Cracker Process Unit Operations
Mixing:

- Formulation
- Dough Types
- Mixing Process
Mixing

• The goal of mixing:
  – To evenly distribute the ingredients
  – To transform ingredients into a cohesive, extensible, machinable dough that can be sheeted or laminated into a continuous sheet prior to cutting

• The goal is achieved by controlling:
  – Formulation
  – Order of ingredient addition to the mixer
  – Mixing duration (length of mixing time for each stage)
  – Speed of mixer blades (RPM)
  – Final dough temperature
Mixing: Formulation

*Products are categorized by the balance of flour, sugar, fat & water*

- **High levels of sugar & fat, relative to flour**
  - Dough remains more fluid & less structure is developed

- **High levels of water & flour, low levels of sugar & fat**
  - Dough develops a firm structure by gluten development
Formulation

The ‘Major Ingredients’ used are:

<table>
<thead>
<tr>
<th>Crackers</th>
<th>Very High</th>
<th>Very Low</th>
<th>Strong</th>
<th>Low</th>
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<td>Snacks</td>
<td>High</td>
<td>Medium</td>
<td>Medium</td>
<td>Medium</td>
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<tr>
<td></td>
<td>Medium</td>
<td>Slightly Higher</td>
<td>Medium</td>
<td>Medium</td>
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</tbody>
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Upright Mixer
Mixing: Dough Types

Crackers

• Fermented doughs (sponge + dough)
  – Firm but extensible dough with relatively low sugar and fat

• Chemically leavened doughs
  – Softer & more extensible with moderate sugar and fat

• Sweet Chemically leavened doughs
  – Higher sugar that softens the dough but remains extensible due to high temperature that aids in developing gluten
Mixing Process
Chemically Leavened
Mixing: Chemically Leavened

Stage 1 – Sometimes Called Cream Up

• The goal is:
  – To uniformly disperse minor ingredients into a fat, sugar, or water mixture

• Ingredients added include ...but not limited to:
Mixing: Chemically Leavened

Stage 2 – Sometimes Combined with Stage 1

• The goal is:
  – Complete cream up stage
  – Combine fat phase with water phase

• Ingredients added include …but not limited to:

![Diagram showing Stage 1, water, syrup, and ammonia bicarbonate]
Mixing: Chemically Leavened

**Stage 3**

- **The goal of mixing:**
  - To evenly distribute the ingredients
  - To transform ingredients into a cohesive extensible machinable dough that can be sheeted or laminated into a continuous sheet prior to cutting
  - Add flour and remaining leaveners + enzymes
  - This is the stage when dough is developed

- **Ingredients added include …but not limited to:**
  - Stage 2
  - Flour
  - CAP
  - SODA
  - Enzymes
Mixing: Fermented Doughs

2-stage mixing process (Crackers)

Stage 1 - Sponge Stage:
- Provides unique flavor and flaky texture to the finished product thru microbial fermentation (yeast & bacteria)
- Partial addition of ingredients (i.e., flour, water, yeast bacteria)
- Combine approximately 20-40% of the flour with water and other ingredients for initial fermentation of approximately 18-20 hours

Stage 2 – Dough-up Stage:
- Final Fermentation Stage – 4 to 6 hours
- Incorporate balance of ingredients to form a cohesive dough for machining
- Resting Stage prior to machining
Biscuit Forming: Crackers - Sheeting
Cracker Forming: Sheeting Line

1. Dough Dump
2. Feed Chute
3. Feed Rolls
4. Gauging/Reduction
5. Relax Apron
6. Cutting
7. Scrap Return
8. Stripping Conveyor
9. Topping Conveyor
10. Topper
11. Pan-on Conveyor
12. Oven Band
Cracker Forming: Three Roll Sheeter

1. **Hopper:** Collects the dough from the Pre-Sheeter
2. **Forcing Rolls:** Force the dough from the hopper to the Compression Roll
   - **Feed Rolls:** 1 grooved roll is more usual. It prevents an impression on the final product
3. **Main Roll:** Fixed position roll permits the gap in/out of the Compression Chamber to be adjusted
4. **Finishing Roll:** Guides dough sheet from the sheeter
   - Smooth surface ensures no impression on final product
Cracker Forming: Four Roll Sheeters

