Project Title:
Research to Apply Kinetic Disintegration System to Process Various Biomass Feedstocks for Pelletization

Contract Number: RD3-69

Milestone Report Number 5

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(Public)
MILESTONE REPORT

EXECUTIVE SUMMARY: MNVAP is researching the application of a Kinetic Disintegration System ("KDS") to biomass pellet production. The biomass pellets can then be more efficiently transported, stored and utilized for the generation of power in facilities that cannot accommodate raw biomass as a feedstock. The KDS technology is capable of handling a wide variety of feedstocks that have varying levels of moisture. In previous milestones MNVAP has determined the baseline performance of the KDS. The necessary components to integrate the KDS into MNVAP's pellet manufacturing process have also been fabricated and installed.

Biomass feedstock consisting of alfalfa was processed through the KDS. The biomass particle size and density was evaluated. Smaller particles entering the KDS resulted in improved through-put and improved energy efficiency. The KDS did not perform well with long stem fiber (+/- 6 inches). To address a concern with inconsistent fiber lengths and limited throughput, additional flail bars were added to the KDS for improved velocity and particle size reduction.

Re-design of the KDS and initial test runs allowed for process and performance optimization to allow data collection. Research conducted in Milestone 5 resulted in knowledge gained regarding operating amperages, classifier space requirement that affects fiber length, drying efficiency, and throughput. However, knowledge gained reinforced the need to utilize MNVAP's current drying system along with the current shredder and Williams hammer mill to achieve a particle size smaller than 2 inches to optimize performance of the KDS.

Milestone 5 activities allowed for a re-design of the product flow through the KDS fiber milling process and into the pelleting operation. These changes address two key points in the overall-goal related to gain knowledge in the use of a KDS to process biomass: attain a processing rate of 5-7 tons per hour, and evaluate the KDS particle size and density to identify attributes of various feedstock.

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TECHNICAL PROGRESS: After initial testing conducted by MnVAP, ideal air velocity, material feed rate into the KDS, and flailing knives were engineered in order to obtain data for the Agriculture Utilization Research Institute (AURI) to conduct process and material comparisons between the current pellet manufacturing process and a process that incorporates the KDS.

Research activities conducted within the plant to obtain improved throughput included: 1) classifier horsepower was increased from a 5 horsepower motor to a 10 horsepower motor to increase product throughput; 2) the classifier within the KDS system was also changed with the horsepower to improve particle size consistency (Photo 1); 3) a variable frequency drive (VFD) was added to the airlock entering the KDS system to provide a more consistent throughput and improved final product. The VFD reduced the potential to 'surge' biomass into the processing system; and 4) in preparation for potential plant installation, a concrete pad was added to the processing area due to the required preconditioning requirement from their current system prior to entering the KDS system.

Alfalfa was ground through the shredder, Williams Hammer Mill, and Roskamp 500 Hammer Mill to evaluate the efficiency performance between various particle sizes. Additional information was obtained by testing two additional varieties of alfalfa with increased moisture, originally processed on the Williams for uniformity, to evaluate the efficiency changes within the KDS at various moisture levels. Data collected included energy consumption, product through-put, particle size evaluation, and product density. Moisture ranged from 8.7% to 18.9%. Particle size ranged from less than 1/32 of an inch to ½ inch. Density was 1.92 lbs. per cubic foot to 15.5 lbs. per cubic foot. The through-put for the KDS was 2,160 lbs. per hour, and MNVAP's current biomass processing was 14,400 lbs. per hour. Pelleting data on through-put could not be conducted at greater levels due to multiple plugging issues with the alfalfa ground through the KDS. Information on KDS performance as it relates to various product moistures and particle size distribution is included in Table B.

Particle size distributions of all samples were determined utilizing a vibrating sieve show in Photo 2. AURI observed difficulty in sieving material from the KDS process due to the lack of uniformity in particle size and stringy fibers that would catch on the screens rather than pass through. Results of product particle distribution and density are shown in Table A for the current process and Table B for the KDS process. The smallest sieve size utilized was a U.S. Standard No. 18 or 1.0 millimeter opening.

ADDITIONAL MILESTONES: none

PROJECT STATUS: The smaller particle size (less than 2 inches) entering the KDS for process resulted in improved through-put and improved energy efficiency. The KDS did not perform well

with long stem fiber (+/- 6 inches), as documented in continued milestones with the processing performance on alfalfa from the '500' mill having a greatly reduced through-put, low moisture removal, and poor energy efficiency value.

To address the concern with inconsistent fiber lengths and limited throughput, additional flail bars were added to the KDS system for improved velocity and particle size reduction.

APPENDIX:

Photo 1 Improved classifier with increased horsepower
Table A Average particle size distribution and density from KDS process
Table B Average particle size distribution and density from current MNVAP process
Photo 2 Top sieve of KDS processed alfalfa

Photo 1 – Improved classifier with increased horsepower

Table A – Average particle size distribution and density from KDS process

U.S. Standard Sieve Size	Sieve size information		Shredder out of KDS	500 out of KDS	Williams out of KDS	Williams Mid moisture out of KDS	Williams High moisture out of KDS
	Micron	Inches	% retained				
1/2"	12500	0.5000	0.14	0.12	0.07	0.12	0.20
3/8"	9500	0.3750	0.10	0.07	0.17	0.41	0.17
1/4"	6350	0.2500	0.63	0.24	0.30	1.08	0.39
3.5	5600	0.2230	0.10	0.05	0.07	0.10	0.15
5	4000	0.1570	0.21	0.05	0.06	0.12	0.15
10	2000	0.0787	6.23	0.49	2.68	4.22	1.85
18	1000	0.0394	6.27	2.01	5.99	6.03	8.63
pan	850	0.0331	86.32	96.97	90.65	87.92	88.45
Avg. Particle Size (mm):			0.93	0.87	0.89	0.92	0.90
Moisture (%):			17.48	10.19	11.24	10.36	8.74
Density (lbs./ft^3):			11.25	15.50	**13.00**	9.50	9.75
Throughput (lbs./hr.):			2160	4671	3203	2160	2291

Table B – Average particle size distribution and density from current MnVAP process

U.S. Standard Sieve Size	Sieve size information		Out of shredder	Out of 500	Out of Williams	Mid moisture of Williams	High moisture out of Williams
	Micron	Inches	% retained				
1/2"	12500	0.5000	32.81	0.17	27.55	45.45	45.82
3/8"	9500	0.3750	6.19	0.51	4.88	6.52	2.07
1/4"	6350	0.2500	7.82	0.40	11.15	6.44	4.16
3.5	5600	0.2230	0.51	0.14	2.26	2.59	2.46
5	4000	0.1570	2.19	0.06	1.27	3.13	1.54
10	2000	0.0787	14.97	0.70	16.06	17.46	14.48
18	1000	0.0394	14.15	25.24	21.54	11.14	14.66
pan	850	0.0331	21.35	72.78	15.30	7.26	14.82
	Avg. Particle Size (mm):		3.39	0.92	3.17	5.01	4.14
	Moisture (%):		18.90	12.73	15.38	15.62	16.29
	Density (lbs./ft^3):		2.64	**13.52**	2.80	3.52	1.92
	Throughput (lbs./hr.):			14400			

Photo 2 – Top sieve of KDS processed alfalfa, note the "stringy" fibers