Raw Material Specifications for Plastics Parts
Implementing ISO 14001

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Abstract: Over the last few decades, efforts to reduce manufacturing costs have focused on direct labor. Major improvements in automation and information technology have reduced labor costs significantly. Therefore raw material costs have emerged as the most significant cost for manufactured goods. Raw material costs are increasing due to global demand. It is important for students to become knowledgeable about the numerous ways to reduce material costs and how this should be specified on a product drawing. This module focuses on specification of raw materials for plastic components and explores what must be considered before deciding to choose a recycled materials and means of implementation of ISO 14001, along with the implications of raw material cost on the overall product cost during the design stage.

Objectives: This module has two objectives. The first is to instill in students that the product drawing (blueprints) plays a central role in implementing ISO 14001 and to a great extent, establishes unit cost. The second objective is to encourage students to carefully reflect on the types and grades of materials they specify and determine whether recycled materials are appropriate for a given application.

Student Learning Objectives:
After studying this material the student will be able to:

- List the various ways to determine part volume.
- Research plastic raw material cost.
- Calculate cost per part given the part volume and cost per unit volume.
- Calculate the percentage of retained value for recycled materials vs. new raw material.
- Explain the fundamental difference between new raw material and recycled raw materials.
- Research and discuss the mechanical property implication of using increasing percentages of regrind material.
- Suggest what aspect of a design limits the life cycle of a product.

MatEd Core Competencies Covered:

2.A	Apply basic mathematical fundamentals
7.B	Discuss the general nature of plastics
7.J	Demonstrate how materials properties are used in engineering design
10.A	Identify properties and applications of thermoplastic materials

19.B Apply cost principles to manufacturing processes and management

Key Words: ISO 14001, specifications, recycling, unit cost, raw material cost
Type of Module: Classroom or Computer Aided Design lab demonstration
Time Required: Up to one class period
Prerequisite Knowledge: algebra, trigonometry and some blue print reading
Grade Level Intended: Tech High School Seniors and College Freshman

Table of Contents:

Equipment and Supplies Needed: Access to a CAD system recommended.

Curriculum Overview and Notes for Instructor:
This exercise is intended to enable educators to help students gain knowledge about how raw material cost is playing an increasingly important role in overall product cost. It also helps them understand the value of recycle materials and the need to maximize recycling to reduce or at least stabilize raw material cost.

The module relates to the ISO 14001 standard for materials recycling; introductory modules regarding ISO 14001 are available at www.materialseducation.org, and are listed in the reference section below.

For this exercise the author uses an *iPod* protective case CAD drawing and component, drawing attached. The instructor may use whatever drawing is available and appropriate, preferably a solid model CAD drawing and related information. From the mass properties chart one can select the part volume, in this case using any units that are convenient. With this information one can simply calculate the raw material cost per unit as:

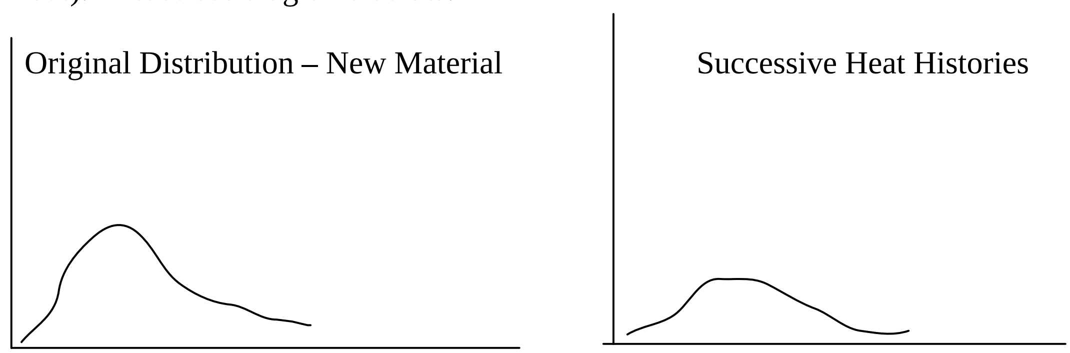
Raw material cost per part = part volume X raw material cost per unit volume

Raw Material Cost Information:
One of the best sources for the most recent raw materials cost information is from Plastics Technology Magazine and their website:
New raw material cost - www.ptonline.com/articles/200902rprice.html
Recycled material cost – www.ptonline.com/pricing/recyc.html
This exercise provides a good opportunity to review the use of various materials as well as unit conversions.

