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Process and Material Selection for Product Recyclability

Frequently Asked Questions (FAQ)

1) Are die cast materials recyclable?
   See page 1-4, Die Casting's Unique Environmental Position, Figure 1-1, and page 1-5, Die Castings Recycling Circle.
2) Is there some comparison between recycled aluminum and virgin aluminum?
   See page 1-4, Comparison of Recycled vs. Virgin Aluminum Chart.
3) How do die castings affect the environment?
   See page 1-4, Die Casting's Unique Environmental Position.
4) Are die castings more readily recyclable than plastics or other non-metallic components?
   See page 1-3, Problems Confronting Non-Metallic Recycling.

Introduction

Designers today are faced with material selection considerations that an earlier generation of engineers did not consider.

In addition to optimizing the cost and performance equation of a new or redesigned product, engineering must now more carefully analyze its long-term environmental impact.

An increasing population has available to it a decreasing number of waste disposal sites, with nearly 70% of landfill capacity predicted to be exhausted by the end of the decade. There has been a vast growth in the use of raw materials not readily recyclable. These forces have led to heightened government concern with the environmentally safe disposal of durable goods waste.

Die casting alloys offer the designer concerned with post-consumer recyclability one of the most advantageous material options. Die castings and the die casting process provide the product engineer who is designing for the environment:

- *Components that can maintain their integrity through disassembly, repair, remanufacturing and reassembly.*
- *Product recyclability, at the end of useful life, with the potential for return to high performance applications.*
- *Knowledge that a proven recycling infrastructure is in place to reclaim recycled die cast parts.*

Here is an overview of current North American environmental concerns, the manufacturing process and material alternatives that offer creative solutions for today's product designer.

1 New Design Responsibilities

Most engineers, as concerned citizens of their society, know that the problems of waste disposal are serious. The U. S. Environmental Protection Agency has estimated that we have reached the point where nearly half of the solid-waste landfills in the United States have been closed.

Disappearing waste disposal sites are an even more serious problem in Europe, where the cost of waste disposal in landfills or by burning has increased dramatically. In Germany, with limited availability of waste sites, the government has introduced a bill to attack the problem of automobile disposal, requiring carmakers to take back old vehicles at no charge to the consumer. Legislation there now bans incineration.

Minimum-content laws have been passed by many U.S. states, mandating the use of recycled materials in new products. Washington has issued an executive order requiring government agencies to give preference to recycled materials when purchasing products. Waste disposal alternatives such as incineration and ocean dumping will no longer be acceptable, with government regulations calling on product manufacturers to insure the minimal environmental impact of their manufactured durable goods.

It appears clear that the product designer will soon not only be responsible for the optimum function and easy fabrication of a product, but will also be required to account for the product's ultimate destiny at the end of its service life.

