Are Nonwood Fibers Right for You? Maybe, Maybe Not!

2017 IMFA Annual Seminar

March 15-17, 2017

Coconut Grove, Florida

Robert (Bob) W. Hurter, MBA, P. Eng.
HurterConsult Incorporated
4 - 5330 Canotek Road
Ottawa, Ontario, Canada K1J 9C1
e-mail: bob@hurterconsult.com
Web site: www.HurterConsult.com

Topics

1) Molded products in general
2) Why consider nonwood fibers
3) General comments on nonwood fibers
4) Selected nonwood fiber properties
5) Nonwood fiber pulping processes
6) Economic considerations
7) Conclusions

Molded products in general

- **Type-1 Molded Fiber Products - Thick Wall**
  - Manufactured using a single mold with product wall thickness from about 3/16 to 3/8 inches (5mm to 10mm).
  - One surface is relatively smooth, with one side rough – sometimes referred to as “rough molding“
  - Primarily used for support packaging of non-fragile, heavier items. (vehicle parts; furniture, motors etc.). As well as, plant, floral and nursery pots and containers.
  - Oven dried.
  - **Typical furnish: wastepaper – ONP (Grade #6) and OCC (Grade #11)**

Molded products in general

- **Type-2 Molded Fiber Products - Transfer Molded**
  - Manufactured using one forming mold and one transfer mold with product wall thickness from about 1/8 to 3/16 inches (3mm to 5mm).
  - Surfaces are relatively smooth on one side – sometimes referred to as “rough molding“.
  - Most common use is for egg cartons and trays. New designs are used for many types of electronic product packaging such as cell phones, DVD players etc. Also, used for hospital disposables, electrical appliances, office equipment, tableware and fruit and drink trays.
  - Oven dried.
  - **Typical furnish: wastepaper – ONP (Grade #6) and OCC (Grade #11)**

IMFA

Molded products in general

- **Type-3 Molded Fiber Products - Thermoformed (Sometimes called "thin-wall")**
  - Manufactured using multiple heated molds with product wall thickness of about 3/32 to 5/32 inches (2mm to 4mm).
  - Surfaces are smooth and forms are well detailed with minimal draft angles.
  - Products are dried in the mold and no oven curing is needed
    - sometimes referred to as “inline molding”.
  - Due to the hot mold pressing process, the walls are somewhat more dense.
  - **Typical furnish: bleached hardwood Kraft pulp**
    - **Some use of pre-consumer wastepaper**

IMFA

Molded products in general

- **Type-4 Molded Fiber Products – Processed**
  - This type is refers to molded fiber products that require some type of secondary or special treatment other than simply being molded and cured.
  - Examples of Type-4 are:
    - Hot or after pressed - Die-cut or perforated - Printed - Colored - Special mold
    - Special slurry formulations - Embossments - Special design features - Special additives
  - **Typical furnish: probably hardwood Kraft pulp**

IMFA

Molded products in general

- Molded products are for the most part:
  - High volume
  - Low value
  - Cost sensitive

Topics

1) Molded products in general
2) **Why consider nonwood fibers**
3) General comments on nonwood fibers
4) Selected nonwood fiber properties
5) Nonwood fiber pulping processes
6) Economic considerations
7) Conclusions

Why consider nonwood fibers

- **The “Marketing” reasons**
  - Compostable
  - Biodegradeable
  - Sustainable
  - More eco-friendly
  - Saves trees

Why consider nonwood fibers

- **The "Real" reasons**
  - New and growing market segment – the "millennials"
  - Decline in ONP availability
  - Decline in OCC quality due to increased recycle content
  - Local hardwood pulp availability
  - Possible economic benefit

Topics

1) Molded products in general
2) Why consider nonwood fibers
3) **General comments on nonwood fibers**
4) Selected nonwood fiber properties
5) Nonwood fiber pulping processes
6) Economic considerations
7) Conclusions

General comments on nonwood fibers

General comments on nonwood fibers

- Nonwood fibers include a very wide range of raw materials, fiber characteristics and forms of delivery
- Exceptions are typical – “one size doesn’t fit all”
- Nonwoods can be broadly categorized as “common” fibers and “specialty” fibers

IMFA

General comments on nonwood fibers

Common nonwoods

- typically short fiber hardwood substitutes
- pulp normally made into paper at same mill
- pulp mill capacity typically smaller than paper mill capacity – balance softwood Kraft for strength
- very few market pulp mills
  - wheat straw, Hungary
  - bagasse, Thailand
  - bamboo, China

