PFI Annual Conference 24- 25 July, 2011

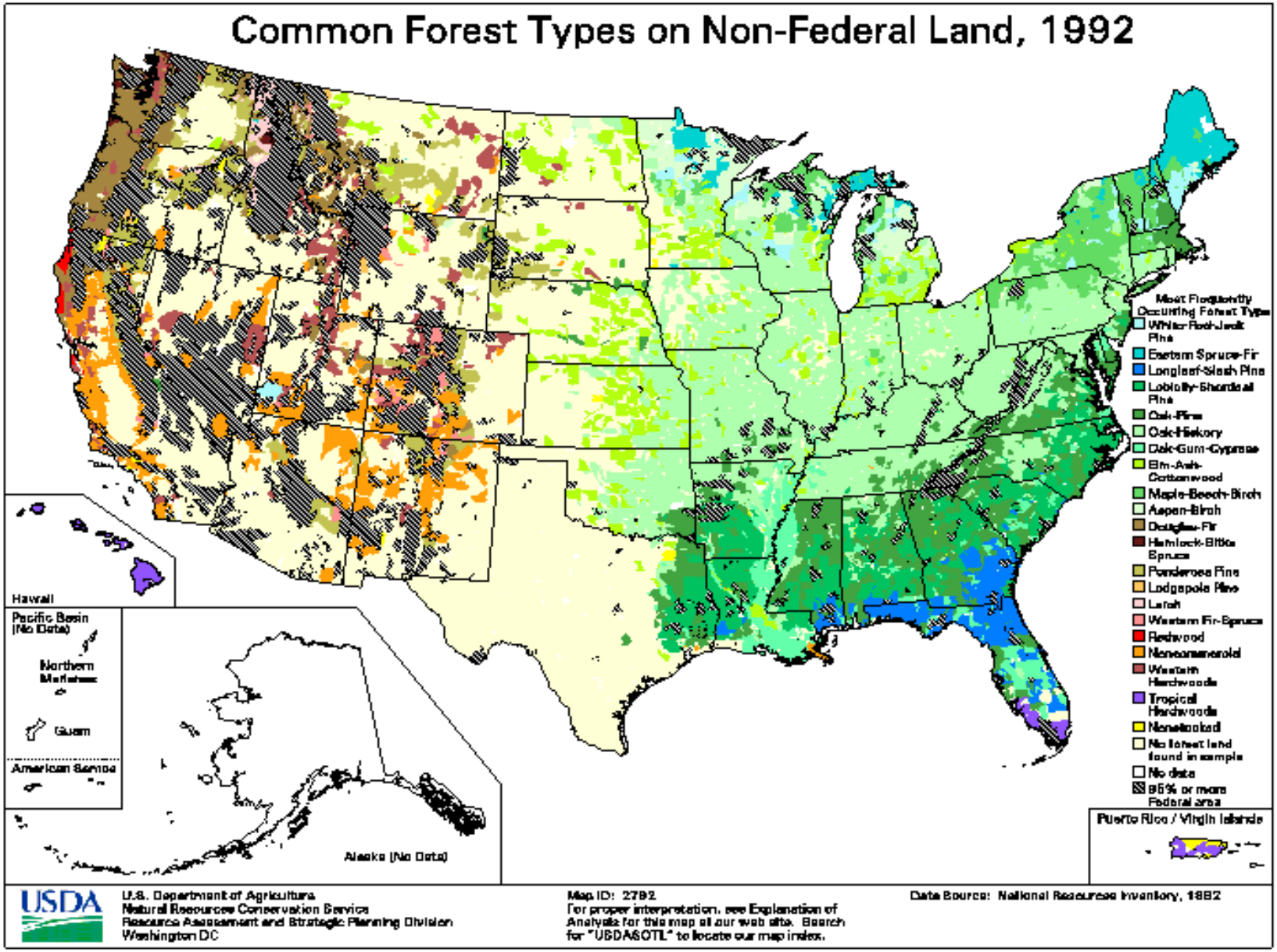
Pellet Plant Optimization and Efficiency

Pellet Plant Optimization and Efficiency Presentation Outline

1. Minimizing Raw Material Variances
2. Optimizing Green Raw Material Size Reduction
3. Optimizing Drying
4. Optimizing Fine Grinding
5. Optimizing Cooling and Screening
6. Optimizing Storage and Outloading

