have been reported [2,5]. CO and CO₂ emissions have been attributed to the auto-oxidative degradation of fatty acids [2]. According to Risholm-Sundman et al. [6] oxidation of unsaturated fatty acids and other extractives under certain conditions would cause the release of volatile aldehydes such as hexanal and pentanal compounds.

* Corresponding author.

E-mail address: fyazdanpanah@chbe.ubc.ca (F. Yazdanpanah).

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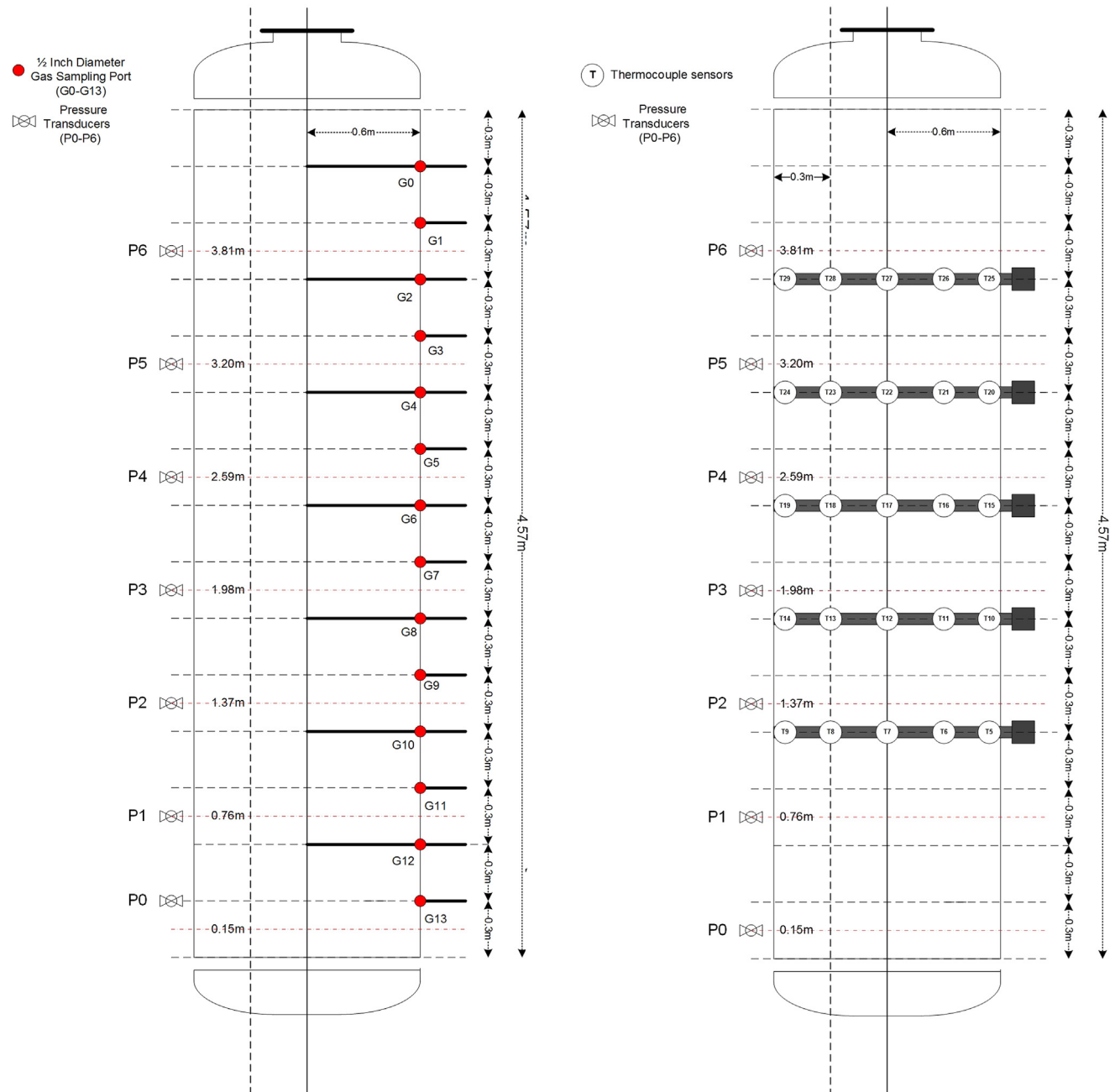


Fig. 1 – Location of gas and pellet sampling ports (left) and location of horizontal thermocouples in the silo (right).

The biological and chemical processes consume oxygen causing its depletion in the storage environment. Depletion of oxygen is partially due to the formation of carbon monoxide. A larger amount of oxygen losses could be due to the radical-induced oxidative degradation of natural lipids, particularly the polyunsaturated linoleic acid [7]. In this process, much oxygen is believed to become chemically bound within the wood structure. Hexanal and other alkanals are hypothesized to be formed by this radical-induced oxidative process of lipids. These oxidation processes and hence gas emission are temperature dependent. Arshadi and Gref [1] have mentioned VOCs being emitted from stored pellets and the circumstances under which the concentration of these gases reached high

levels. Large amounts of VOCs especially terpenes have been emitted during wood and sawdust drying [8,9].

Ocean transportation of wood pellets in confined spaces can rapidly produce lethal levels of CO and an oxygen-deficient atmosphere that may affect adjacent access space and make these spaces dangerous for people to enter [10]. Svedberg et al. [11] indicated oxygen depletion and toxic gas emissions in the marine vessel stairway adjacent to the cargo hatches that contained wood chips and logs. In 2002, high levels of CO were measured in the compartments of an ocean vessel discharging pellets in Rotterdam, the Netherlands, which were shipped from Vancouver, British Columbia, Canada. One person was killed and several people were severely

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