Cereal straws
Corn stalks
Grain sorghum stalks
Reeds and grasses
Sugarcane bagasse
Some bamboos

General comments on nonwood fibers

Specialty nonwoods

- typically long fiber
- properties equal to or better than softwood Kraft pulp
- pulp made into paper on same site or sold as market pulp
- bast and leaf fiber pulps
  - high end specialty pulps
  - very special applications
  - command very high prices
  - usually very small pulp mills

Bast fibers	flax, hemp, jute, kenaf
Cotton fibers	staple, linters
Leaf fibers	abaca, sisal
Some bamboos	

- cotton linters and bamboo pulps
  - may be produced in larger mills
  - linters pulp is expensive
  - bamboo pulp typically in price range of woodpulp

IMFA

Topics

1) Molded products in general
2) Why consider nonwood fibers
3) General comments on nonwoods
4) **Selected nonwood fiber properties**
5) Nonwood fiber pulping processes
6) Economic considerations
7) Conclusions

Selected nonwood fiber properties
Fiber Dimensions

	Length (mm)			Diameter (microns)			L/D ratio
	Max.	Min.	Avg.	Max.	Min.	Avg.	
Bagasse	2.8	0.8	1.7	34	10	20	85:1
Corn stalks	2.8	0.68	1.26	20	10	16	75 :1
Hemp (bast)	55	5	20	50	16	22	1000:1
Hemp (core)			0.5			31	16:1
Kenaf (bast)	7.6	0.98	2.7			20	135:1
Kenaf (core)	1.1	0.4	0.6	37	18	30	20:1
Rice straw	3.48	0.65	1.41	14	5	8	175:1
Wheat straw	3.12	0.68	1.48	24	7	13	110:1
Softwood	3.6	2.7	3.0	43	32	30	100:1
Hardwood	1.8	1.0	1.25	50	20	25	50:1

IMFA

Selected nonwood fiber properties
Chemical Properties

	Alpha Cellulose (%)	Lignin (%)	Pentosans (%)	Ash (%)	Silica (%)
Bagasse	32 - 44	19 - 24	27 - 32	1.5 - 5	**0.7 - 3**
Corn stalks	35 – 40	14 - 16	26 - 28	3 - 7	**0.4 - 3**
Hemp (bast)	55 - 65	2 - 4	4 - 7	5 - 7	< 1
Hemp (core)	39 - 49	16 - 23	16 - 23	3 – 4.5	< 1
Kenaf (bast)	31 - 39	15 - 18	21 - 23	2 - 5	< 1
Kenaf (core)	34	17.5	19.3	2.5	< 1
Rice straw	28 - 36	12 - 16	23 - 28	15 - 20	**9 - 14**
Wheat straw	29 - 35	16 - 17	26 - 32	4 - 9	**3 - 7**
Softwood	38 - 49	23 - 30	19 - 26	1	< 1
Hardwood	40 - 45	26 - 34	7 - 14	1	< 1

