

INTRODUCTION, EXPERIENCE, AND APPLICATION OF
THE EXTRUSION PROCESS

Submitted by
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In partial fulfillment of the requirements for
FDST 896, Independent Study
In conjunction with Teacher Enhancement in Physics & Engineering Workshop
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Preface:

I intend to use these materials as a subunit within my work and machines unit. After studying forces, work, and simple machines, this would be an aspect of compound machines and their applications as extended to the process of food production.

The Curriculum Plan/Overview:

Day 1: Introduction to Extrusion

Presentation and discussion will be done incorporating the following pages copied onto transparencies and shown on the overhead projector. [I have pictures from the class session and the Internet which I will include on the transparencies and also have some from the sites such as Maldari and Schaaf companies that I will have linked from computer to TV monitor to show for examples.]

Examples of extruded products such as pop cans, PVC pipe, macaroni, Minute Rice, Froot Loops, cat food, etc. would be shown and displayed after students' input during discussion of their ideas.

Examples of home extruders which will be used in the lab activity (food grinders, Spritz cookie presses, and pasta makers) will also be shown.

Note: In the past, I have seen a program on TV about pasta production that I am trying to locate. This could be shown as well sometime during this unit, either on this introductory day or after the lab.)

Day 2: Lab Activity: "Experience Extrusion"

This incorporates 3 main types of extruders: food grinders; spritz cookie presses; and pasta makers. There will be several versions of these available to use from hand cranked to electric. Students will witness and experience the process of extrusion, recognize the components of the machines compare and contrast the different versions, and analyze some of the differences between home use and large-scale industrial applications.

Day 3: Post Lab Discussion

Discuss variables involved - which are independent and which are dependent. Analyze some of the extruded products. Discuss their experience, comparisons of small-scale and large-scale operations, and advantages/disadvantages of the uses of extruders.

Follow-up: encourage students to be more aware of extruded products, do more research into the extrusion process and into relevant career opportunities.

INTRODUCTION TO EXTRUSION

What is extrusion?

method of forming substances by forcing them through a perforated plate or die to produce tubes, rods, or other desired shapes (like squeezing toothpaste out of a tube)

What types of materials can be extruded?

metals (aluminum, copper, steel, etc.)

plastics (polyethylene, polystyrene, nylon)

foods (typically high starch content)

Examples of products formed by extrusion?

[Input of student ideas first]

metals:

automobiles

building construction

food or beverage cans

appliances

plastics:

pipes

milk cartons

packing peanuts

toys

foods:

pastas

breakfast cereals

multigrain snacks

pretzels

jelly beans

precooked rice

pet foods & treats

Why extrusion?

- efficient, continuous production
- processing of relatively dry viscous materials
- control thermal changes
- improved characteristics of product
- uniformity of product

What is an extruder?

device to shape by forcing material through a specially designed opening often after a previous heating of the material

Types of extruders by function:

Forming

- pasta (traditional)
- high-pressure (plastics)

Cooking

- low-shear cooking (precooked pasta - Collet (puffed cereals - "Kix")

Texturizing

- high-shear cooking (high protein -

Extruder Parts & Components:

power supply - operates main screw

feeder - regulates rate/pressure of flow

barrel - surrounds screw(s)

screw (single or twin) - conveys material

die or nozzle - shapes product

special arrangements or attachments - example: knife, co-extrusion unit

Home Extruders Examples

Food grinder

meats

cooked potatoes

fruits

Pasta maker

spaghetti

macaroni

noodles

lasagna

Spritz cookie press

traditional

holiday

Extrusion Complexity

Extrusion involves:

mixing

melting

high heat

high pressure

short reaction times

Product Results From:

ingredients

process

interactions of ingredients & process

Some extrusion process variables:

raw materials

feed rate

in-barrel moisture

screw speed

barrel temperature

die characteristics

screw design

Examples of screw element variations:

- large pitch conveying -> fast
- small pitch conveying -> slower, more
- kneading or cut flight -> mix
- shearlock -> high pressure & inject
- reverse pitch -> higher pressure

Moisture as a variable

Works as:

- plasticizer
- viscosity modifier

Impact of moisture increase:

- viscosity decrease
- torque decrease
- product temperature decrease
- bulk density increase (expansion
- die pressure decrease

Extrusion Processing

- common in food industry
- very complex to fully understand
- highlights interaction of chemical and engineering sciences a part of your life every day!

Name_____ Class_____ Date_____

LAB ACTIVITY: "EXPERIENCE EXTRUSION"

Purpose: To witness and experience the process of extrusion, recognize the components of a simple extruder, compare and contrast different versions of common home extruders, and analyze some of the differences between home use and large-scale commercial applications.

Supplies and Equipment Needed:

food grinders:	hand-cranked	
	electric (food processor)	
	fine and coarse discs	
pasta maker:	rolling pin, cutting board, and knife	
	electric attachment (food processor)	
	assorted plates	
Spritz cookie presses:		
	manual	
	easy-squeeze trigger	
	electric	
	assorted discs	
meat	flour	cookie sheets
cooked potatoes	bowls	spatulas
pasta dough	waxed paper	cooling racks
cookie dough	plastic wrap	plastic bags

Procedure:

1. Wash hands thoroughly with soap and water before and after each of the three procedures.
2. The class will be divided and rotated through each of the types of extruders until all groups get to experience each or as time allows. Go to one of the stations and follow the procedure for that particular extruder, then proceed to the others as available.
3. **Food grinding procedure:**
 - a. Follow the grinder assembly instructions provided on sheets by the machines.
 - b. Extrude about 4-6 cubes of meat through each grinder using the fine disc.
 - c. Extrude about 4 chunks of cooked potatoes through each grinder using the coarse disc.
 - d. Answer the appropriate questions in the Observations and Questions section.
 - e. Place extruded foods in separate plastic ziploc bags and refrigerate.