Minimizing Raw Material Variances

External Selection


Common Forest Types on Non-Federal Land, 1992
Most Frequently Occurring Forest Type
White-Red-Jack Pine
Eastern Spruce-Fir
Longleaf-Slash Pine
Loblolly-Shortleaf Pine
Oak-Pine
Oak-Hickory
Oak-Gum-Cypress
Elm-Ash-Cottonwood
Maple-Beech-Birch
Aspen-Birch
Douglas-Fir
Hemlock-Sitka Spruce
Ponderosa Pine
Lodgepole Pine
Larch
Western Fir-Spruce
Redwood
Nonoccurring
Western Hardwoods
Tropical Hardwoods
Nonstocked
No forest land found in sample
No data
85% or more Federal area
Hawaii
Pacific Basin (No Data)
Northern Marianas
Guam
American Samoa
Alaska (No Data)
Puerto Rico / Virgin Islands
USDA
U.S. Department of Agriculture
Natural Resources Conservation Service
Resource Assessment and Strategic Planning Division
Washington DC
Map ID: 2792
For proper interpretation, see Explanation of Analysis for this map at our web site. Search for "USDA&OTL" to locate our map index.
Data Source: National Resources Inventory, 1992

Woody Biomass Sources

Energy Crops-
Roundwood

Natural Selection

Purpose Grown

Forest
Residuals

Logging Slash

Chipped in the Woods

Mill
Residuals

Planer Shavings

Sawmill Sawdust

Woody Biomass Forms

Wood Chips

Papermill Chips 1 ½” -

Mixed Chips ¾” -

Micro Chips 3/8” -

Forest Residuals

Chipped in Forest

Shredded at Mill

Mill Residuals

Planer Shavings

Sawdust

Woody Biomass Forms

Wood Chips

Papermill Chips 1 ½” -

Mixed Chips ¾” -

Micro Chips 3/8” -

Forest Residuals

Chipped in Forest

Shredded at Mill

Mill Residuals

Planer Shavings

Sawdust

Minimizing Raw Material Variances

Internal Homogenization

Raw Material FACTS vs FICTION

- FACT- Any mix of hardwood and softwoods or various species can be successfully pelletized by adjusting the equipment and processes.
- FICTION- You do not need to pay much attention to the raw material mix.

- FACT- A basic workable raw material analyzing and mixing systems is required in a mixed species wood pelleting plant
- FICTION- A complicated and expensive raw material analyzing and mixing systems is required in a mixed species wood pelleting plant.

- FACT- Raw Materials with varying moisture contents can be successfully mixed at appropriate points in the process to produce good quality pellets.
- FICTION- Raw materials with varying moisture contents can be thrown into the dryer and come out at a common moisture content.

- FACT- Chip size variance is critical to good drying, grinding, and pelleting
- FICTION- Any available wood chips size and mix is OK.

Homogenous and clean material.

High raw material uniformity assures ease of operation.