2 Implications of the Emerging "Green" Consensus

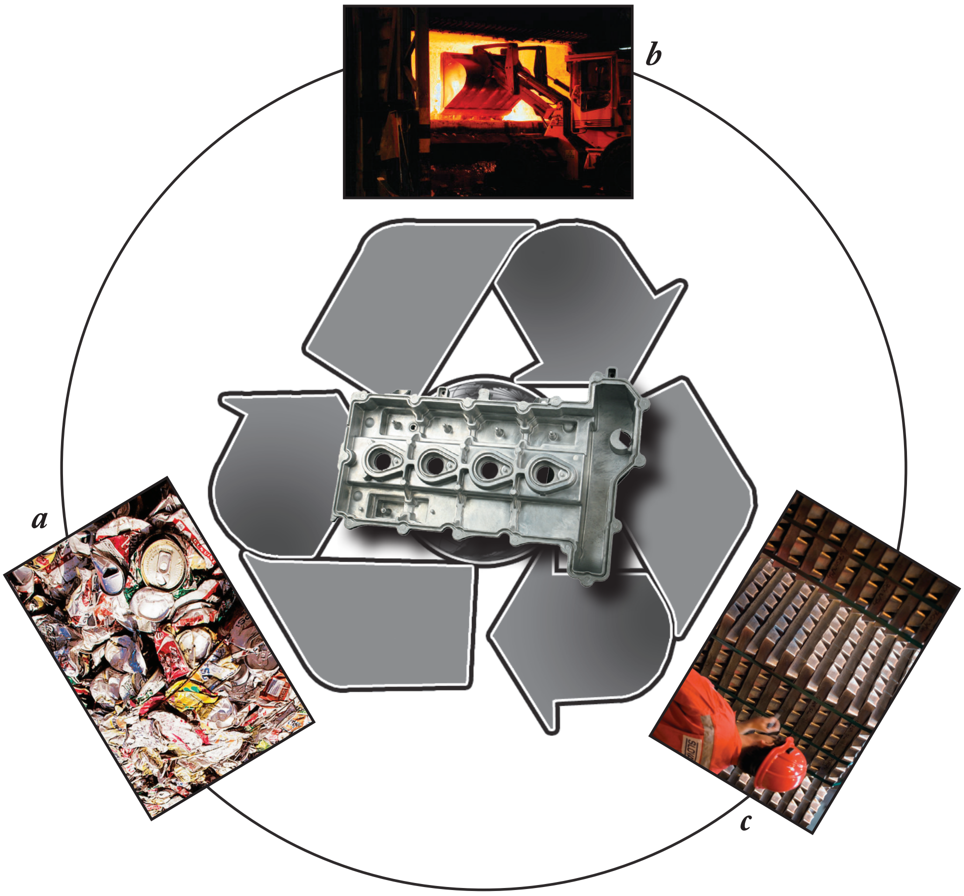

Figure 1-1 Circle of recycling to create a die casting. Recycled cans are collected (a), cans are remelted with other aluminum scrap (b) to create ingots (c), ingots are used to create a die casting (center).
Images Courtesy of © Norsk Hydro, © Alcoa, © NADCA.

The need for manufacturers to focus on ecological consequences has been stated not only by business management scholars from institutions like Northwestern's Kellogg School of Management and the University of Michigan, but by business leaders as well. Companies like AT&T, NCR, Whirlpool Corp., DEC, and Northern Telecom have publicly addressed the issue.

The obvious conflict between business and environmental interests is being altered by a trend toward business "greening" encouraged by a new awareness among consumers. American consumer surveys have shown that 80% of Americans said they would pay more for environmentally safer products. Based on actions that follow from such findings, designing for the environment appears here to stay. The recyclability of a car model or other durable goods may soon become a competitive feature in a consumer's purchasing decision.

Increasing numbers of people are asking more sophisticated questions about products and the environment, such as concerns over the life cycle of the products they use and the potential for recycling.

Companies which address environmental concerns in the design of their products will be at a long-term competitive advantage. Among other guidelines, an orientation involves (1) the minimum use of virgin materials and non-renewable forms of energy, and (2) minimizing the environmental cost of products and services over their entire life cycles, from their creation to disposal or completion.

There are four steps in adopting a strategy for environmental excellence in manufacturing to be competitive in the 21st century:

- *Conducting an environmental vulnerability assessment of processes and products.*
- *Conducting a life-cycle assessment for each product and process.*
- *Designing and developing green products for existing and new markets.*
- *Moving toward zero-waste manufacturing processes.*

3 The Designer's Material Choices

A product engineer designing products for environmental compatibility encounters many material suppliers who claim that their materials and processes offer recyclability. Other considerations being equal, what the designer of today's products must distinguish between are theoretical or future possibilities of reprocessing a material, on the one hand, and in-place recycling, on the other.

The facts are that metals can claim the support of an existing world-wide infrastructure that economically collects, reprocesses and channels these reprocessed materials back into the manufacturing process — to allow reuse at costs significantly less than purchasing virgin materials.

Supporting the automotive industry, a network of automotive dismantlers daily make their living selling salvaged metal auto parts and then placing the remainder of the vehicle in the hands of "shredders." The shredding process, which has proven its economic viability, results in the recycling of almost 75% of the weight of a typical car — nearly all of this as ferrous and nonferrous metal. Over 85% of the aluminum in a car is currently reclaimed and recycled.

The non-metallic portion of a product is generally regarded by recyclers as "fluff," consisting mostly of plastic. Nearly one-quarter of all solid waste is estimated to be plastics, and less than 3% of this plastic is being recycled.

Problems with plastic product recyclability were pointed out by a national task force in 1994 who requested that plastics marketers refrain from use of the universal symbol for recycling in advertisements, since it was regarded as misleading in relation to plastics.

The greater proportion of non-metallics in a product, the less its value to the recycling industry, and, increasingly, there are fewer and fewer places for disposal of this material.

4 Problems Confronting Non-metallic Recycling

While most plastics are capable of being recycled, the infrastructure for such recycling is far from being in place. While many early recycling efforts among consumers have met with cooperation, end results to date have not been promising.

4.1 Reprocessing Gap

With some exceptions in the case of plastic bottles and foam containers, the monetary incentive and basic infrastructure either to handle collected plastics and to reprocess it economically is lacking.

Also, there is no substantial market for most of the durable plastic scrap. Existing recycling organizations continue to regard most plastics as they always have, as non-metallic material with little established value, that must be separated out from profitable, reclaimable metal. For even the lower level of plastics applications, virgin resins remain significantly lower in cost than recycled plastics.

4.2 Separating Plastic

The plastics industry recognizes that it will be some time before a working infrastructure for plastics recycling and reprocessing is in place, particularly for injection-molded resins. The introduction of plastic composites, to approach the strength of cast metal, has caused still further recycling problems.

In Europe there has been action to subject reinforced engineering plastics to additional taxation, based on their incompatibility in the eventual recycling stream. While incineration has been curbed for reasons of air pollution, heat and flame-resistant plastics might further limit such disposal as an economic alternative.

Process and Material Selection for Product Recyclability

The incompatibility problem in reclamation also occurs with the wide variety of non-reinforced engineering resins in use, as well as with plastic product combinations which join the properties of several plastic resins in a single product. Unlike plastics, a combination of several aluminum alloys made from different processes can be directly recycled. A component produced as a combination aluminum die casting and aluminum extrusion can readily be remelted and reprocessed — as the two have been, separately, since nonferrous alloy recycling began.