1. Hopper: Collects the dough from the Pre-Sheeter
2. Feed Rolls: 2 grooved Rolls allow the dough to be more evenly ‘pulled’ through the Hopper
3. Pressure: Pressure in the gap helps to:
   - Cavity - Produce a smooth edged, even sheet width
   - Compression - Prevent the build up of old dough in the Sheeter
   - Chamber - Consistent density of sheet
4. Finishing Roll: Smooth rolls guide a more even, relaxed dough sheet from the Sheeter
Cracker Forming: Laminators

- The goal is to achieve layering of dough to develop a light tender texture in the finished product.
- Strong, firm doughs that are extensible may be sheeted without tearing or crumbling.
- Prepares an even thickness dough sheet for gauging and cutting.
Cracker Forming: Laminators

Sweep Laminator

- Produces a continuous layered dough sheet

Cut-sheet Laminator

- Individual dough sheets are cut with a knife and layered on top of each other
Cracker Forming: (Trouble Shooting)
Adjusting for holes in a sheet

*Dough leaving the sheeter or laminator has ragged edges, or holes*

- **Causes:**
  - Not enough dough in the hopper or
  - Bridging in the hopper
  - Forcing roll speed too slow or
  - Finishing roll speed too fast
  - Too much dough in hopper
  - Uneven distribution of dough

- **To Correct:**
  - Adjust the correct dough hopper level
  - Increase forcing roll speeds
  - Decrease finishing roll speeds
  - Check sensors are working correctly
Cracker Forming: (Trouble Shooting)
Adjusting For Uneven Layers On The Incline Conveyor

Uneven layers will:
• Effect uniformity of dough weight across the band

This will:
• Cause thickness variations
• Color and moisture variations
• Cause inconsistent stretch (pull) across the sheet width
• Can result in texture variations

To correct:
• Slow down, or speed up Laminator Takeaway Conveyor

Uneven layers should always be corrected! Weights and product color are impacted by uneven layers!
Cracker Forming: (Trouble Shooting)
Sweep Laminators

• To correct a short sheet on incline conveyor increase the speed of the “sweeps”
• To correct a long sheet reduce the speed of the “sweeps”
Cracker Forming: (Trouble Shooting)
Cut Sheet Laminators

- To correct a short sheet increase the period between the sheet being cut

- To correct a long sheet shorten the time between sheet cutting
Cracker Forming: Sheet Reduction
Auxiliary Rolls

- Compress and reduce laminated layers to a single dough sheet thickness
- Gradual reduction = less stress on the dough
  - 2:1 reduction ratio at each roll is suggested
- Number of auxiliary rolls on each line usually vary between 1 and 3
Cracker Forming: Sheet Reduction
Final Gauge Roll

- Regulates the finished weight of the product
- Dough piece weight (too heavy or too light) affects the final product moisture
- Piece weight will affect finished package weights (i.e., SALTINES and BUTTER Crackers)
Cracker Forming: Sheet Reduction (Trouble Shooting)
Adjusting Dough Feed At Final Gauge Roll

*Speeds of Conveyors and Rolls have to be set to supply the correct amount of dough into the Rolls which they are feeding*

**Correct Speed**
- In-feed Conveyor (IC) delivering correct amount of dough
- IC & FGR speed balanced
- Sheet width optimized
- Even weight across
- NO ACTION

**Overfeed/Bunching**
- IC running too fast
  - (Overfeed)
- Dough bunches at entrance to FGR
- Uneven weight
- Sheet width too wide
- SLOW DOWN IC

**Underfeed/Stretching or Ragged Edges**
- IC running too slow (‘starving’)
- Dough stretches into FGR
- Uneven weight
- Holes in dough sheet
- SPEED UP IC
Cracker Forming: Rotary Cutting

1. Cutting Roll
   – Designed for an individual product
   – Piece shapes and dockers are embossed
   – Coated to prevent dough from sticking on cutter

2. Backup Roll
   – A hard rubber anvil roll
   – Provides the pressure to maintain uniform cutting

3. Cutting Apron
   – Must be a seamless or woven apron to prevent:
     • Uneven wear
     • Uniform cutting
   – Types of apron selected depend on the:
     • Dough characteristics
     • Need to help dough piece extract from the cups
3. If the dough stretches it is likely to produce a “short” strip when cut. To correct check the conveyors after the FGR are not running too fast.

