Introduction to Packaging Engineering (2)
Paper Making, Metal Forming

Presented to the Activities Unlimited, Science Club
By Harry Bennett
February 21, 2017

Agenda

- What is Packaging?
- Packaging Technologies
- Focus on Paper Making
- Focus on Metal Forming (cans & sheet metal)
- Questions

Packaging Engineering is an applied science

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All Disciplines of Engineering are Applied Sciences

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Engineering – Applied Science	Basic Science
Mechanical Engineering	Physics – mechanics
Electrical Engineering	Physics – electricity and magnetism
Chemical Engineering	Chemistry
Biomedical Engineering	Biology
Packaging Engineering	**All of the above plus:** **Material science** **Industrial Engineering** **Project Management** **Marketing** **Art and Design** **Communication skills** **Manufacturing** **Distribution**

Packaging Technologies studied at Rutgers

- Printing and Decorating
- Environmental and Sustainability Issues
- Paper and Paperboard
- Paperboard Cartons
- Metal Cans and Containers
- Glass Containers
- Polymer Chemistry
- Shaping Plastics
- Plastic Applications
- Closures
- Adhesives
- Flexible Packaging Laminates
- Corrugated Fiberboard
- Distribution Packaging

Paper and Paperboard

Source and Preparation of Fiber

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- Paper is defined as a matted or felted sheet usually composed of plant fiber
- Paper has been made from:
  - Rags (linen)
  - Bagasse (sugar cane)
  - Cotton
  - Straw
  - **Cellulose fiber (derived from wood)**

Pulping Methods

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- Wood
  - 50% Cellulose
  - Non-fibrous Carbohydrates, Lignin
- Mechanical Pulping
  - Physically grind the wood
  - Breaks the fibers
- Chemical Pulping
  - Chemicals dissolve Lignin
  - Alkali Sulfate (Kraft) Process, Preferred for Soft Woods
  - Acid Sulfite Process

Source and Preparation of Fiber

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- Definition of Board is vague and variable
- ISO
  - >250 g/square meter (51 lb.1000 sq. ft.) = Paperboard
- US
  - **>300 micrometers (.3mm) (0.012") (12 point) thick = Paperboard**
  - **(Reference… Copy Paper = 20 lb.; ~0.004")**

Source and Preparation of Fiber

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Approximate fiber length of cellulose used in papermaking	
Fiber Source	***Typical Fiber Length***
Main Sources	
Hardwood (e.g. poplar, aspen, maple)	2mm/0.08"
Softwood (e.g. pine, spruce, hemlock)	4mm/0.16"
Other Sources	
Straw, bagasse	<2mm/0.08"
Bast (e.g. Linen, cotton)	> 12mm/0.5"
Recycled paper	Varies depending on source

Definitions

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Formation

- Evenness of fiber distribution, uniformity of fiber distribution

Creeping

- Over long loading periods, paper fibers move and distort or creep. Long-term static compressive strength is much less than dynamic compressive strength.

Dry Wax

- Low-density bleached Kraft and sulfite papers are used to produce "dry-waxed" paper.

Definitions

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Wet Wax

- Highly calendared bleached Kraft and sulfites are used for "wet waxing". Wax coats the surface and produces a high surface gloss.

Calendar Process

- After paper is formed and dried, it is usually passed between multiple sets of heavy rollers. The objective is to improve caliper consistency, and iron and smooth out the surface of the paper stock to make it more suitable for printing.

Source and Preparation of Fiber

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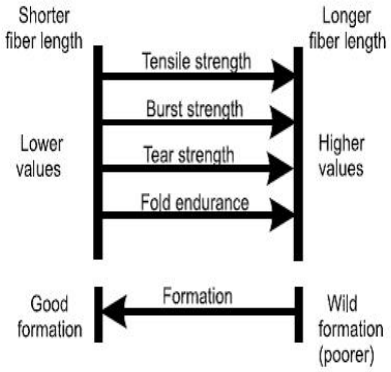
Figure 5.1

Paper qualities and fiber length.



