Semi Annual Project Report – 4

NDIC Grant Project: Commercial Application of Soybean Stalk as a New Alternative Fiber in Particle Boards

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This is a forth report which summarizes the project activities between November 2015 and July 2016. The research funds for this project are provided by NDIC and Masonite PrimeBoard Company located in Wahpeton, ND. The main goal of this project is to explore and demonstrate the feasibility of using soybean stalks as an alternate material for manufacturing particle boards. The specific tasks set to achieve the project goal include (1) understanding the material collection and transportation logistics, (2) equipment and machinery changes required to efficiently process soybean stalks, and (3) optimization of the formulations for manufacturing soy stalk based variable density particle boards.

The investigator from NDSU (Dilpreet Bajwa) met with their collaborators from Masonite PrimeBoard (Andrew Sutherland, New Plant Manager) on July 15, December 17th 2015, March 16 and April 8th, 2016 along with graduate student Evan Sitz to discuss project progress and share the results of the work that has been going on at NDSU. The project team again revisited the research plan to ensure project tasks are planned and executed satisfactorily. It was again decided that communication between all collaborators, students and funding agency be conducted seamlessly via emails or visit to Masonite PrimeBoard plant in Wahpeton, ND. The company also gave an update on the current material processing issues and discussed various items related to incorporating soy stover in the wheat straw. It was decided that communicating every month should help to meet all the deadlines.

Described below are some of the major highlights of the last six months (June 2015 – October 2015) work on the project followed by additional detail specifically discussing the contributions made by each party.

Project Update

NDSU (D. Bajwa, S. Bajwa, E. Sitz)

In the last seven months the research work focused on primarily material processing, identifying the factors that influence the production of fines when particleboards are made using soy straw and wheat straw. The hammer mill and sieve shaker purchased through the NDIC funding was extensively helpful to understand how material properties can influence the production of fines.

Hammer Milling of Straw Fibers

The primary objective of this task was to identify the impact of processing variables on the particle size and production of fines. Both wheat and soybean straw fibers were milled using a W-6-H Model Hammer Mill (Schutte Buffalo, Buffalo, NY). A picture of the hammer mill used can be seen in Figure 1. Two different screen sizes (round holes; 3/8" and 1" holes), three different milling speeds as controlled by the variable frequency drive (equivalent hammer tip speed; 26.9 m/s, 35.9 m/s, 44.9 m/s), and three different fiber moisture contents (5 wt%, 15 wt%, 25 wt%) were tested in accordance with the design of experiment.

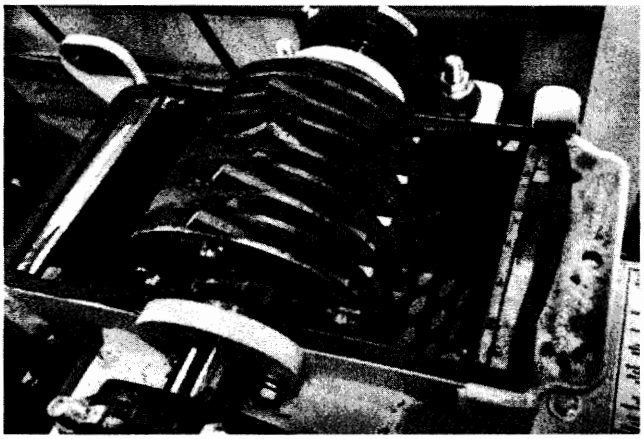

Figure 1. Schutte Buffalo Hammer Mill with Inset Showing Hammers

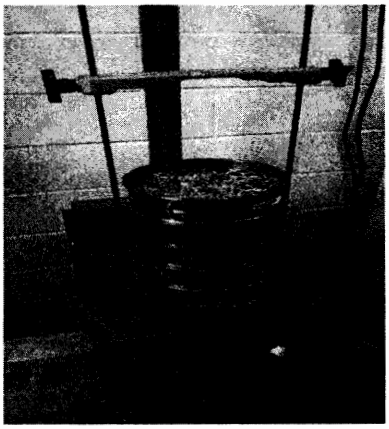

Figure 2. Seive shaker with seives

Characterization of Fiber Distribution

Once the hammer milling of all wheat and soybean fibers at each condition were completed, the fines content, and viable fraction for each sample set needed to be obtained. The fiber distribution was found by using a Humboldt H-4325 Series Sieve Shaker to separate the different fiber sizes from the milled samples. A picture of the sieve shaker is shown in Figure 2. Four different sizes of sieves were used as an adaptation of ASTM E1757: a 20 mesh sieve, a 40 mesh sieve, a 60 mesh sieve, an 80 mesh sieve, and a final catch pan to catch particles finer than 80 mesh. Statistical analysis was conducted on the data obtained in this research to gain objective results on the effect that each variable had on the response values considered.

Results

The results of hammer milling of soy stover and wheat straw at various conditions were evaluated by analyzing the fines content and viable fraction produced after processing of the fibers. The results of several processing conditions with multiple replications show that the lowest fines content fraction observed occurred for several conditions, with the lowest finest content being

0.30% ± 0.04% for soybean at 15% moisture using a 44.9 m/s hammer tip speed and 1" round holes screen. The highest fines content was found to be 2.63% ± 0.61% for wheat at 25% moisture using a 35.9 m/s hammer tip speed and 3/8" round holes screen. The highest viable fraction content was 32.62% ± 2.51% for soybean at 5% moisture using a 44.9 m/s hammer tip speed and 3/8" round holes. The lowest viable fraction was 4.77% ± 1.16% for wheat at 15% moisture using a 26.9 m/s hammer tip speed and 1" round holes. From the ANOVA it was seen that all four main factors (material type, screen size, moisture content and hammer tip speed) had a significant effect on the fines content, and the fines content was also significantly influenced by several higher order interactions between factors. Specifically the wheat straw's fines content and viable fraction were both significantly affected by the fiber's moisture content, the screen's hole sizes, and hammer tip speeds. The soy stover's viable fraction was significantly affected by the fiber's moisture content, the screen's hole sizes, and hammer tip speeds. However, it was found that for the fines content, the hammer tip speed has negligible effect on the fines content, while the screen size and moisture content proved to be significant effects.

Overall for both wheat straw and soy stover, the optimal levels to be used in an industrial application are wholly dependent on the cost of production. Reduction of fines helps to keep retention of fibers high, as the fines are unrecoverable for usage in board production. However, it is also possible that the increase in the viable fraction and subsequently smaller amount of material that needs to be further processed could outweigh the financial loss of the fines. Further economic analysis of the production with material costs and processing costs could potentially be performed to find what conditions induce the least cost solution, but no claims can be made in that regards based solely on this research.

Future Tasks

The next two tasks will focus on manufacturing particleboards both in laboratory and at the Masonite PrimeBoard production facility in Wahpeton, ND using wheat and soy stover and evaluating their physical and mechanical properties followed by economic analysis of harvesting, bailing and transporting soy stalk to the production site. The results from that work will help to identify the optimal ratio of two different fibers that can be used in production so that particleboards quality and performance is not compromised. The economic analysis will be help to compare the cost of using soybean straw versus wheat straw.