Semi Annual Project Report – 5

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

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Report Date: January 17, 2017

This is a fifth report that summarizes the project activities between August 2015 and January 2017. The research funds for this project – "Commercial Application of Soybean Stalk as a New Alternative Fiber in Particle Boards" 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. In the last six months research focused on the evaluating the material processing variables and analyzing the data obtained from processing and testing particleboards.

The investigator from NDSU (Dilpreet Bajwa) met with their collaborators from Masonite PrimeBoard (Andrew Sutherland, New Plant Manager, and Evan Sitz, New Engineer) on January 13th to discuss project progress and share the results of the work that has been going on at NDSU. It is worthy to mention that Evan Sitz (a graduate student) who worked on this project for two years was hired by Masonite PrimeBoard as an engineer. The project team again revisited the research plan and related tasks to ensure project tasks are being executed satisfactorily. All the goals were reviewed to check if any critical task was missed in the last two years. Importance of communication was again stressed between all collaborators, students and funding agency. It was decided we meet more frequently in Wahpeton, ND in the next few months and share information via emails, with Masonite PrimeBoard plant personnel. The company also gave an update on the current material use, processing and discussed various items related to incorporating soy stover in the wheat straw.

The major highlights of the last six months (August 2016 – January 2017) work are described below followed by additional detail specifically discussing the contributions made by each party.

Project Update

NDSU (D. Bajwa, S. Bajwa, A. Norris)

In the last six months the research work focused on primarily on evaluating material processing, variables, analyzing the data statistically to derive meaningful conclusions. The aim was to identify critical material processing variables that Masonite PrimeBoard can follow while processing new feedstock on their equipment and reduce generation of fines. The particleboards using wheat and soy fibers were manufactured in in the lab and their physical and mechanical properties were again evaluated to confirm the earlier reported findings. The hammer mill, sieve shaker and universal testing machine purchased through the NDIC funding was extensively helpful to evaluate material processing variables and the mechanical properties of the particleboards.

Identification of key variables impacting production of fines

In this task the primary gaol 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) as shown in Figure 1. As reported earlier two different screen sizes, three milling speeds and three different fiber moisture levels were considered in this experiment.

Results

The data analysis showed that the key variables that are related to production of unwanted fines. The 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. The wheat straw's fines content and viable fraction were both significantly affected by the moisture content, the screen's hole sizes, and hammer tip speeds. However for the soy stover's viable fraction was significantly affected by the fiber's moisture content, the screen's hole sizes, and hammer tip speeds. Overall 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.

Physical and Mechanical Properties of the Particleboards

Once the soybean straw fibers, wheat straw fibers, and resins had been obtained the materials were ready to be pressed into a testable board. The fibers were analyzed for moisture content using an Arizona Instrument LLC Computrac® Max® 4000XLMoisture Analyzer (Chandler, AZ). The water and resin was sprayed using an atomizing spray gun, with the fibers themselves being continually agitated in a cement mixer. After sufficient spraying of the resin, the mixture of resin and fibers were laid into a custom produced aluminum mold that would press 305 mm x 305 mm panels. Once the fibers had been laid out, a second, the top half of the mold with a Teflon sheet between it and the fibers was laid onto the top half using guide pins. The two halves of the mold

were then placed into a preheated Carver Hot Press Model 4122 (Figure 2). Once the final press load had been achieved, the mold was held together for 5 minutes, with the load applied to the boards being equivalent to 2117 kPa of pressure on the surface of the pressed board. After cooling and conditioning the boards were tested for physical and mechanical properties using MTS Universal testing machine (Figure 3). The different jigs used to test the particleboards are shown in Figure 4 a-c.

Figure 1. Hammer Mill

Figure 2. Carver Hot Press

Figure 3. MTS System

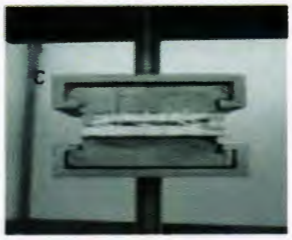

Figure 4. Test jigs a. Three point bending jig b. Bending test c. Internal bond test

Physical and Mechanical Property Test Results

The moisture absorption tests showed that the resin choice and fiber choices were the only significant factors affecting the water absorption. The model accuracy was given by R2 = 86.04%, with adjusted R2 = 83.42%, indicating the model has good adequacy in determining the variability in water absorption properties. The statistical test results for modulus of rupture show that the resin and fiber type and the interaction between the fiber choice and the edge or center sample position were the most influential factors. The model accuracy was given by R_2 = 75.06%, with adjusted R_2 = 70.57%,

indicating the model has moderate accuracy in determining the variability in MOR properties. The modulus of elasticity test results shows that the resin was the most influential factor, while fiber choice does not have a significant effect. The model accuracy was given by R2 = 52.76%, with adjusted R2 = 48.38%, indicating the model has poor accuracy in determining the variability in MOE properties. For internal bond the resin choice and fiber choices as well as their interaction were significant factors in affecting the internal bond strength. For screw withdrawal test resin, fiber type, the sample's position within the board and the interaction between the fiber choice and the resin choice were the most influential factors. It can be concluded that for both wheat and soy straw, the optimal levels to be used in an industrial application are wholly dependent on the cost of production. Soy straw is effective alternative to wheat straw. Although medium density wheat and soy straw board don't meet ANSI 208.1 or 208.2 requirements, it is feasible that boards could still be used in low load applications that do not require the standards of ANSI boards.

Masonite PrimeBoard Tasks

Our industrial partner Masonite PrimeBoard mainly focused on the following tasks in the last six months:

1. As planned in the research PrimeBoard plant continued using soy straw in their production run. In the last six months they used approximately 500 thousand pounds of soy straw. The inclusion of soy straw required some minor adjustments on the initial processing side.
2. Several material processing and handling trials to reduce production of fines were conducted based on the preliminary information obtained from NDSU work is helping them to run trials.
3. The company reported that the storage life of soy stalk is better than wheat straw. Although color was visible on soy stalk bales but the product quality is better than wheat straw. This information will help them to procure and store soy straw for longer period.
4. One challenge with soy straw is the contamination in the straw. Due to heavy rains last year the bales had soil, corn beet etc. They are exploring a better time for collecting, bailing and transporting the material to their plant.
5. They are also studying the impact of moisture on processing the raw material in winter.

Future Tasks

The main objective left in the project is the economic analysis of harvesting, bailing and transporting soy stalk to the production site. The economic analysis of the material collection and transportation cost as well as processing costs will be performed to find what conditions induce the least cost solution. The work related to these task will be carried out in next 8-10 months. The results from this work will help to identify the optimal ratio of two different fibers that can be used in production of particleboards of high quality.