

SUMMARY REPORT—CONTRACT R-023-032
APPLICATION OF AGRICULTURAL BYPRODUCTS
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Jamileh Shojaeiarani and Dilpreet Bajwa, Dept. of Mechanical Engineering, NDSU

Most of the work in this period focused on making pellets with different fraction of materials and testing the mechanical durability for those pellets. There were two experiments that were conducted in the laboratory. A laboratory scale durability test machine was fabricated to conduct mechanical durability tests.

The materials that were tested included: Sunflower Hulls, Soy Stover, Culled Beans and Wood Flour

Experiment 1 – To understand the effect of different fractions of raw material on solid biofuels durability:

Mechanical durability is a measurement of the ability of fuels to resist degradation due to shipping and handling. The mechanical durability index of pellets was determined according to ISO/TC 238 N 117. In order to find the mechanical durability, 500 ± 10 g of pellets were placed in the tumbling box device and rotate for 10 min at 50 ± 2 rpm. After that, the sample was passed manually through a sieve with round screen holes of 3.15 mm diameter in a way that the fine particles were separated without creating any new fine particles. The durability is calculated from the mass of sample remaining after separation of abraded and fine broken particles. Table 1 shows the mechanical durability index of different formulations.

Table 1 - Mechanical durability index for various formulations.

Material Formulation	Durability (%)
80% Wood 20% Sunflower	97.52
60% Wood 40% Sunflower	94.53
80% Wood 20% Bean	96.11
60% Wood 40% Bean	90.27
80% Wood 20% Soy Stover	95.37
60% Wood 40% Soy Stover	88.64

Experiment 2 – Evaluate the effect of particle size on the moisture absorption rate in biofuels:

Solid biofuels are hygroscopic by nature and water absorption can affect solid biofuels efficiency in two different ways: 1) water contents above 16 % can lead to biological degradation 2) reduction thermal efficiency since a portion of the combustion heat is used up to evaporate moisture in the biofuels. In order to evaluate the water absorption tendency in solid biofuels with three different particle size, the pellets made of 20% sunflower hulls and 80% wood of about 100 g from each particle size were placed in a moist chamber (80%, 20 °C) for 25 days. The initial moisture content and weight of pellets were determined and the percentage of the weight change

after every 24 hours was measured and the water absorption due to high humidity is determined. The maximum water uptake was observed in pellets with smaller particle size. The maximum moisture absorption values of different particle size pellets are shown in table 2.

Table 2 - Initial and final moisture content of 20% sunflower hulls and 80% wood flour pellets

Particle size distribution	Initial moisture content (%)	Final moisture content (%)
2 mm	7.76	17.94
3 mm	7.85	16.91
4 mm	7.85	16

Solid biofuels with 4 mm particle size were chosen to find the moisture absorption behavior in solid biofuels. Moisture diffusion coefficient in solid biofuels was calculated based on the shape and size of pellets. Moisture absorption was proved to follow the kinetics of a Fickian diffusion process. Which means the diffusivity in solid biofuels is assumed to be independent of moisture concentration. The moisture increase in solid biofuels is exponential to a point of maximum moisture content.

Observed data shows that moisture absorption rates of solid biofuels reduced very sharply during the initial period and quickly become approximately asymptotic to the time axis. After 17 days the moisture absorption rate of solid biofuels almost reached the final stable values. Figure 1 shows a typical plot of moisture uptake versus square root of time for samples.

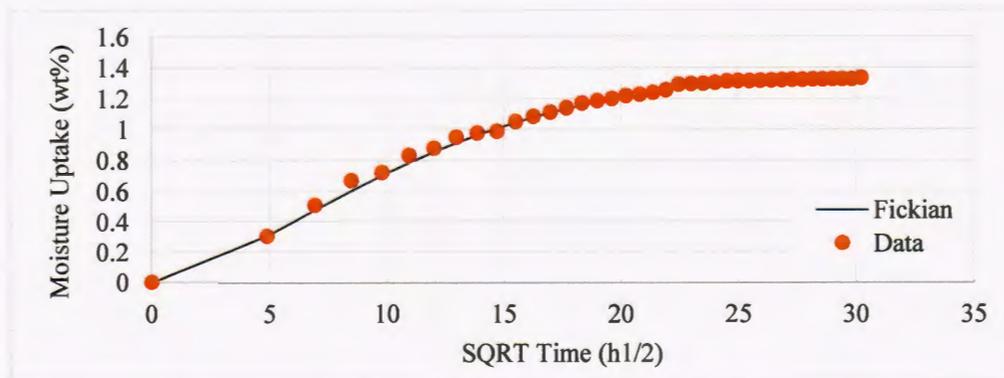


Figure 1. The schematic diagram of moisture uptake in solid biofuels showing experimental data and Fick's diffusion.

Results - The test results show 20-40% sunflower hulls, culled bean can be added to wood to maintain durability index of 90% or above. The particle size doesn't have substantial impact on the final moisture absorption of pellets made using 20% sunflower hulls and 80% wood.