IMFA

Selected nonwood fiber properties

Southern BHK

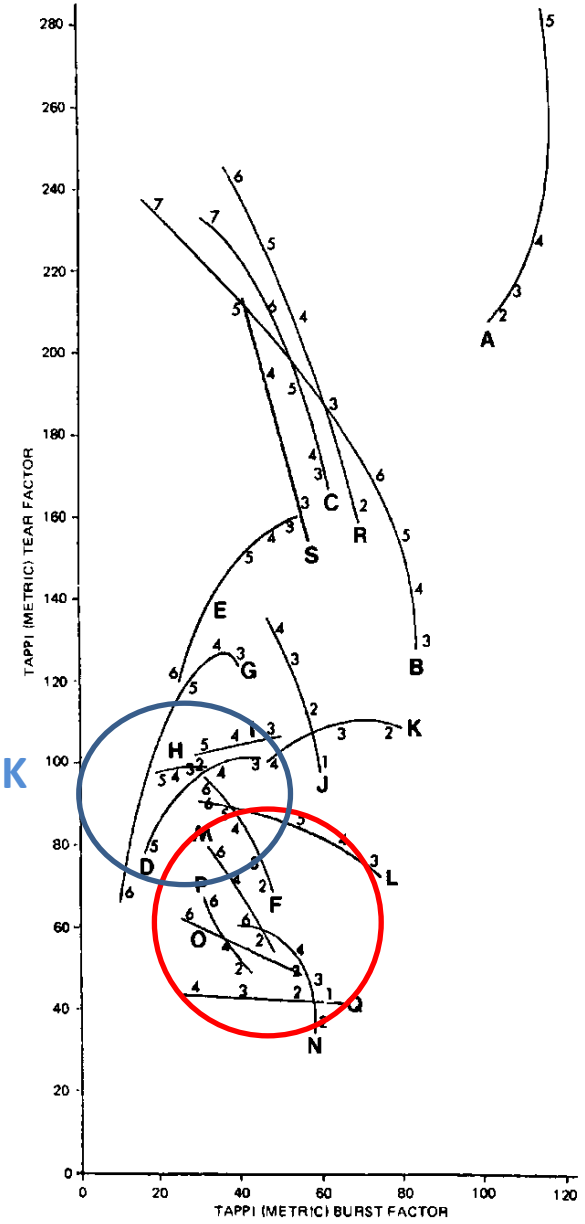

Fig. 3. Laboratory beating — strength tests on chemical pulp from various wood and non-wood plant fibers. Digits superimposed on the curves represent Canadian Standard Freeness tests ÷ 100.

Curve A: Abaca (bast fiber) unbleached sulfate pulp

B: U.S.A. Southern pine unbleached sulfate pulp

C: U.S.A. Douglas-fir unbleached sulfate pulp

D: U.S.A. southern market hardwood bleached sulfate pulp

E: Bamboo unbleached sulfate pulp

F: U.S.A. West Coast bleached sulfite pulp

G: Esparto unbleached soda pulp

H: Reed unbleached sulfate pulp

I: Estimated average mixed tropical hardwoods unbleached sulfate pulp

J: Kenaf whole stalk unbleached soda pulp

K: Eucalyptus (hardwood) unbleached sulfate pulp

L: U.S.A. aspen (hardwood) bleached sulfate pulp

M: Rice straw unbleached soda pulp

N: Wheat straw unbleached soda pulp

O: Bagasse unbleached soda pulp

P: Bagasse bleached soda pulp

Q: Kenaf woody core material unbleached soda pulp

R: Kenaf bast ribbon unbleached soda pulp

S: Sisal pulp

Source: Joseph E. Atchison Consultants Inc.

IMFA

Selected nonwood fiber properties

- Tappi Test Methods
  - Designed for pulp & papermaking
  - Are not directly related to molded products which are 3-dimensional
  - A stronger pulp does not necessarily mean a better pulp in relation to molded products

Topics

1) Molded products in general
2) Why consider nonwood fibers
3) General comments on nonwoods
4) Selected nonwood fiber properties
5) **Nonwood fiber pulping processes**
6) Economic considerations
7) Conclusions

Nonwood fiber pulping processes

- 2014 IMFA presentation
- Nonwoods can be pulped using all of the same processes used for wood:
  - Full chemical – i.e. Kraft, sulfite, soda
    - Caustic soda is most used for nonwoods
  - High yield semichemical – i.e. NSSC, Kraft, soda, carbonate
    - Caustic soda is most used for nonwoods
  - Mechanical – i.e. TMP, CTMP, BCTMP, APMP
- Small mills not suited to full chemical pulping due to chemical recovery requirements

Nonwood fiber pulping processes

- **High yield semichemical pulping**
  - May be pressurized or atmospheric
  - Atmospheric pulping uses more chemicals and more time than pressurized pulping
  - Pressurized pulping typically has higher CAPEX than atmospheric pulping
  - Pulp yield: 65 – 75% on od basis on cleaned raw material

Nonwood fiber pulping processes

- **Mechanical pulping**
  - Single or 2 stage refining
  - Higher energy consumption than semichemical pulping
  - Lower chemical charge than semichemical pulping or no chemicals
  - TMP yield: 95 – 98% on od basis on cleaned raw material
  - CTMP yield: 88 – 93% on od basis on cleaned raw material
  - APMP yield: 85 – 90% on od basis on cleaned raw material

Nonwood fiber pulping processes

- **Alternative chemistry**
  - Potassium or ammonium based pulping chemicals
  - May be possible to field spread a “nutrient rich” co-product – i.e. the black liquor/effluent
  - Vastly (Tranlin, Inc.), Virginia wheat straw market pulp project
    - Based on US patents, high alkaline ammonium sulfite pulping followed by ECF bleaching
    - Co-product fertilizer
    - Will mix black liquor with other fertilizer components on-site to provide balanced fertilizer