The exercise can also be used to make sure student understand what should be listed on a product drawing for the Raw Materials Specification. This includes

- Type, grade, and manufacturer of raw material;
- Alternative grades and manufacturers; and
- The maximum percentage of regrind material that is acceptable.

If there is doubt about what percentage of recycled material should or could be used in a given application, life cycle and field-testing must be conducted. The "gold standard" for plastic raw material testing is to measure the molecular weight distribution. This is done using a gel permeation chromatography unit (GPC). This instrument is actually a "molecular sieve" which separates plastic molecules by size and amount. The distribution shifts as plastics raw materials see successive heat histories. You could discuss with the students how the distribution will shift with successive heat histories and why. Basically you can explain to students that with each successive heat history the molecular structure breaks down and the chains get shorter. Therefore the distribution will broaden and shift (flatten out). Please see diagrams below.



The GPC can be used to "fingerprint" a material and help establish an acceptable distribution for a given product based on its function and its intended service life. Another tool is the extrusion plastometer which measures melt viscosity in grams per ten minutes. The best mechanical property test is either life cycle or impact type test to determine product's durability particularity as increasing amounts of regrind is used. Regardless, there will be a gradual erosion of mechanical properties as the molecular structure breaks down as the number of heat histories increases for example tensile strength, impact strength, and fatigue resistance.

Module Procedure

1. Pre- class exercise and possible homework assignment

Ask the students to review a simple product drawing and consider (guess-estimate) what percentage of a plastic component cost is made up of labor, raw materials, and processing. Refer them to the following web site: www.plasticstechnology.com. This website has the latest information on raw material cost of both new resin and recycled resins.

Then ask the students to take a simple product and determine its raw material cost. This can be done by simply weighing the part. Volumetric data from a CAD 3D solid model would be helpful but not necessary. This information is usually found in the mass properties table for most CAD software.

2. Classroom or CAD Lab Discussion

Discussion and demonstration – Use a drawing of a product to discuss and determine raw materials costs for the product, preferably one with a solid model CAD drawing and related information. From the mass properties chart, available with the CAD software, one can select the part volume. For the *IPod* nano used by the author, the part volume is .524 cubic inches, but any units that are convenient may be used (please see the product drawing at the end of this module for reference). Using this information, have the students calculate the raw material cost per unit as:

Raw material cost per part = part volume X part cost per unit volume

Follow this with a discussion on what should be listed on a product drawing in terms of raw materials specification. This includes:

- Type, grade, and manufacturer of raw material
- Alternative grades and manufacturers.
  - Why?
- The maximum percentage of regrind material is acceptable.
  - But how do you know how much?

Conclude with a discussion on

- The importance of the product drawing (blueprints) in establishing unit cost of a product;
- How to determine the maximum amount of recycled material that is acceptable to use (refer to the instructor discussion above);
- Why it is important to consider recycling of raw material in designing and developing a product;
- The economic implication for a given industry if aggressive vs. poor recycling practices prevail on the overall cost of raw materials, and
- How ISO 14001 can be implemented in other ways to reduce product cost.

References:

The following educational modules are available at www.materialseducation.org:

1. Defining Sustainability via ISO 14001, Robert Simoneau, Keene State College
2. Materials Selection for Sustainable Products, Robert Simoneau, Keene State College
3. Implementing ISO 14001: Sustainable Design, Robert Simoneau, Keene State College.

