Cost Modeling Challenge

- How much equipment to buy?
- What is the cost of producing your various products?
  … for your business…

?

Your Business

Modeling the Cost of Pizza Manufacture: Defining Scope

?

Diagramming Flows Example: W & P

Catalog For Each Process Step

-- Labor -- Energy -- Equipment -- Tools

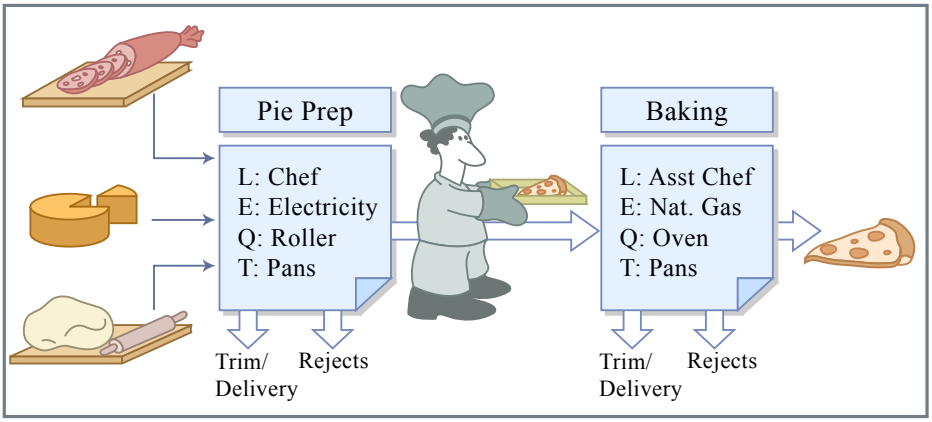


Figure by MIT OCW.

Data Collection & Model Development

- For each resource in your diagram
  - How much does a unit cost?
  - How many units are required?
- Begin data collection early!!!
  - Start with low risk sources
    - *Probably smaller firms*
  - End with high value sources

Step Four: Relate Costs to What is Known

- Process Involves Four Steps
  1) Begin At The Current Endpoint (initially, the costs)
  2) Ask: How Can That Quantity Be Broken Down?
     -- Initially, How Many Do I Need x How Much Does Each Cost
  3) Analyze Required Information (i.e. parameters)
     -- Are Those Parameters Acceptable Endpoints?
     -- Can I (the model) Derive Them From A Simpler Or More Relevant Set Of Information?
  4) If No, Repeat 1 With New Endpoints
- Watch Out For Interdependent Parameters
  - e.g. Part Mass & Part Dimensions

Step Four Example: Pepperoni Costs

- Start at the end
- Think in terms of annual quantities

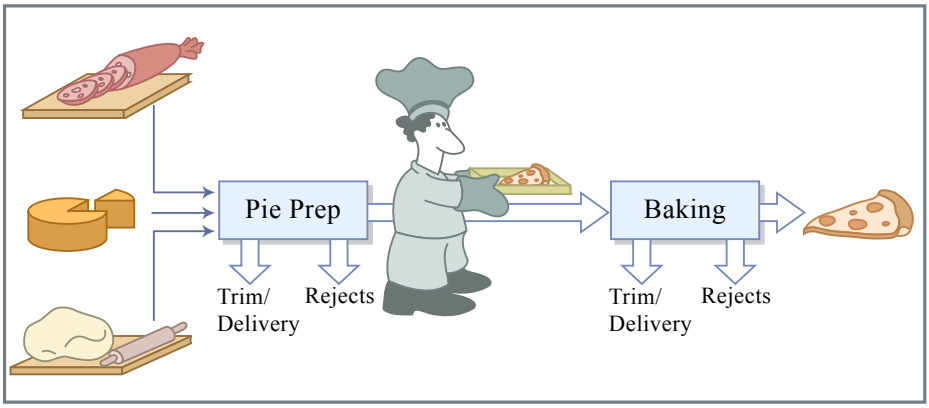


Figure by MIT OCW.

Two Important Quantities

- Production Capacity =
  Qty. of "Good" Parts Capable of Being Produced
  - How much CAN a plant produce?

- Production Volume =
  Quantity of "Good" Parts Produced
  - How much DOES a plant produce?

Generally, Both Are Measured In Units Per Year
(e.g., parts / year, kgs / year)

Slices per Pizza

- General area covering is difficult to solve
  - Solutions for small number of circumscribed circles has been solved
- Approximate:

78% 90%

Calculating Effective Production Volume: Work Backwards from Final Step

Prepped Pizzas Produced / Year = Good Preps + Rejects

effective $PV_{Prepping}$ = $PV_{Prepping}$ + Rejects

Can model Rejects as % of total production

$effPV_{Prep} = PV_{Prep} + R \times effPV_{Prep}$

$$effPV_{Prep} = \frac{PV_{Prep}}{(1 - R)}$$

But what is PV_{Prep}?

