Chapter 5
Identification of Agricultural Crop Residues Using Non-Destructive Methods

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ABSTRACT

Biomass is a bulky and inhomogeneous material, making it difficult to transport and store. In order to solve this problem, it has been found that the most common way to overcome the limitation of the biomass bulk density is to increase it with fine shredding. This chapter investigated the ability to identify specific operation conditions in a prototype biomass shredder by developing and utilizing non-destructive testing and artificial intelligence techniques. In order to demonstrate the performance of proposed methods, three different case studies investigated the different operation conditions from the vibration signals acquired through the ball bearings of the biomass shredder. The results showed that the two classifiers can provide reliable results using as inputs statistical features in time and frequency domain. These statistical features can be used with success for identify different operating condition. The combination of the statistical features with the appropriate classifiers gives a powerful tool for the agricultural biomass shredder condition monitoring.

DOI: 10.4018/978-1-5225-8027-0.ch005

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INTRODUCTION

Biomass forms the third accessible energy resource in the world after coal and oil (Bapat, Kulkarni, & Bhandarkar, 1997). The utilization of biomass residues for sustainable heat, power and biofuel production is an important part of future energy concepts (Lesage, Graf, & Westphal, 2010). One of the major challenges of biomass utilization for heat, power and biofuel production is its unfavorable handling properties. Biomass is an inhomogeneous and bulky material, making it both expensive and difficult to transport and store. Furthermore, it is difficult to comminute into small particles and has a relatively low energy density (compared to fossil fuels) and high moisture contents. The typically density range for straws and grasses is 80-100 kg m\(^{-3}\) and for wood biomass in the form of chips and sawdust is 150–200 kg m\(^{-3}\) (Mitchell, Kiel, Livingston, & Dupont-Roc, 2007; Sokhansanj & Fenton, 2011). This is an important limitation for the use of this material as a source of energy due to storage and transport difficulties (Tumuluru, Wright, Kenny, & Hess, 2010).

Biomass density has a significant effect both on handling and storage. Also, it depends on particle size and shape, specific density, material composition and moisture content (Lam et al., 2008). According to Emami and Tabil, the bulk density of biomass raises while handling, being transported and being stored, something that can be caused by compaction due to vibration, tapping, or normal load (Emami & Tabil, 2008). For Fasina, biomass compaction behavior is very important in terms of capacity sizing and supply logistics (Fasina, 2006). Particle size distribution plays a significant role in flowability and other properties; even a small change in the particle size may cause significant alterations in the resulting flowability (Ganesan, Rosentrater, & Muthukumarappan, 2008). According to this, it has been repeatedly found that the most common way to overcome the limitation of the biomass bulk density is to increase it with the fine shredding.

Although milling is one of the oldest methods of biomass processing, a very little knowledge about this processing based on the mechanical properties of the grinding materials. According to Lopo particle size reduction plays an important role in the utilization of biomass in energy production and animal feedstock (Lopo, 2002). Size reduction is an important pretreatment of biomass for energy conversion. Apart from that, it is also crucial to the densification process. For example, in the production of fuel pellets and briquettes, the biomass has to be shred before being transformed into a denser product. In 2015, Xavier et al. indicated that the size reduction increases the total surface area and the number of contact points in the compaction process making it possible to obtain the agglomerate of density equal to approximately 1200 kg m\(^{-3}\). This affects the chemical structure of biomass losing some of the water under pressure (Xavier, Moset, Wahid, & Møller, 2015).
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