Semi Annual Project Report - 2

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

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This is a second report which summarizes the project activities for the period from October 2014 to April 2015. The research funds for this project were provided by NDIC and Masonite PrimeBoard Company located in Wahpeton, ND. ***The goal of this project is to explore and demonstrate the feasibility of using soybean stalks as an alternate material for manufacturing particle boards***. The various 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 investigators from NDSU (Dilpreet Bajwa & Sreekala Bajwa) met with their collaborators from Masonite PrimeBoard (John Robinson and Andrew Sutherland) met at the beginning to discuss and develop a comprehensive plan that can lead to successful completion of this project, and has been communicating on a bimonthly basis to discuss problems and progress. **Evan Sitz, a graduate student in Mechanical Engineering Department was hired in September 2014 to work on this project**. Additional communication between all collaborators, students and funding agency was carried out seamlessly via emails.

Described below are some of the major highlights of the last six months (Oct 2014 – April 2015) of the project followed by additional detail specifically discussing the contributions made by each party.

NDSU (D. Bajwa and S. Bajwa) – The PIs received the primary equipment required for sizing and processing of raw materials, and testing of finished product. A new hammer mill with multiple screens was purchased from Schutte Buffalo and installed in the Pilot Plant of Agricultural and Biosystems Engineering building at NDSU.

Two main tasks conducted by researchers at NDSU include 1) Processing of soybean and wheat stalks 2) Manufacturing of particle boards and testing

Task 1 - Hammer milling of straw (Soy and Wheat) is an integral step involved in the processing and has been incorporated into the fiberboard and resin testing in order to identify optimal processing conditions for producing viable fibers from baled straw. Several material processing experiments were run using hammer mill to size soy stalks to evaluate the impact of operating and material conditions on material loss as fines. The effect of straw moisture content, milling speed, and screen size used in the fiber milling process on the amount of fines produced from the process were quantified; larger fines content has been shown to deteriorate particleboard performance and generally reduce processing efficiency. Wheat and soybean straw fibers were milled, under the processing conditions of the straw as follows: fiber moisture content was set at 5 wt.%, hammer tip speed set at 88.2 ft./s, 117.8 ft./s, and 147.3 ft./s; and screen sizes of 3/8" and 1" round holes. Initial testing has shown that milling speed did not affect the amount of fines

in soybean straw while wheat fibers produced more fines content as milling speed increases. Initial testing has shown that more fines were produced at lower fiber moisture content.

Task 2 - A second set of experiments focused on the manufacturing and testing of the fiber boards. Several tests were performed to characterize the properties of medium density particleboards composed of wheat and soybean fibers as well as soybean based resins. These tests include initial resin characterization for potential resin mixtures, testing of the mechanical properties of particleboards for preliminary formulations. Preliminary resin characterization was carried out to determine viable resin mixtures to be used in the preliminary and final fiberboard formulation. Four resins that are commonly used in the fiberboard processing industry were identified for use, including methylene diphenyl diisocyanate (MDI), phenol formaldehyde (PF), urea formaldehyde (UF), and melamine urea formaldehyde (MUF). Lap shear testing was used to evaluate the adhesive shear strength of the resins, with the four resins mixed at various ratios by weight. Five formulations of particleboards were created using various mixtures of wheat and soybean fibers. Mechanical testing was performed on the particleboard formulations in accordance with ASTM D1037, with flexure testing, water absorption, internal bond strength, and screw withdrawal resistance tests being performed.

Masonite PrimeBoard (J. Robinson and A. Sutherland) – In the last six months, Masonite PrimeBoard purchased additional soybean straw for use in their particleboards as well as conducted several commercial trials to understand the processing, drying and refining of the material. To date they have purchased over 2,500 tons of soybean straw valued over $200,000. Currently the material is being stored in the open area outside their manufacturing facility, similar to how they store wheat straw.

Material Collection and Transportation - Most of the soybean straw was procured from within 50-75 mile radius of the manufacturing facility. The optimal collection and bailing method was found to be using private contractors (bailers). The standard bale sizes that can fit the current processing equipment include 4'x4' or 3'x4' bales. The weight of the bale has to be around 1000 lbs. The freight and transportation cost of these bales ranges from 10-15 $/ton.

Some of the initial processing trials conducted on the production lines using soybean straw and wheat straw blends have shown promising results. The soybean straw had lower moisture content than wheat straw therefore it required less drying. However the soybean straw was less bulky (higher bulk density) and much stronger than wheat straw, requiring additional processing. The processed soybean straw material exhibited stringy strands. Additional processing has also caused production of more fines which is a negative attribute. The material processing data generated by NDSU will be incorporated into future trials that may help to reduce the fines. The particleboards made from soybean and wheat straw blends exhibited mechanical properties comparable to 100% wheat straw boards. A series of trials are planned in coming months that will focus on modifications of processing equipment and raw material properties as well as composition of the particleboards.

Future work will focus on the fiber hammermilling operation and identify the changes required in the current processing equipment for minimizing the fines, and improving the fiber aspect ratio.

Particleboard manufacturing trials will be conducted at Masonite's manufacturing site. The particleboards will be evaluated for their quality and performance characteristics.