Chapter 2
Heat Transfer

How Baking Works

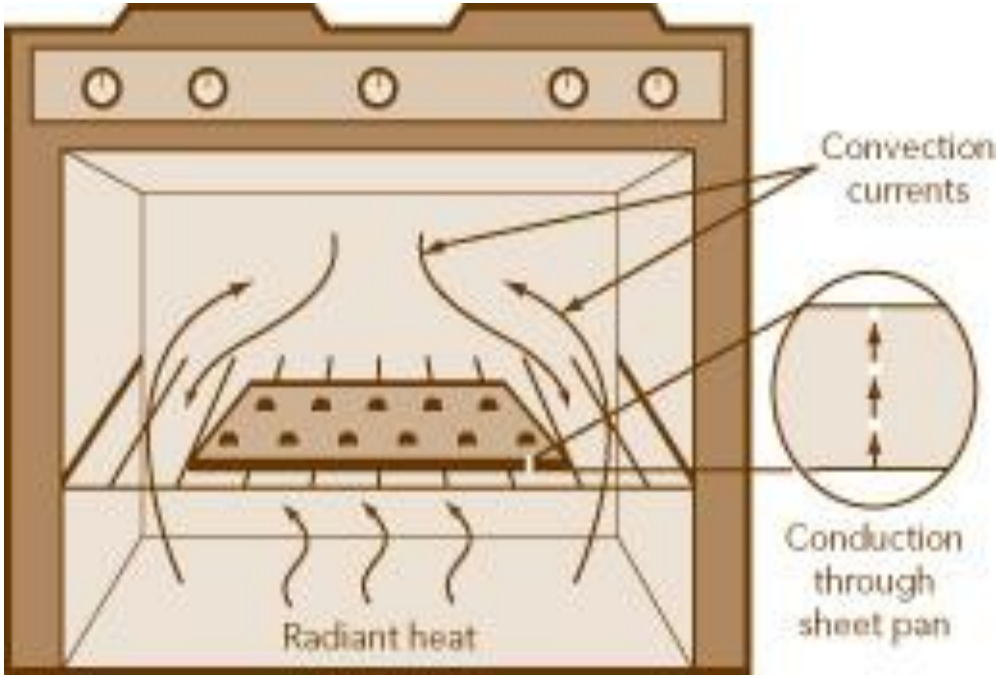
Words, Phrases, and Concepts

- Radiation
- Conduction
- Convection
- Carryover cooking
- Heat insulators
- Induction

Heat Transfer

- Heat is a form of energy.
- Heat moves from hot objects to colder ones.
  - Continues until everything is at the same temperature.
- Three main forms of heat transfer:
  - Radiation
  - Conduction
  - Convection

Heat Transfer



Baking, like most means of heat transfer, relies on multiple means of transferring heat.

Radiation

- Transfer of heat through space
  - Very fast
  - Heat moves from radiating heat source to surface of food.
  - Molecules on surface of food vibrate, becoming warm from the frictional heat.
  - Indirect heating method
    - that is, there is no direct contact between heat source and food.
- Examples of radiating heat sources: oven walls, toasters, heat lamps, hot pans.

Radiation

- Dark objects radiate more than light ones.
- Dull objects radiate more than shiny ones.

TABLE 2.1 RADIANT HEAT TRANSFER OF VARIOUS MATERIALS

MATERIAL	RELATIVE RADIANT HEAT TRANSFER
Black body (dull)	1.0
Brick	0.93
Aluminum (dull)	0.2
Aluminum (shiny)	0.04

Radiation

Why might bread brown faster when baked in dull, old pans?

Radiation

Radiation is also how microwave energy is transferred.

- Microwave ovens generate microwave energy in a *magnatron*.
- Absorbed microwave energy causes some molecules in foods to flip back and forth, generating frictional heat.
  - Water and sugar molecules, in particular, generate frictional heat quickly.
- Microwave ovens heat faster than conventional ovens.
  - Microwaves penetrate 1-2 inches into food while radiant heat energy heats food surfaces only.

Conduction

- Transfer of heat, molecule by molecule, through food.
  - Slow.
  - Direct heating method
    - that is, direct contact is needed for heat conduction.
  - Examples:
    - Heat is transferred from pans directly to surface of food.
    - Heat is transferred from surface of food to interior.

Conduction

- In stovetop cooking, heat is conducted:
  - directly from heat source to pan bottom, then through pan to food.
- In baking, heat is conducted:
  - through pans to surface of food.
  - from the surface to the interior of foods.
- During cooling, conduction continues, until food reaches the same temperature as its surroundings.

Conduction

Carryover cooking is cooking that occurs after food is removed from the stovetop or oven.

- Once properly cooked, vanilla custard sauce should be transferred from its hot pan to a cool bowl, to prevent excessive carryover cooking.
- Cheesecake should be removed from the oven before it is completely baked, to allow for carryover cooking.

Conduction

- Materials vary in how well they conduct heat. In general:
  - Solids conduct better than liquids; liquids conduct better than gases (air).
  - Metals conduct best of all.
  - Thin-gauge metals conduct faster than thick-gauge metals.
    - But thin-gauge metals often conduct unevenly.
- Poor conductors are called *heat insulators*.

Conduction

TABLE 2.2 HEAT CONDUCTIVITIES OF VARIOUS MATERIALS

MATERIAL	RELATIVE HEAT CONDUCTIVITY
Silver	4.2
Copper	3.9
Aluminum	2.2
Stainless steel	0.2
Marble	0.03
Water	0.006
Teflon	0.002
Wood	0.001
Air	0.0003

Why are copper pots good for quickly cooking and caramelizing sugar?

Why do two nesting sheet pans prevent cookie bottoms from burning?

Conduction

- The principles of conduction apply when cooling products.
  - To cool product, transfer it to a cool pan or cool surface, to conduct heat away from the product.
  - *Example*: confections and marble
    - If marble is unavailable, is a wood or metal surface better for cooling?
- Which method would cool a bowl of sauce more quickly: placing it in an ice water bath or in a freezer?

Conduction

Pots and pans vary in:

- Heat conductivity
- How they will react with food
  - Examples: aluminum and fruit fillings; custard sauces
- Cost
- Ease in use and cleaning
- Durability

Conduction

Pot or pan	Common Use
Copper pots	Stovetop cooking of sugar syrups
Aluminum bakeware	Cookies, cakes, breads
Stainless steel pots (with aluminum core)	Stovetop cooking of fruit fillings and custards
Cast iron pans	Baking cornbread with a dark, crisp crust
Ceramic ramekins	Slow-baked custards and creams
Silicone molds	For baking slowly; for easy removal of delicate items

Convection

Aids transfer of heat through liquids and gases.

- Warm liquids and air rise, cold liquids and air sink.
  - Because warm liquids and air are lighter, less dense.
- Creates movement within liquids and air.
  - Like having an invisible hand stirring the pot.

Convection

- Increase convection in a saucepan:
  - By stirring, especially if liquid is thick.
- Increase convection during baking:
  - Use convection ovens, which have fans that force the movement of hot air.
  - Use reel and rotating ovens, which move product through the air.
  - Convection, reel, and rotating ovens bake more rapidly and more evenly.

Induction

Induction stovetop cooking:

- Is very fast.
- Is energy efficient.
- Keeps bakeshop cooler.
  - Because there is less loss of heat.
- Requires cookware that is magnetic.
  - Test this by placing a magnet against pan surface.
  - Strong magnetic field generated below smooth cooktop generates frictional heat within pans.