+ Source and Preparation of Fiber

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- Untreated Cellulose is highly absorbent
- Sizing Agents:
  - Group of additives that help control water and ink penetration
- Starches, gums:
  - Improves burst and tensile strength, stiffness and pick resistance
- Wet-strength resins:
  - Improve wet tensile strength retention under high humidity conditions
- "Furnish":
  - Mixture of fiber, water, and additives that is fed into a papermaking machine

Representative Paper-Making Machines

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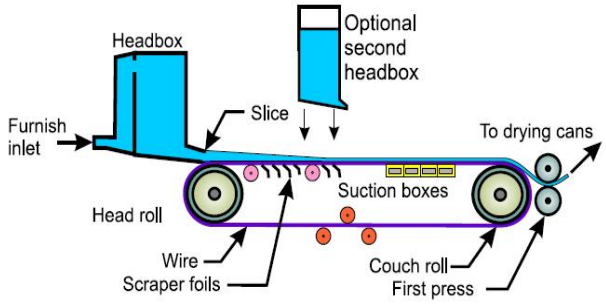

Figure 5.3
Furnish pours out of the headbox of a fourdrinier machine and onto an endless wire or screen where excess water can be drained. The fibers remain trapped on the screen.

Source and Preparation of Fiber

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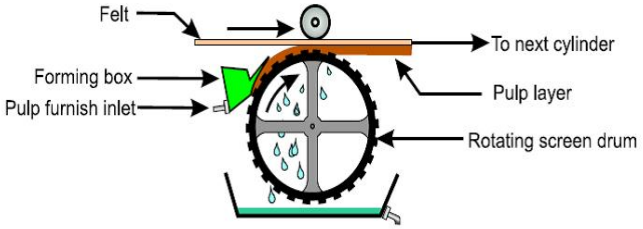
Figure 5.4
A single cylinder station on a cylinder-type machine.



Source and Preparation of Fiber

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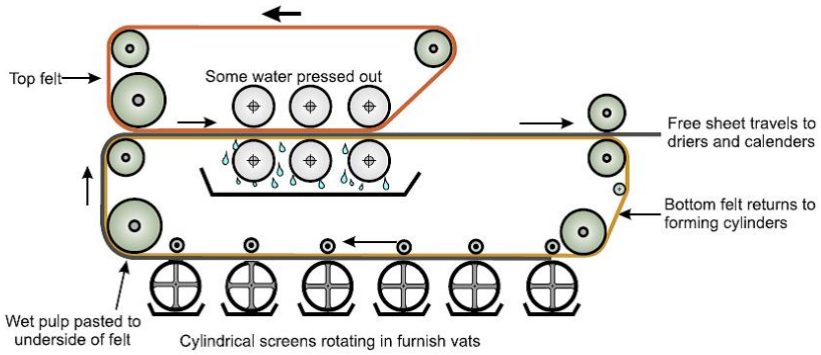

Figure 5.5

A cylinder machine with six cylinders at which paper layers can be formed.

Source and Preparation of Fiber

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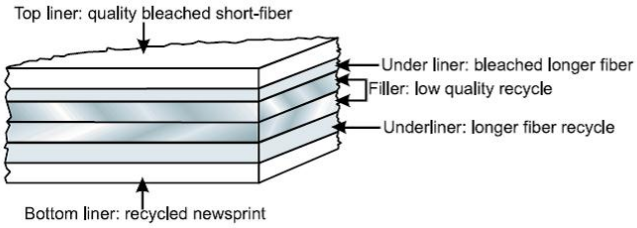
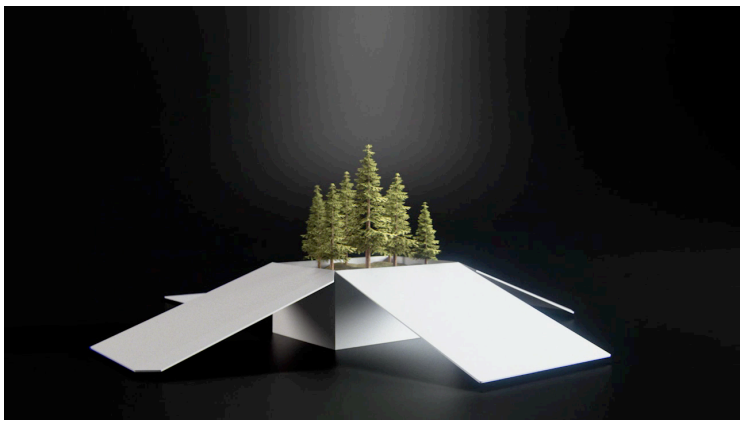


Figure 5.6

Cylinder boards are multi-ply boards. An advantage is that the plies can all be different.