Homogenity of raw material for ease of operation

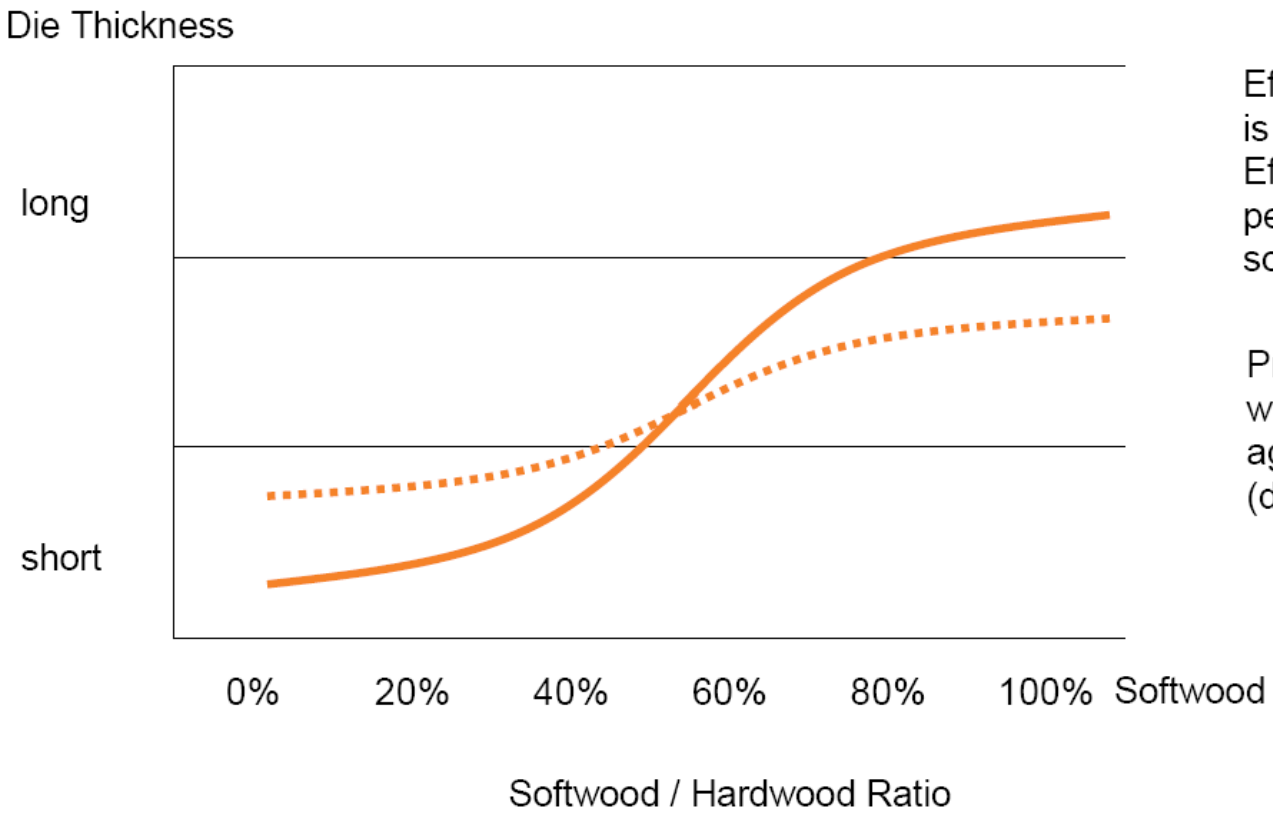
- Uniformity of tree species utilized
- Cleanliness – free of sand or other foreign materials

Hardwood

Softwood

Active die channel length for 6mm pellets	20-35mm	35-45mm
Active die channel length for 8mm pellets	25-50mm	50-85mm
Mixed softwood/hardwood feedstock	Requires feedstock mixing or frequent changes of dies	

Effect of Hardwood/ Softwood Mix on Die Channel Length



Effect on die channel length is equal for both wood types. Effect minimized when high percentage of hardwood or softwood (solid line).

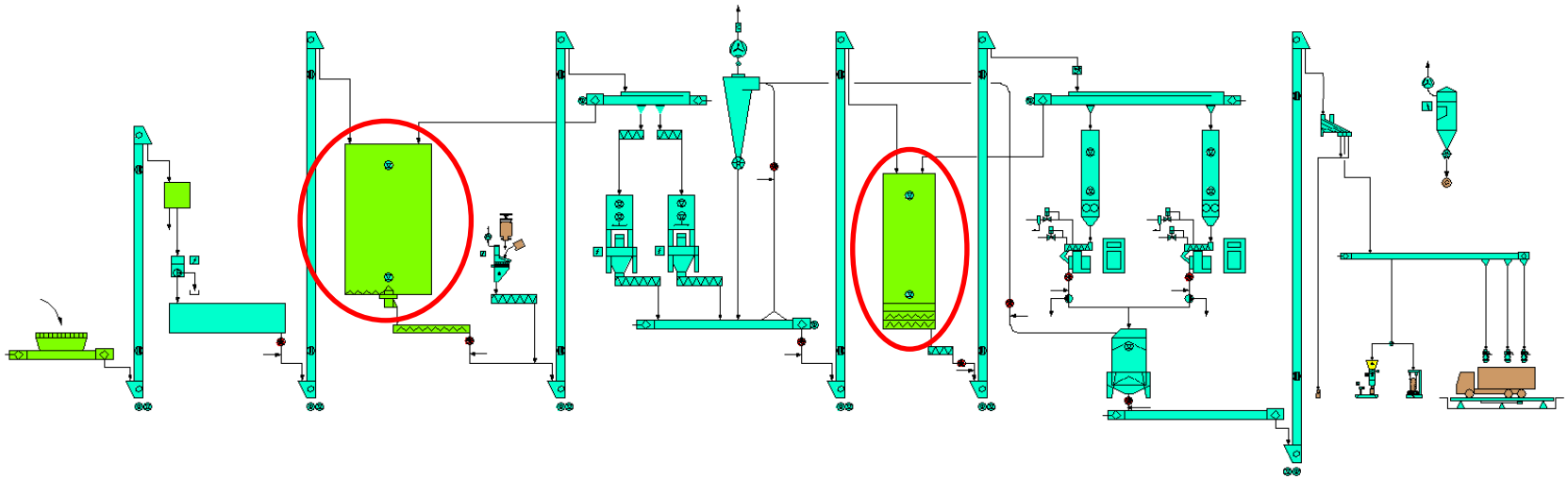
Process parameters like water, steam or binding agent help to reduce effect (dotted line).