Nonwood fiber pulping processes

- **Alternative chemistry** (continued)
  - **BUT … KOH and NH_3OH**
  - Are weaker alkalis than caustic soda (NaOH) so need more
    - i.e. need about 1.3 lbs KOH to replace 1 lb NaOH
  - Are more expensive that NaOH
    - i.e. $0.50/lb 45% liquid KOH versus $0.27/lb 50% liquid NaOH
  - Fertilizers:
    - Contain three basic components: nitrogen, phosphorus and potassium
    - Amount of each various depending on use and location
  - Pulp mill black liquor will contain only one component

Nonwood fiber pulping processes

- **Alternative chemistry** (continued)
  - Dry versus liquid – slow release versus fast release
  - What happens if there is a crop failure for whatever reason?
  - USDA, FDA, EPA & other approvals for field spreading
  - Requires a completely different marketing chain
  - Recommend working with a fertilizer company
  - The perils of co-product economics

Topics

1) Molded products in general
2) Why consider nonwood fibers
3) General comments on nonwoods
4) Selected nonwood fiber properties
5) Nonwood fiber pulping processes
6) **Economic considerations**
7) Conclusions

Economic considerations

- **#1 reason to consider nonwoods**

- Following slides:
  - Generally compare 3 OPEX parameters:
    - Fiber raw material – wheat straw
    - Electric energy
    - Primary pulping chemicals (NaOH, hydrogen peroxide) usage
  - For 2 processes:
    - APMP
    - Semi-bleached high yield semichemical – atmospheric pulping

Economic considerations

- Following slides (continued):
  - Based on generic average information gathered from various published sources
  - Calculations are rough estimates only for comparison purposes
  - Actual inputs and costs will be project and site specific

Economic considerations

Wheat straw	APMP	Semi-bleached high yield semichemical
Finished pulp	1.00 odt	1.00 odt
Add bleaching loss	1.14 odt	1.05 odt
Add pulping loss		1.50 odt
Add preparation loss (15%)	1.34 odt	1.77 odt
Add moisture (13%)	1.54 t	2.03 t
Delivered cost	$85/t	$85/t
Wheat straw cost	$130.90/odt pulp	$172.55/odt pulp
Source: Delivered cost is average from USDA 2016 Billion Ton Study Update.		

Economic considerations

Primary chemicals (wheat straw)	APMP	Semi-bleached high yield semichemical
Caustic soda (NaOH)	60 lb/odt pulp (3%)	200 lb/odt pulp (10%)
	1.14 odt pulp	1.50 odt pulp
	68.4 lb NaOH/odt	300 lb NaOH/odt
	$0.54/lb NaOH	$0.54/lb NaOH
	$36.94/odt pulp	$162.00/odt pulp
Source: Current caustic soda spot bulk price from manufacturers as 100% NaOH.		

Economic considerations

Primary chemicals (wheat straw)	APMP	Semi-bleached high yield semichemical
Hydrogen peroxide (H_2O_2)	80 lb/odt (4%)	100 lb/odt (5%)
	1.14 odt pulp	1.05 odt pulp
	91.2 lb H_2O_2/odt	105 lb H_2O_2/odt
	\$1.03/lb H_2O_2	\$1.03/lb H_2O_2
	\$93.94/odt pulp	\$108.15/odt pulp
Source: Current hydrogen peroxide spot bulk price from manufacturers as 100% H_2O_2.		

IMFA

Economic considerations

Electricity (wheat straw)	APMP	Semi-bleached high yield semichemical
Finished pulp	600 kWh/odt pulp	200 kWh/odt pulp
Electricity cost	$0.0663/kWh	$0.0663/kWh
	$39.78/odt pulp	$13.26/odt pulp

Source: US average electricity cost for industrial users December 2016
https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

Economic considerations

Summary	APMP	Semi-bleached high yield semichemical
Wheat straw	$130.90/odt pulp	$172.55/odt pulp
Caustic soda	$36.94/odt pulp	$162.00/odt pulp
Hydrogen peroxide	$93.94/odt pulp	$108.15/odt pulp
Electricity	$39.78/odt pulp	$13.26/odt pulp
Total	**$301.56/odt pulp**	**$455.96/odt pulp**

Economic considerations

- Other wheat straw pulp OPEX costs:
  - In addition to the foregoing costs, there are other OPEX costs such as:
    - Labor - approx. same for all processes
    - Other chemicals – i.e. chelants – highest for semichemical
    - Steam – highest for semichemical
    - Effluent treatment – highest for semichemical
    - Maintenance
    - Debt service