Paper Making



Metal Forming (Cans and Containers)

Metal Container Background

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- Steal
  - One of the older material used for round, square and rectangular boxes and canisters (specialty cookies)
  - Tin plated sheet steal, mechanically seamed or welded (soldered) steal container with friction or hinged lids
- Sanitary Food Can
  - 1800's: Thermal processing of food packed in hand-soldered cylindrical cans.
  - Advantages: Withstand processing temperatures, inexpensive, high speed lines, rigid, recycle, total gas and light barrier

Metal Container Background

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- All steal (3-piece) Containers:
  - Original can, 3-piece, Body plus assembled top and bottom
  - Fabricated from flat sheets, cut to size, bend to shape, mechanically clinched or welded (soldered) to hold final shape
- Impact extruded, (2-piece) Can
  - Body and bottom as single piece,
  - Reduced metal, improved appearance, eliminate a potential leakage site at side seam
- Easy to change the length and diameter of 3-piece can; 2-piece can requires new tooling

Metal Container Background

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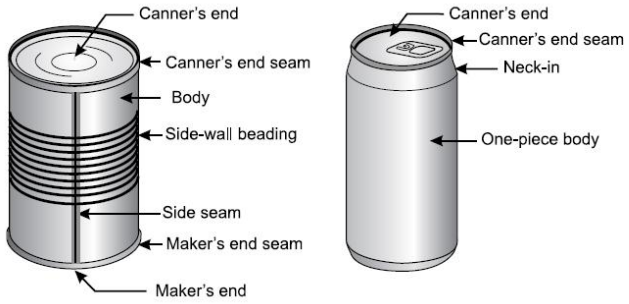

Figure 7.1
Three-piece (left) and two-piece (right) can construction.

Metal Container Background

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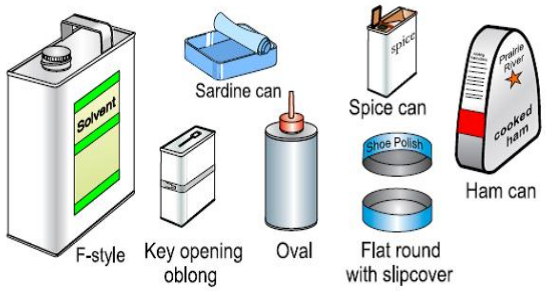
Figure 7.2
Examples of specialized can shapes.



Can-making Steels

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- "Tin" Can
  - Low carbon (black plate) steal (which corrodes easily in presence of moisture)
  - Originally steal sheets were dipped in vats of molten Tin to protect the steal… "tinned canister"
  - Today… electrolytically tin-plated (ETP); ~ 0.38 micrometers (0.000015 inch)
  - Bright appearance, differential application
- Electrolytic chrome-coated steal (ECCS; TFS – Tin Free Steal)
  - Chrome and Chrome Oxides used to protect steal
  - Grey appearance
  - More economical that ETP but can not be welded
  - Often used for can ends

Three Piece Steal Cans

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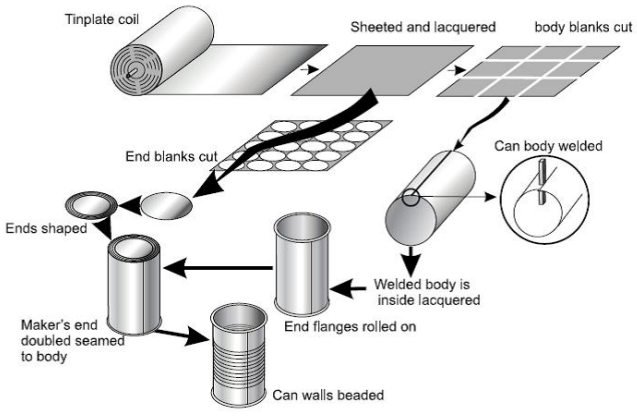
Figure 7.4
Three piece can production.