Minimizing Raw Material Variances

Moisture Equalization

Grinding and pelleting bins.

Allow equalization of moisture content and de-couple unit operations.



- De-coupling of unit operations by buffer bins increases availability
- Residence time in grinding and pelleting buffer bin allows equalization of moisture content across wood particles – reduced moisture fluctuation equals more stable operation

Moisture Equalization- Pre-Drying

- Covered Chip Storage
  - A-frame Building over Tripper Conveyor

Moisture Equalization- Post Drying - Chip Silo w/ Rotary Screw Reclaimer

Minimizing Raw Material Variances

Wet Material Size

Woody Biomass Forms

Wood Chips

Papermill Chips 1 ½” -

Mixed Chips ¾” -

Micro Chips 3/8” -

Forest Residuals

Chipped in Forest

Shredded at Mill

Mill Residuals

Planer Shavings

Sawdust

Woody Biomass Forms

Wood Chips

Papermill Chips 1 ½" -

SIZE VARIANCE:
Max. 1 ½" x 1 ½" x ¾"
Min. ¾" x ¾" x ½"
Av. 1 ¼" x 1 ¼"x ¾"

MOISTURE VARIANCE in CHIP:
Target +10% MCWB
- 5% MCWB

MOISTURE VARIANCE between CHIPS
Target + 20% MCWB
- 10% MCWB

Mixed Chips ¾" -

SIZE VARIANCE:
Max. ¾"x ¾"x 3/8"
Min. ¼" x ¼"x ½"
Av. ½" x ½"x ¼"

MOISTURE VARIANCE in CHIPS:
Target + 20% MCWB
- 5% MCWB

MOISTURE VARIANCE between CHIPS
Target + 25% MCWB
- 20% MCWB

Micro Chips 3/8" -

SIZE VARIANCE:
Max. 3/8"x 3/8"x ¼"
Min. 1/8" x 1/8"x1/8"
Av. 3/8"x 3/8"x ¼"

MOISTURE VARIANCE in CHIPS:
Target + 5% MCWB
- 5% MCWB

MOISTURE VARIANCE between CHIPS
Target + 10% MCWB
- 10% MCWB

The ADVANTAGES of GREEN MICROCHIPS (3/8” minus)

- DRYING-
  - Average chip moisture is measurable and easily adjusted
  - Moisture within chips is more constant (+/- 5%)
  - Moisture variance between chips is more constant (+/- 10%)

- FINE GRINDING
  - Grinding energy is greatly reduced due to smaller chip size
  - Capacity is increased due to smaller chip size and more consistent moisture content
  - Particle size control is improved

- PELLETIZING
  - Capacity is increased due to more consistent particle size and moisture content
  - Pellet quality is improved due to improved particle size control

Hardwood vs Softwood Green Chip Drying

- HARDWOODS-
  - The harder hardwoods (Oak, Hickory, Cherry, etc.) require up to 10% more energy than soft softwoods for green chip drying
  - The softer hardwoods (Maple, Aspen, polar, etc.) require average energy for green chip drying.