4. If dough is too relaxed it is likely to bunch and change the product size, or strip length. To correct check FGR out feed conveyor/cutter apron speeds are not too slow.

5. Relaxation Conveyor typically runs slower than FGR out feed to allow the dough sheet to relax properly prior to cutting.
Cracker Doughs: Tied-Cut & Scrap-Cut

- Cracker dough cutting can be divided into two types, dependent on the cracker shape & cutter design

**Tied-Cut**

**Scrap-Cut**
Forming: Tied-Cut Products

• Effective system which allows for full loading of the oven band
• Cut dough pieces remain interlocked in a continuous sheet
• Edge trim is re-combined into the process when doughs are tied-cut
  – (98-99% fresh dough: 1-2% scrap)
• Crackers are baked as a peel
• Individual crackers are separated from the sheet after baking
Forming: Scrap-Cut Products

• Round or irregular shaped crackers
• Individual pieces are cut out and dockers are imprinted
• The intervals or spacing between the shaped pieces in the cutting pattern is the scrap
• Greater quantities of scrap dough are re-combined into the process at sheeting
  – 30-40% trim re-worked dough
• Re-combined scrap impacts dough texture and rheology
  – Less extensible than fresh dough
  – Should be re-combined evenly across the band
Forming: Dockers

• Docker holes are imprinted during cutting
• They are an integral part of the distinctive product patterns
  – Dockers are a method of controlling the thickness of the baked product by pinning laminate layers together
  – Help reduce blisters in the baked product
  – Provide a uniform bake through the products interior where residual moisture levels tend to be higher
Cracker Baking
Different Zones Do Different Jobs

- Ovens are divided into different zones, but the principles of the baking stages remain the same
  - **Stage 1:** Structure Development
  - **Stage 2:** Moisture Removal
  - **Stage 3:** Color & Flavor Development
Stage 1: Cracker Structure Development

*Front End Heat is Critical*

- Development of the cracker structure starts as starch begins to cook
- Drying begins
- Ammonia, carbon dioxide gases & water vapor are formed and released. These cause the cracker to ‘lift’
  - Dimension development
  - Stack height
  - Gases expand & give more ‘lift’
  - Structure development
  - Ammonia aroma carried away by gas bubbles

- Bottom heat allows the cracker to heat up, without drying out the top surface too quickly. If the top surface dries out too quickly, it may cause:
  - Moisture to get trapped inside the cracker center
  - The cracker to have low stack height and high moisture
  - Possible ‘checking’ problems
Stage 2: Cracker Moisture Removal

- Continues to remove ‘free water’ from the dough piece
- Maximum gas/dough piece expansion achieved
- Product volume relaxes
- Fixing the product structure:
  - Starch cooks
  - Gluten proteins change (denaturize)
- Crusting of the product surface begins

- Drying
- Shell/Surface Formation

- If crusting of the surface begins too early in the second stage, ‘blisters’ may result
Stage 3: Cracker Color Development

- Majority of moisture removed during Stages 1 & 2 and coloring now occurs
- Structure is fully set and product is firm
- The color develops due to:
  - Sugar caramelization
  - Sugar / protein reactions (Maillard browning)
- These also develop flavor
Checking: Major Causes/Approaches to Resolve/Prevent Checking

Mixing:
- Maintain consistent dough temperatures in mixing
- Maintain consistent mixing time from batch to batch
- Evaluate formulation: fat level, emulsifiers, dough improvers, aeration and invert sugar
- More thorough blending of ingredients to counteract checking
- Use lecithin/emulsifiers