Assume that PV_{Prep} = Total Pizzas Baked / Year (i.e., $effPV_{Baking}$)

$$effPV_i = \frac{effPV_{i+1}}{(1 - R)}$$

For last step, substitute PV for $effPV_{i+1}$

Next Question …

What is the cost of equipment?

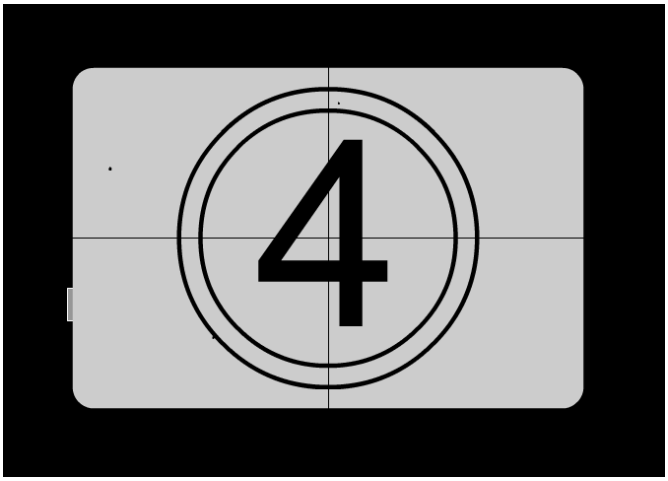
How much equipment to buy?

A Little Intro - http://www.remcousa.com/flash.html

Massachusetts Institute of Technology
Cambridge, Massachusetts

MSL
Materials Systems Laboratory

A Little Intro - http://www.remcousa.com/flash.html



Key Structuring Constraint -- Time

- Hours of daily operation an operational constant
- To get more than a day's production, you need more resources
- Inverting that calculus can be used to scale/size an operation
- Defines capital requirements

Considering Elements of Time

- **Total processing time**
  - **Processing**
  - **Load/Unload Time**
  - **Time spent making bad/unsold pizza**
- **Other times**
  - **Downtime Due To Scheduled Breaks**
  - **Unscheduled Downtime**

Determining Equipment Requirements: Compare Time Needed With Time Available

- **Time Needed**
  - **To Make Product + To Load/Unload**
  - **Total Number of Pies (effective PV)**
  - **Cycle Loading (Analogous To Multiple Cavities)**
- **Time Available**
  - **Shifts, Days**
  - **Less Breaks, Downtime, Maintenance**
- **Ratio: Line Utilization/Requirements**

Determining Equipment Requirements: Compare Time Needed With Time Available

- **Minimum equipment requirement:**

$$\frac{\text{Annual Required Production Time}}{\text{Annual Available Operating Time}}$$

Distribution of Capital Costs Over Time

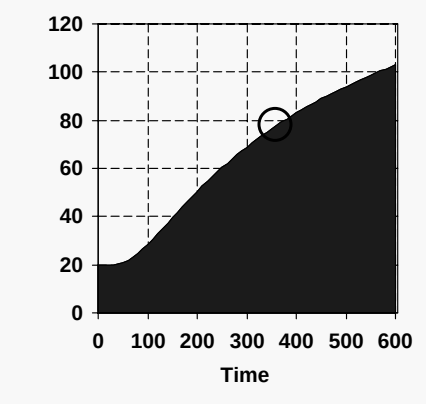
- **Simplicity Is Best At Outset**
  - **Complex capital accounting relies on extra knowledge, usually case specific**
- **Simple amortization -- opportunity cost of capital**
  - **Distributed over goods sold, not made**
- **Note: NOT DEPRECIATION!!**

Dedicated Capital Or Not?

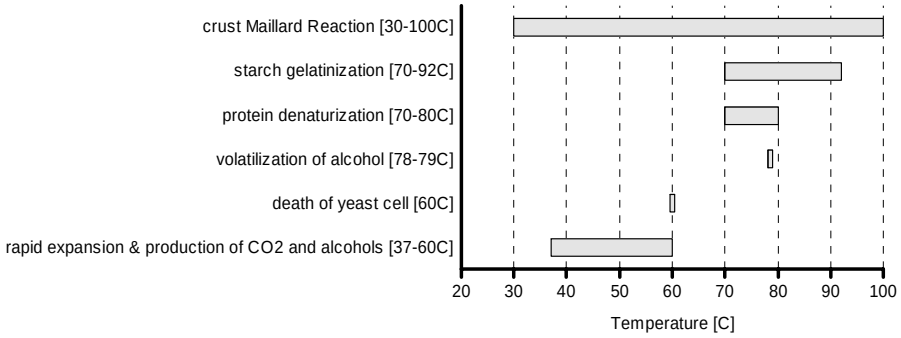
- **Dedicated: Can only be used to make a single good**
- **Non-dedicated: Can be used to make other goods**
  - **Note: Just because it can be used doesn't necessarily mean it will be used!**