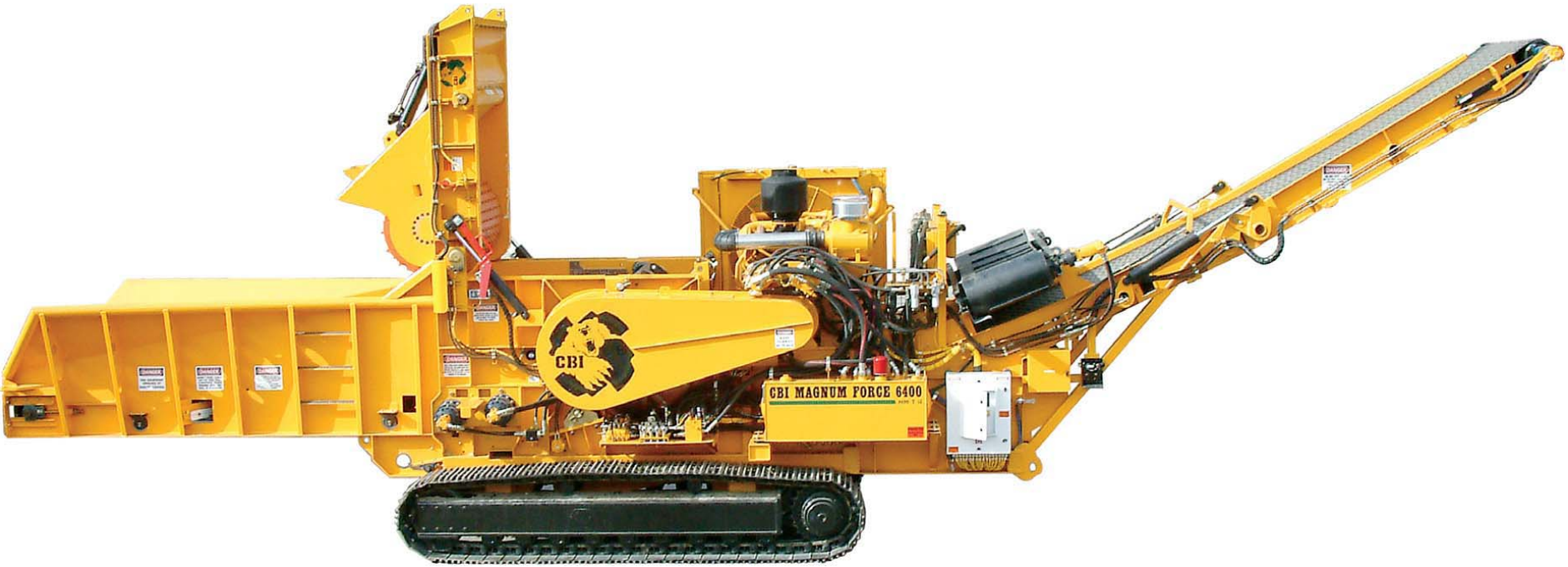
- SOFTWOODS-
  - The softer softwoods (Spruce, Southern Pine, Western Larch, etc.) require less than average energy for green chip drying
  - The harder softwoods (Douglas Fir, Northern Pine, Yew, etc.) require average energy for green chip drying.

soft softwood- hard softwoods- hard hardwoods soft hardwoods

→ → → → → Drying Energy → → → → → → → →

Micro-chipper, Stationary, Disc Style

Micro-chipper, Mobile, Drum Style



Optimizing Raw Material (Chip) Drying

Optimization Process-- DRYING

- Establish consistent optimal production rate (tph)
- Monitor and regulate average dried moisture % (MCWB)
  - 9% MCWB (+/- 1%)
- Minimize moisture content variances between particle sizes
  - Minimize inlet temperature
  - Maximize residence time
- Minimize VOC and particulate emissions
  - Minimize inlet temperature

Optimization- ROTARY DRYERS

- Establish optimum residence time
  - Minimum to dry biggest chip
  - Control with internal flighting
- Establish optimum airflow
  - Minimum velocity to entrain small particles
  - Minimum volume to carry product
- Establish optimum heat
  - Minimum inlet temperature to dry to desired MCWB
  - Balance with airflow

Optimization- CONVEYOR DRYERS

- Establish optimum residence time
  - Minimum to dry biggest chip
- Establish optimum airflow
  - Minimum velocity to pass through material bed depth
- Establish optimum heat
  - Minimum inlet temperature to dry to desired MCWB
  - Adjust by zone for efficiency

When To Use Rotary or Conveyor

Drier type	**Rotary**	**Conveyor**
Particle Size	< 1/4” thickness & < 2” in other 2 dimensions	Sawdust to >1/4” thickness OR > 2” in other dimensions
MC In (% WWB)	45 -65	45 - 65
MC out (% WWB) for Wood Pellet Indus	10	10
Air Temperature In (°F)	600 – 800 (315 – 425°C) (depending on inlet MC)	200 – 300 (90 - 150°C)
Air Temperature Out (°F)	180 (80°C) for 10% outlet MC	20 – 40 (10 – 20 °C) Less than Air Temp In
Heat Source	Gas, Oil, Biomass	
Fines Recirculation Concern	No	Yes
PM Concern Inside Discharge Air	Yes	Less than Rotary
VOC Concern	Yes	No

