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Production of straw pellets for the biofuel industry – Energy analysis

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Agricultural biomass such as barley, canola, oat and wheat straw residues have the potential to be used as feedstock for the biofuel industry. Densification of biomass into durable compacts is an effective solution to facilitate easy and economic handling, transportation, storage, and utilization. In this study, an integrated approach to the postharvest process, and a feasibility study of lab-scale and pilot scale densification of non-treated and steam exploded straw was performed to develop baseline data and correlations to assist in performing an overall specific energy analysis. Lab-scale experiments were performed to study the compression characteristics of ground non-treated and steam exploded straw obtained from three hammer mill screen sizes of 6.4, 3.2 and 1.6 mm at 10% moisture content (wb). Four preset pressures of 31.6, 63.2, 94.7 and 138.9 MPa were applied using an Instron testing machine to compress samples in a cylindrical die. Pilot scale pelleting experiments were performed on non-treated, steam exploded and customized (adding steam exploded straw grinds in increments of 25% to non-treated straw) straw grinds obtained from various hammer mill screen sizes at 10% moisture content (wb). The pilot scale pellet mill produced pellets from ground non-treated straw at hammer mill screen sizes of 0.8 and 1.6 mm and customized samples having 25% steam exploded straw at 0.8 mm. It was observed that the pellet bulk density and particle density are positively correlated. The density and durability of agricultural straw pellets significantly increased with a decrease in hammer mill screen size from 1.6 mm to 0.8 mm. Interestingly, customization of agricultural straw by adding 25% of steam exploded straw by weight resulted in higher durability (>80%) pellets but did not improve durability compared to non-treated straw pellets. In addition, durability of pellets was negatively correlated to pellet mill throughput and was positively correlated to specific energy consumption. It was determined that the applied pressure (60.4%) was the most significant factor affecting pellet density followed by the application of steam explosion pre-treatment (39.4%) for lab-scale single pellet experiments. Similarly, the type of biomass type (47.1%) is the most significant factor affecting durability followed by the application of pre-treatment (38.2%) and grind size (14.6%) for pellets manufactured from a pilot-scale pellet mill. However all biomass types (straws) had durability levels which were in an acceptable range. The pellet mill consumed the highest proportion of total specific energy followed by hammer mill, cooler and chopper for non-treated barley straw at 1.6 mm grind size. A decrease in grind size to 0.8 mm for non-treated straw significantly increased the proportion of energy contributed by the hammer mill. The most significant factor for customized straw is the specific energy required for steam explosion pre-treatment followed by pellet mill. Total specific energy required to form pellets increased with a decrease in hammer mill screen size from and with customization of straw at the 0.8 mm screen size. It has been determined that the net specific energy available for production of biofuel is a significant portion of original agricultural biomass energy for all agricultural biomass being in the range of 89% to 94%. The applied pressure (58.3%) was the most significant factor affecting specific energy required to manufacture pellets, followed by the biomass type (15.3%), pre-treatment (13.3%) and grind size (13.2%), for lab-scale single pellet experiments. Pelleting at a higher grind size would result in substantially less energy being consumed in pellet manufacture. Consequently it is recommended to develop or use pellet mills that could pellet agricultural straw grinds obtained from higher hammer mill screen sizes (>1.6 mm) to increase the net available specific energy for production of biofuels. It should be noted that the pellet mill used in these studies was an older, less efficient model that the horizontal machines currently available in the market.

Biography

Greg Schoenau is a Professor Emeritus in the Mechanical Engineering Department at the University of Saskatchewan in Canada. He has published extensively and is the author or co-author of more than 150 papers in the areas of energy efficiency and control systems. He has served terms as Head of the Mechanical Engineering Department and as Associate Dean Research for the College of Engineering. In addition he has been active in various scientific and professional organizations.

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