4. Pasta making procedure:

- a. manual process - Obtain an egg-sized amount of pasta dough. Place on a clean, floured surface. Roll out to a thickness of about 1 mm or paper thin. Using a knife, cut into narrow strips about 6 mm wide. Shake out strips and place on a towel to dry.
- b. electric maker - Assemble the pasta maker attachment with the flat noodle plate. Turn mixer to speed 10. Slowly feed 1 walnut-size piece of dough into the hopper; dough should self-feed. The grind worm (screw) should be visible before adding a second piece of dough. When the extrusion is 24 cm long; stop the mixer and gently pull noodles away from the plate. Lay on waxed paper and separate immediately. Dry on a towel.
- c. Answer the appropriate questions in the Observations and Questions section.
- d. When the noodles are thoroughly dry, they will be placed in plastic bags.

5. Spritz cookie pressing procedure:

- a. Load cookie dough into each of the three presses that have similar design discs in place. Make 4-6 cookies with each press onto a cookie sheet. (See instructions for the presses that are available at this station if you are unsure how to use them.)
- b. When the cookie sheets are ready, they will be taken to be baked.
- c. Answer the appropriate questions in the Observations and Questions section.
- d. When the cookies are done baking, they will be cooled and saved for sampling during the post-lab discussion.

6. Make sure to maintain cool temperatures for all food products and clean up your areas as you proceed.

Observations and Questions:

1. Sketch a cross section of one of the machines and identify. Label the main extruder parts/components: power supply feeder barrel screw die

2. Compare and contrast each version of the 3 extruders as to ease of use, rate of production, and uniformity of product.

food grinders -

pasta makers -

Spritz cookie presses -

3. Considering the above analyses, now compare your small-scale production with a large-scale commercial production. What would be three similarities between the two?

4. What would be three differences between the small-scale home productions and large-scale commercial productions using extruders?

Some teacher notes:

>The tables need to be disinfected before beginning the food lab and after the lab.

>The foods need to be kept cool, so refrigeration or coolers with ice will need to be nearby. Students will need to remove just the amounts needed for each part and put extruded products in the refrigerator or coolers as well.

>Be conscientious as to the safety precautions in operating the machines! Advise students before beginning the lab.

>This lab will require significant preparation in the making of the pastry and cookie doughs. Perhaps an arrangement could be made with the Family and Consumer Science classes to help out with this! Some interdisciplinary collaboration would be advised. In addition, they could maybe use the ground meat and pasta for a lab.

>This might actually take 2 days to complete.

Post Lab Discussion

Discuss each of the observations and questions from the lab.

Include also:

What are some variables involved in the process of extrusion? Which of these are independent and which are dependent?

Analyze the use of various extruders and their products. (Include sampling the cookies!)

What are advantages and disadvantages of using extruders?

Would you be likely to use any of these yourself?

Which did you like to use the best?

What is your favorite extruded food product?

If you'd like to learn more, continue with research into the extrusion process and related career opportunities! There is much to learn!

RESOURCES

“APV Snacks,” Internet: <http://www.apv.com/Industries/Food/snacks.htm>

“Design and Performance of Pasta Dies,” Internet: http://www.Maldari.com/design_and_performance_of_pasta_htm

“Developing Product Through Extrusion,” Kazenzadeh, Massoud, Ph.D., Internet: <http://www.foodproductdesign.com/archive/1992/0792PE.html>

“Extruded Snacks, Breakfast Cereals, Co-extruded Products,” Schaaf Technologie GmbH, Internet: <http://www.schaaf-technologie.de/products.html>

“Extruder, The,” Internet: <http://www.dow.com/stryron/process/xt/equip.htm>

“Extrusion,” The Britannica Concise Encyclopedia, Internet: <http://education.yahoo.com/search/be?lb=t&p=url%3Ae/extrusion>

“Extrusion” and “Pasta,” Grolier Multimedia Encyclopedia, CD, Grolier Electronic Publishing, Inc., 1995

“Extrusion Application,” Jackson, David S., Dept. of Food Science and Technology, UNL, Teacher Enhancement in Physics and Engineering Workshop, June 12, 2003

“Extrusion Process, The,” Internet: <http://www.brass.org/Training/Lecture/sld035.htm>

“Food Extrusion,” Engineering Aspects of Food Irradiation, Internet: <http://baen.tamu.edu/users/rmoreira/bsen474/extrusionpdf/snacks.pdf>

“Food Extrusion Control System,” Moreira, Rosana, Internet: <http://baen.tamu.edu/users/rmoreira/pdfindex/extrusion.pdf>

“Food Extrusion Line,” Internet: http://www.markmaninc.net/Extruder_and_cutting.htm

“New Food Technologies - Processing Food for Safety, Convenience, and Taste,” Food Today Articles, Internet: <http://www.eufic.org/gb/food/pag/food31/food314.htm>