Optimizing Dried Chip Fine Grinding

Optimization Process– FINE GRINDING

- Temper Dried Chips in Silo
  - 1 hour minimum for surge
  - 1- 8 hours desired for moisture equalization
- Overfeed Fine Grinders
  - Dual level distribution conveyor w/ gates
  - Carry overage back to silo
- Regulate infeed to Hammermills
  - Maximum flow based on Motor load
  - Separate out metal and stones
- Control fine particle size distribution
  - Rotor speed and hammer profile
  - Screen location and hole size

Grinding and pelleting bins.

Moisture equalization to increase productivity and availability.

- De-coupling of unit operations increases average plant availability
- Intermediate storage bins are critical to equalize moisture content before entering moisture sensitive grinding and pelleting unit operations
- Typical example for hammermill capacity depending on moisture content (all other variables constant):

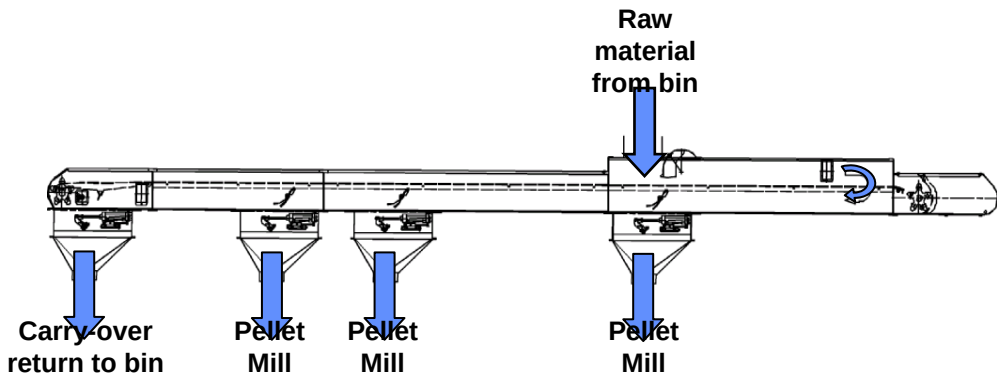
  9.5% H_20 16.5% H_20

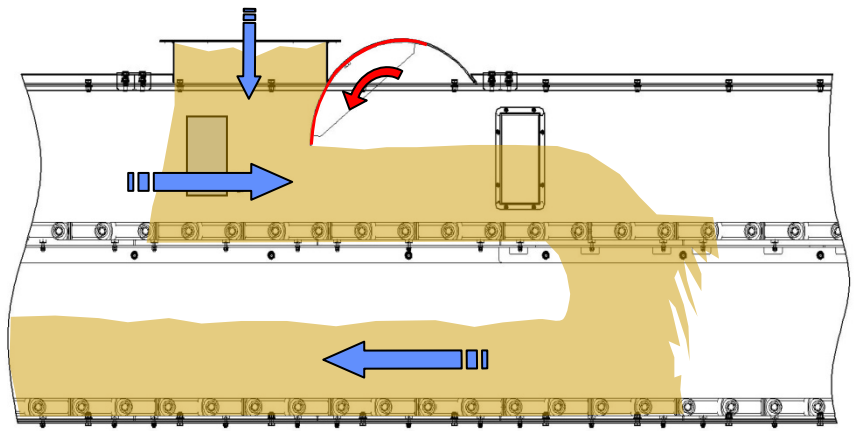
  3.3 t/h 1.4 t/h

Return carry over.

Distribution chain conveyor with two-way casing for return carry over.

- Two-way casing with gravity opening
- Proportioning slide to adjust material flow
- Window to check depth of material
- Rugged, forged and hardened fork-type chain
- Self-aligning roller bearings
- Standardized, low-maintenance slip-on gearing





Key equipment – Hammer mill DFZK Vertica.