Economic considerations

- **Wastepaper for comparison – Type-1 & Type-2**
  - Typical furnish: 95% ONP (Grade #6), 5% OCC (Grade #11)
    - Could be 50% ONP, 50% OCC but may affect shrinkage
  - Yield: 95% (based on max. 5% out throws)
  - Electricity: 50 kWh/t
  - Wastepaper pricing: RISI March 2, 2017
    - ONP: Los Angeles $115 – 125/t ($120.00/t avg.), New York $90 – 95/t ($92.50/t avg.), Chicago $85 – 90/t ($87.50/t avg.)
    - OCC: Los Angeles $145 – 155/t ($150/t avg.), New York $130 – 140/t ($135.00/t avg.), Chicago $120 - 130/t ($125.00/t avg.)

IMFA

Economic considerations

Wastepaper	Los Angeles	New York	Chicago
Finished pulp	1.00 odt	1.00 odt	1.00 odt
Add repulping loss	1.05 odt	1.05 odt	1.05 odt
Add moisture (6%)	1.12 t	1.12 t	1.12 t
95% ONP, 5% OCC	$121.50/t	$94.63/t	$86.38/t
Wastepaper cost	$136.06/odt pulp	$105.97/odt pulp	$96.73/odt pulp
50% ONP, 50% OCC	$135.00/t	$113.75/t	$106.25/t
Wastepaper cost	$151.18/odt pulp	$127.38/odt pulp	$118.98/odt pulp

IMFA

Economic considerations

Electricity (wastepaper)	Los Angeles	New York	Chicago
Finished pulp	50 kWh/odt pulp	50 kWh/odt pulp	50 kWh/odt pulp
Electricity cost	$0.1105/kWh	$0.0582/kWh	$0.0608/kWh
	$5.53/odt pulp	$2.91/odt pulp	$3.04/odt pulp

Source: US average electricity cost by state for industrial users December 2016
https://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_6_a

Economic considerations

Wastepaper			
	Los Angeles	New York	Chicago
95% ONP, 5% OCC	$136.06/odt pulp	$105.97/odt pulp	$96.73/odt pulp
Electricity	$5.53/odt pulp	$2.91/odt pulp	$3.04/odt pulp
Total	**$141.59/odt pulp**	**$108.88/odt pulp**	**$99.77/odt pulp**
50% ONP, 50% OCC	$151.18/odt pulp	$127.38/odt pulp	$118.98/odt pulp
Electricity	$5.53/odt pulp	$2.91/odt pulp	$3.04/odt pulp
Total	**$156.71/odt pulp**	**$130.29/odt pulp**	**$122.02/odt pulp**

IMFA

Economic considerations

- Other wastepaper pulp OPEX costs:
  - In addition to the foregoing costs, there are other OPEX costs such as:
    - Labor
    - Steam
    - Effluent treatment
    - Maintenance
  - Given the simplicity of the wastepaper processing system, all of the above are likely lower that the wheat straw options.

Economic considerations

Summary	
Pulp type	**Total rough cost for fiber, primary chemicals & electricity**
Wheat straw APMP	$301.56/odt pulp
Wheat straw semi-bleached high yield semichemical pulp	$455.96/odt pulp
95% ONP, 5% OCC – Los Angeles	$141.59/odt pulp
95% ONP, 5% OCC – New York	$108.88/odt pulp
95% ONP, 5% OCC – Chicago	$99.77/odt pulp
50% ONP, 50% OCC – Los Angeles	$156.71/odt pulp
50% ONP, 50% OCC – New York	$130.29/odt pulp
50% ONP, 50% OCC – Chicago	$122.02/odt pulp

IMFA

Topics

1) Molded products in general
2) Why consider nonwood fibers
3) General comments on nonwoods
4) Selected nonwood fiber properties
5) Nonwood fiber pulping processes
6) Economic considerations
7) **Conclusions**

Conclusions

1) Economics should be the #1 driving force for using nonwoods.

2) For small nonwood pulp lines (likely <100 odt/d), process selection will be critical to economics

3) Nonwoods can be and are used to make molded products, mainly Type-3.

4) With current wastepaper pricing & processing simplicity, nonwoods are not cost competitive in Type-1 and Type-2 molded products.

5) Increased wastepaper prices in the future may change the economics for using nonwoods in Type-1 and Type-2 molded products.

Are Nonwood Fibers Right for You? Maybe, Maybe Not!

Any Questions?