Forming:
- Minimize dough weight difference across the conveyor belt
- Minimize sheet reduction using multiple gauge rolls
- Uniform distribution with fresh dough
- Use more dockers
- Product design and shape
- Keep dough weights similar for various geometric shapes
- Keep scrap return to the dough feed rolls hopper as warm as possible
Checking: Major Causes/Approaches to Resolve/Prevent Checking

Baking:

• **Keep oven humidity as high as possible in the first half of the oven** (i.e., reduce exhausting rates)

• **Oven band type: mesh versus solid**

• **Slower bake times – use more of the oven**

• **Maximize band loading** (minimize spacing between cracker pieces). This helps reduce individual cracker moisture variation from center of the cracker to the edges/sides

• **Use more open mesh baking bands**

• **When feasible, maintain top & bottom temperatures/heat levels as equal as possible**

• **Use dielectric dryers when possible**
Checking: Major Causes/Approaches to Resolve/Prevent Checking

Post Baking:

• Cool the product as slowly as possible. Use covered tunnels rather than open air conveyors
• Cool the product when possible in a humid environment
• Avoid sudden, very cool drafts
• Heated conveying systems
• Post bake shingling at 45 degree angle
• Product bed height
• Di-electric heating
Radio Frequency (RF) Dryer for Post-Bake Conditioning

- Located either after, or in the oven itself
- The product is baked to a higher moisture level in the oven
- Makes the water in the product vibrate & heat up which releases the moisture
- Higher moisture levels will attract more dielectric energy. Therefore it is a “self regulating” moisture control

![Diagram showing a conveyor with a high frequency dielectric system and radio frequency power source.](image)

**High Moisture = More Energy**  **Low Moisture = Less Energy**
Thanks!

Questions?
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Mihaelos (Michael) Mihalos is a Senior Associate Principal Engineer of North America Region Biscuit Process Dev./RD&Q for Mondelēz International. He is responsible for managing leading edge, very complex technology development projects.

Mihalos joined Nabisco in 1988 as a Process Engineer in Biscuit Engineering and holds various U.S. patents for his development work. He has held a variety of technical positions in his 26 years at Nabisco/Kraft/Mondelēz International in areas such as Biscuit Process Engineering, Process R&D, Technical Services, Manufacturing Development, Pilot Plant, Growth Engineering, Global Biscuit Product Development (PD) and currently in North America Snacks Growth & Innovation/PD as part of Research and Development. He is a recipient of the Kraft Foods 2011 Technical Leadership Award for Research, Development and Quality.

He spent time in biscuit manufacturing facilities understanding bakery biscuit operations and processing and currently continues to provide pilot plant and technical support in the area of process development for Snacks Growth & Snack Platforms for cookies, crackers & snacks. Responsibilities include management of all schedule, budget, scoping components and leading overall efforts in process development of new products. He identifies and develops new processes and process technologies in support of the product development business plan and implements “Field Ready” technologies used in product/platforms. He has developed multiple process capabilities in innovative technologies implemented this expertise to improve productivity, product quality, and commercialization of new products resulting in 60+ U.S. and International Patent and pending patent applications. He provides process leadership by hosting a Process Development Community of Practice conference within Mondelēz International organization to share new technologies as well as brainstorming opportunities from the various business categories such as beverages, coffee, cheese, gum and candy, etc.

Prior to joining Nabisco, Mihalos worked in both research & development and engineering as a chemical engineer for Colgate Palmolive in Jersey City, NJ.

Mihalos is a member of the American Institute of Chemical Engineers, Institute of Food Technologists and both a member as well as certified by the American Chemical Society. He is also an alumnus of both Columbia University and Fordham University. Mihalos received a B.S. in Chemistry from Fordham University, a B.S. in Chemical Engineering from Columbia University and an M.S. in Chemical Engineering from Columbia University. He is an alternate for the Biscuit & Cracker Manufacturer Education Committee and presents at the annual technical conference. He also edited the processing section in the 4th edition of “Baking Science and Technology” Volume II. Mihaelos lives in Palisades Park, NJ. He likes to play basketball, read, and visit museums to learn about ancient cultures.