The most economical hammermill for Sawdust and small particles

- Medium Capacity to 3 tph
- No need for aspiration
- 20% lower electricity consumption than a comparable horizontal hammer mill
- Significantly lower noise level (83dB) than comparable horizontal hammer mill (>90dB)
- Intrinsically safe operation – full load operation point typically above upper explosion limit
- Very easy and quick change of screens and hammers
- Small footprint

Key equipment – Hammer mill DFZC-1265.

The Workhorse for wood chips and larger particles

- High throughput capacity to 7 tph
- Good particle size control
- Air aided material outfeed
- Easy removal of doors and screen frames for excellent access for change of screens and hammers
- Screen in 4 sections for easy change
- Frequency controlled feeder rate
- Heavy particle and metal separator
- Aspiration sensor to prevent feeding of hammermill when aspiration is not working
- Pneumatic or mechanical conveying

Key equipment – Hammer mill DFZP

Extra Capacity grinding for wood chips and larger particles

- Highest throughput capacity to 15 tph
- Sliding doors for excellent access for change of screens and hammers
- Screen in 4 sections for easy change
- Feeder with integrated heavy particle and iron separator to increase lifetime of screens and hammers
- Frequency controlled feeder rate
- Heavy particle and metal separator
- Aspiration sensor to prevent feeding of hammermill when aspiration is not working
- Automatic reversing rotation for maximum hammer life

Effect of Moisture on Wood Chip Grinding

- 10% moisture content is ideal for wood grinding
  - lowest grinding energy
  - best particle size control
- Overdried material (< 6% MCWB)
  - increases required grinding energy
  - reduced particle size control
- Underdried Material (> 10% MCWB)
  - 10% decrease in capacity for every 1% increase in moisture
  - poor particle shape and size

Effect of Chip Size on Wood Chip Grinding

- 100% passing a 3/8” square sieve is ideal for wood grinding
  - lowest grinding energy
  - best particle size control
- Oversized material (> ½” x ½” x ¼”)
  - increases required grinding energy
  - reduced particle size control
- Undersized Material (< 1/8” x 1/8” x 1/16”)
  - reduced capacity due to clogging
  - poor particle shape and size

Optimizing Ground Wood Pelletizing

BÜHLER

Optimization Process– PELLETIZING

- Temper Ground Wood in Silo
  - ½ hour minimum for surge
  - 1- 2 hours desired for moisture equalization
- Overfeed Pelletizer Hoppers
  - Dual level distribution conveyor w/ gates
  - Carry overage back to silo
- Condition Ground Wood
  - Steam conditioning is best
  - Water conditioning takes 30 minutes +
- Regulate Infeed to Pelletizer
  - Maximum flow based on Motor load
  - Separate out metal and stones

Optimization Process– PELLETIZING

- Maintain Roll/ Die Clearance
  - Inspect Daily
  - Adjust frequently
- Optimize/ Maintain Die Geometry
  - Best Geometry for wood mix
  - Monitor wear and change as needed
- Adjust Machine Locally to:
  - Minimize vibration (roll/ die clearance, particle size, moisture)
  - Maximize pellet quality (adjust moisture, feed rate, etc.)
  - Maximize production (feed rate, conditioning. etc.)

Grinding and pelleting bins.

Moisture equalization to increase productivity and availability.

- De-coupling of unit operations increases average plant availability
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Over-feeding w/ return carry over.

Distribution chain conveyor with two-way casing for return carry over.

- Two-way casing with gravity opening
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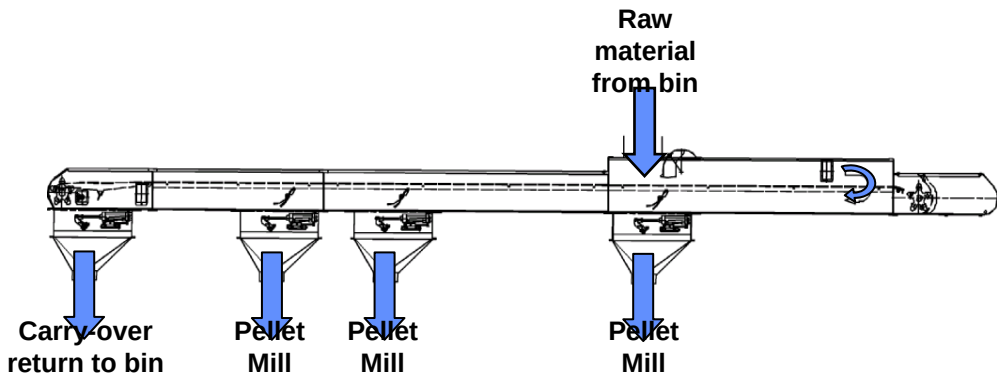