Considering Process Time for W&P

- **Assumptions:**
  - **Initial temp: 20˚C**
  - **Oven temp: 225˚C**
  - **α: 7.5E-9**
  - **Thickness: 10 mm**
- **How long will it take to cook?**
- **What's the centerline temperature reach target? … 80 ˚C**



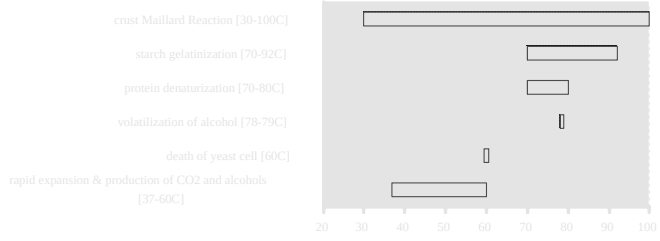
Considering Process Time for W&P
Breadmaking: Temperatures



Ref: Oregon State; Nutrition & Food Management (NFM236)
http://oregonstate.edu/instruct/nfm236/bread/index.cfm

Engineering Estimation Needed

- **What's the target temperature?**
  - **Near alcohol volatilization?**
    - ***Limited by protein denaturization***
- **How long does it take to get to that temp?**



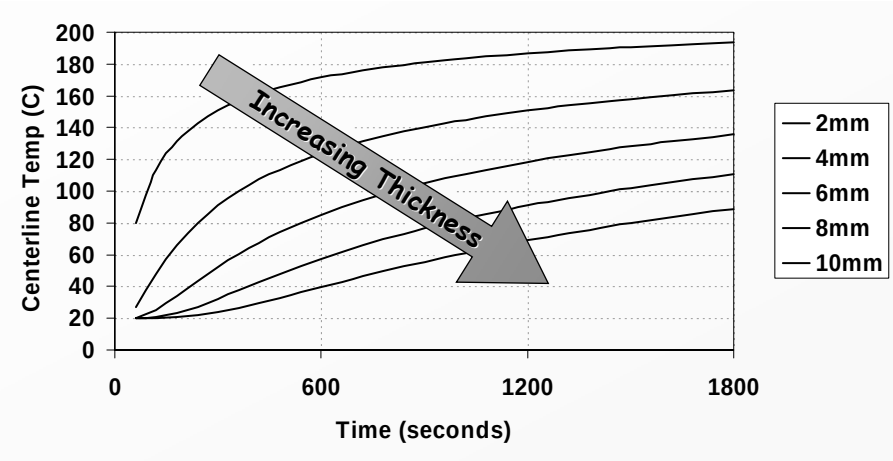
Heat Transfer, Non-Steady State

- **Let's rely on some experts**
  - **Tufts' Gourmet Engineering class, EN43**
  - **Transient Conduction chapter: http://www.tufts.edu/as/tampl/lecture_notes/ch4.html**
  - **Assume constant surface temperature:**

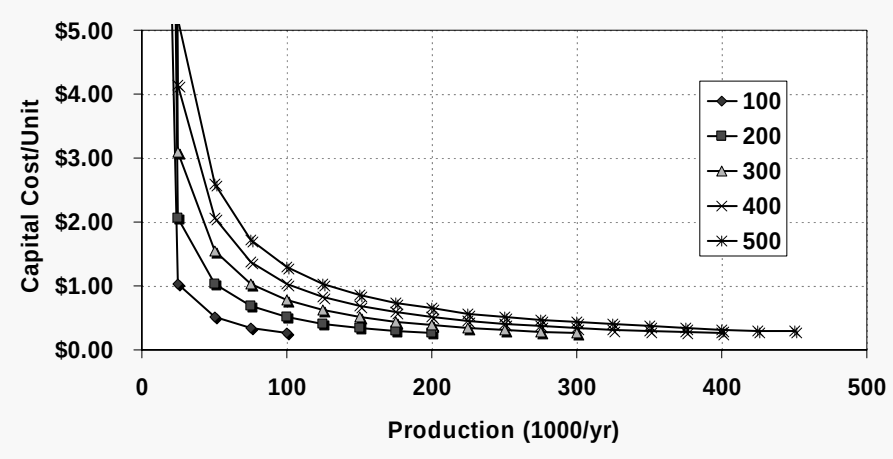
$$\frac{T(x,t) - T_{surface}}{Ti - T_{surface}} = \text{erf}\left\{\frac{x}{2\sqrt{\alpha t}}\right\}$$

A relation between time, temperature and position

Time, Temperature and Thickness



Consequences of Capital Utilization



Recap

- Modeling as successive decomposition of problem of cost
  - Refine estimates
  - Reduce number of independent cost elements
  - Seek to construct framework