Three Piece Steal Cans

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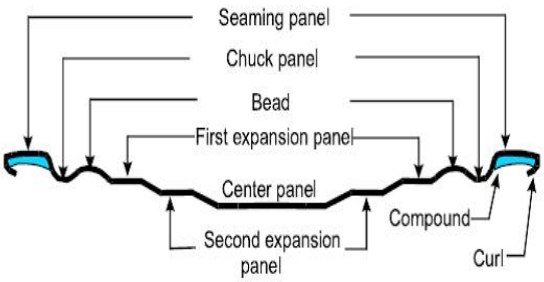
Figure 7.5

Representative can-end embossing pattern.



Three Piece Steal Cans

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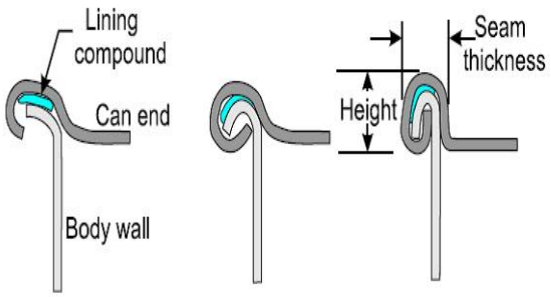

Figure 7.6

Double-seaming is the attachment of the can end to the body. It involves two curling steps.

Three Piece Steal Cans

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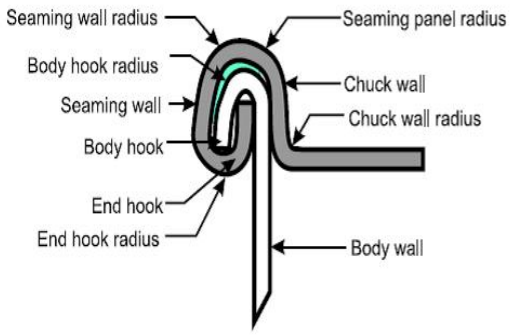

Figure 7.7
The double seam is a critical can component. Every angle, radius and dimension must be correct to ensure a hermetic seal.

Two Piece Drawn Cans

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- 3 methods to make steal or aluminum 2-piece cans
  - Draw
  - Draw and redraw (DRD)
  - Draw and iron (D&I)

Two Piece Drawn Cans

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- Draw Process
  - Shallow profile can (height less than diameter)
  - Drawn from circular metal blanks
  - Side and bottom wall thickness is same as blank thickness
  - Blanks can be decorated before drawing (decoration must be distorted)
- Draw and Redraw Process
  - Cans with height greater than diameter will require a second or third draw
  - First draw produces a shallow cup
  - Subsequent draws reduce diameter as cup is deepened
  - Body flanges are added for assembly of can end

Two Piece Drawn Cans

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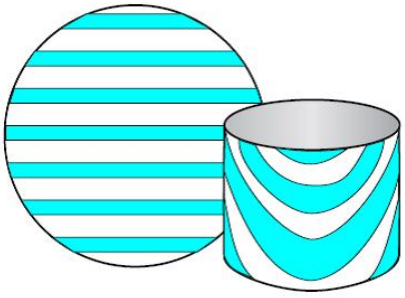
Figure 7.8

Straight lines on a blank (left) become distorted in different directions when drawn into a can (right).



Two Piece Drawn Cans

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- Draw and Iron Process (D&I)
  - Cut blank and draw cup
  - Cup redrawn to finished diameter and pushed through series of ironing rings, each of slightly smaller diameter
  - Rings "iron" the metal into a thinner sheet than the original thickness
  - Bottom of can has original blank thickness; side walls are considerably reduced in thickness; overall metal area of the final can is greater than the original blank
  - Necking operation reduces the end-piece diameter
  - Thin wall cans not suitable for thermal processing; primary use is carbonated beverage cans.