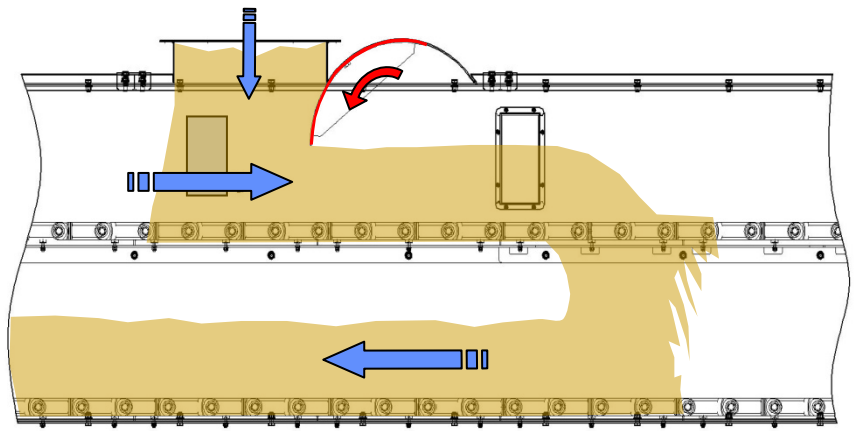

Pellet Quality starts with the right Pelletizer, configured correctly.....

Steam conditioning.

Steam conditioning is the most efficient method to plasticize wood particles.

- Plasticity is a function of temperature and moisture content
- Steam conditioning is significantly faster and more efficient method to plasticize wood
- Overdrying (<6% H_20 content) and high temperature drying lowers the sorption isothermes of wood, i.e. the woods capability to re-absorb water is reduced
- Steam conditioning increases both pellet quality and pellet mill throughput

Automatic inlet bypass.

Standard feature increases machine availability.

- Pneumatically operated inlet bypass to automatically release feeding overload situations
- Clears most overload situation without having to shut down the pellet mill
- Standard feature

Optimizing Pellet Cooling & Screening

Optimization Process– Cooling & Screening

- Minimize Handling of hot pellets
  - Gravity feed into Cooler
- Cool to set pellets
  - Reduce temperature below 50°C
  - Hold for 5 minutes +
- Screen (Sieve) to remove fines
  - Improve bulk/ bagged pellet quality
  - Return fines to process

DFKG- Counter Flow Cooler

- Uniform Cooling through Conical Screen
- Uniform Pellet Spreading
- Low Air Volume Requirement
- Gentle Handling of Pellets
- Constant Product Discharge Rate
- Sealed Clean Chamber
- Trouble Free Operation

DFTA- Oscillating Sieve (Screen)

- 2 -4 fraction sieving
- Dust Tight enclosure
- Low Air Volume Requirement
- Low energy vibratory motors
- Vibration dampened frame
- Gentle Handling of Pellets
- Trouble Free Operation

Optimizing Pellet Storage & Outloading

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Pellet Storage and Outloading

- Multiple Silo storage
- Flexible silo infeed outfeed mixing
- Loadcell batch weighing system
- Rail car or truck loading
- Load leveling option
- Rail Car indexing option

Ship Loading/ Unloading.

Professional handling and storage of Biomass and Wood Pellets

- **Products & services**
  - Design and construction of facilities for unloading and loading ships and for handling and storing grain, oilseeds, and derivatives.
  - Range of supply:
    - Bulk storage equipment.
    - Ship loaders and unloaders.
    - Conveyor components.

- **Customer value**
  - Customized systems assembled from standardized components.
  - High throughput rates.
  - Low maintenance costs.
  - Top uptime and reliability.

Pellet Plant Optimization & Efficiency- SUMMARY

- An efficient, optimized pellet plant is evidenced by a consistent full volume flow of high quality pellets into the storage silos.
- The Woodyard can be decoupled but the Drying/ Fine Grinding/ Pelleting/ Cooling/ Screening/ and Storage processes must be integrated for maximum efficiency
- 95%+ plant availability is not inherent, it requires a properly adjusted and well maintained integrated system
- Since wood is not homogenous, an optimized plant requires frequent adjustments for raw material, ambient, and operational changes