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Evaluation:

Student evaluation questions (discussion or quiz):

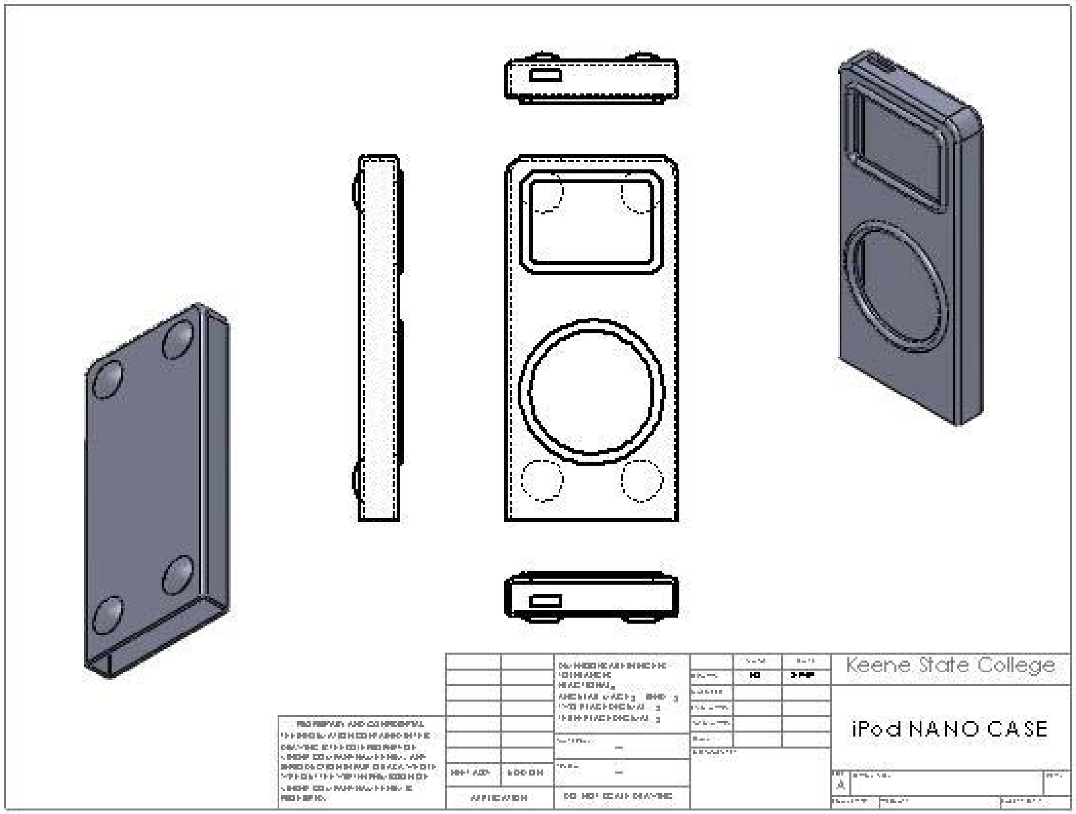
1. Given a simple product drawing, calculate its volume.
2. Calculate cost per part given the part volume and cost per unit volume.
3. Explain the fundamental difference between new raw material and recycled raw materials.
4. Show what aspect of the design limits the life cycle of the product.
5. Discuss the importance of using recycled product in terms of cost, product life and performance.

Instructor evaluation questions:

1. At what grade level was this module used?
2. Was the level and rigor of the module what you expected? If not, how can it be improved?
3. Did the module work as presented? Did they add to student learning? Please note any problems or suggestions.
4. Was the background material sufficient for your background? Sufficient for your discussion with the students? Comments?
5. Did the module generate interest among the students? Explain.
6. Please provide your input on how this module can be improved, including comments or suggestions concerning the approach, focus and effectiveness of this activity in your context.

Course evaluation questions (for the students):

1. Was the module clear and understandable?
2. Was the instructor's explanation comprehensive and thorough?
3. Was the instructor interested in your questions?
4. Was the instructor able to answer your questions?
5. Was the importance of materials testing made clear?
6. What was the most interesting thing that you learned?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