Two Piece Drawn Cans

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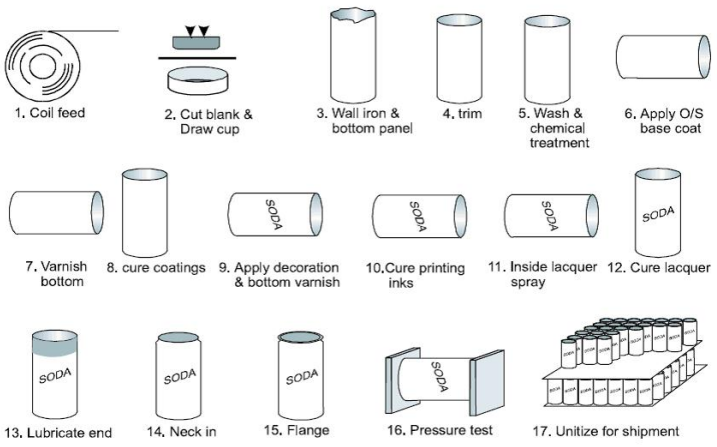

Figure 7.9

The manufacturing sequence for a necked D&I can.

Two Piece Drawn Cans

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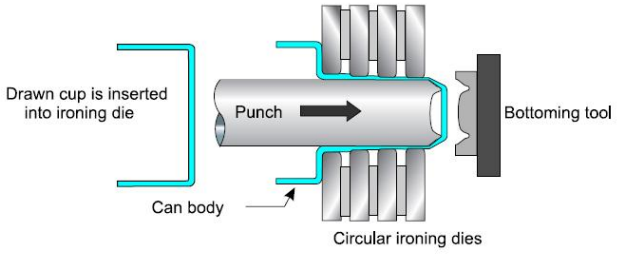

Figure 7.10
In the D&I process, the second draw and ironing stages occur in one continuous movement. The illustration exaggerates the punch and ironing rings. The punch finishes its stroke against the bottoming tool.

Impact Extrusion

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- Impact Extrusion
  - Forms ductile metal into seamless tubes
  - Materials include: tin, lead and aluminum
  - Metal slug is placed on a shaped striking surface or anvil
  - Punch strikes slug with great force
  - Metal flows like a liquid up along side the striking punch
  - Tubes with dispensing orifices start with a hole in the slug.

Impact Extrusion

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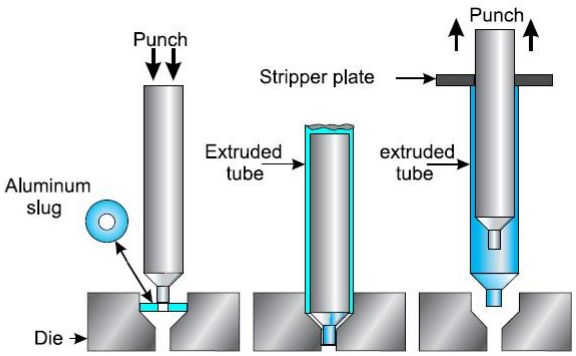
Figure 7.12
Impact-extrusion sequence.



Impact Extrusion

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Figure 7.15
Production sequence of an impact extruded aerosol can. The slug (1) is impacted into a cylinder (2). The top end is trimmed (3), washed (4) and inside coated (5). A white base coat is applied and U.V. cured (6) and then the graphics are applied (7). The end is turned down (8) and then through a multi-step forming sequence the can end is rolled to the standard one inch opening.

Can Dimensioning

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- Nominal dimensions given in 3 digits:
  - 1st = whole inches
  - 2nd & 3rd = 16th of an inch

307-by-314 = 3-7/16s in diameter by 3-14/16s in height

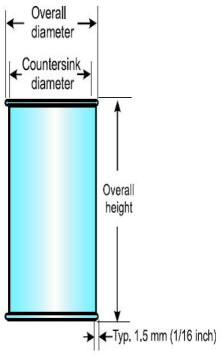

Figure 7.16
Nominal can dimensions.

Decoration

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- Labels
  - Paper or plastic
  - Avoids multiple inventories of cans when there is a large number of SKU's in the same size can
  - Requires label application equipment
- Print directly on metal
  - Lithography is used when can blank is decorated flat; inks and varnishes are baked on or ultraviolet (UV) cured
- D&I cans and other round cans have no registration point and must be printed by offset letterpress
- Shrink Labels
  - Allows preprinting from any printing process for process art; must allow for distortion when applied to can

Metal Forming Video

Questions?

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Thank You

And

Have a Good Day