4.3 Plastic Degradation

Studies by the plastics industry have indicated that, even with a plastics recycling infrastructure in place, the use of recycled engineering plastics can yield unpredictable results.

Unlike recycled metals, the effects of temperature, time and the environment can degrade the potential performance of a recycled engineering thermoplastic, aside from the obvious effect on the aesthetics of the final product molded from recycled material. While post-consumer recycled resins are already being molded for low appearance uses, unpredictable performance degradation may render such material unusable for stricter engineering applications.

As an alternative to injection-molded engineering thermoplastics, recyclable die cast metals offer the product designer the opportunity to respecify product components as precision die castings, often with newly realized cost savings and strength and performance advantages.

Comparison of Recycled vs. Virgin Aluminum	
Energy Savings	95% Energy savings; recycling of one aluminum can saves enough energy to run a Television for three hours.
Environmental Impact	Reduces pollution by 95%.
Natural Resource Savings	4 lbs. of bauxite saved for every pound of aluminum recycled.
Miscellaneous Information	Enough aluminum is thrown away to rebuild our commercial air fleet four times every year

5 Die Casting's Unique Environmental Position

Nearly all metals — and die castings in particular — have always been readily recyclable. Die castings are not hazardous waste and pose no problems in handling or reprocessing, as do some non-metallics.

Die castings offer the product designer recyclable components with engineering advantages not available in other metalforming processes. The major cost and performance benefits of parts consolidation possible with plastic components can be carried forward in die casting designs with additional advantages.

Net-shape die castings can be produced with thinner walls than comparable plastic parts, and can provide greater strength and product durability over a longer life cycle — with added serviceability.

Cost-effective die cast components can survive higher temperatures and user abuse, compared to plastic counterparts.

Threaded inserts and EMI/RFI shielding, additionally required for many plastic electronic housings, can be eliminated with a die cast housing, resulting in lower unit costs. Metal inserts in plastic housings serve to further complicate plastic recycling.

Parts redesigned as a single die cast unit from a combination of metal and plastic components, or from components produced in a variety of metals, can not only result in significantly lower costs and improved performance, but also yield advantages for recyclability. Many examples exist over a wide range of die cast product applications.

- *The housing frame for a tabletop bundling machine for applying plastic strapping was redesigned as a near net-shape die casting, replacing 27 separate components consisting of stampings and heavily machined parts.*
- *A die cast feed horn wave guide for a satellite receiving system was produced as a single net-shape part, as opposed to multiple components requiring several manufacturing processes.*
- *The die cast design for a passenger car gearshift selector tube, part of a passive restraint steering column, replaced a steel shaft and multiple-piece assembly at a savings of over $1.00 per part, for a $3 million annual cost reduction.*
- *A multiport valve body for a tractor-trailer spring brake release valve became a single die casting, to replace a multiple assembly of fittings with significantly reduced machining costs.*
- *An office machine bracket, redesigned as a single die casting, originally consisted of eight metal components, each produced from six different alloys and processes.*
- *A trimmer-mower housing die casting has enabled a number of significant advantages, such as steerable wheels and a sleek design, setting it apart from competitors who utilize stampings. Housings fabricated from stampings contain more parts and are not lower in cost.*
- *A die cast lower crank case for a motorcycle was designed to eliminate costly secondary machining operations and additional engine parts.*
- *A bracket for an electronic enclosure was converted from a machined part to a die casting. The die casting is cast to net-shape and eliminates all machining.*
- *A die cast modem frame was designed to replace an assembly. The assembly was a plastic part sandwiched between two metal plates and held together with self-tapping screws. The one-piece die casting results in cost savings to the customer.*
- *A die cast head node for a mountain bike was converted from investment cast parts, to a unique design, yielding a 30% weight savings, part and assembly cost savings, better consistency in impact and fatigue and better performance.*

5.1 Eliminating Waste through Increasing Product Life

Since scrap avoidance is one of the most effective ways to reduce waste, a new design emphasis is being placed on increased product life.

A designer should weigh the snap-fit capability of molded plastic against the ability to disassemble and reassemble high-strength die cast components, with product integrity maintained over their useful life. The proven ability of a die cast product to be serviced and/or rebuilt can result in a doubling of its total life cycle. Aluminum die cast brake housing bodies on heavy trucks, for example, can be remanufactured after 750,000 miles of service and reinstalled to perform for an additional 750,000 miles.

6 Die Casting's Recycling Circle

Aluminum die casting alloy recycling has been in place almost from the beginning of custom die casting production. Today newspaper advertisements for aluminum scrap, such as the one shown here, are not uncommon.

Specifications for aluminum alloys have been developed that provide for a full range of compositions that can utilize recycled metal. A wide variety of aluminum scrap can be reprocessed to produce all of the most widely specified die casting alloys.

Over 95% of the aluminum die castings produced in North America are made of post-consumer recycled aluminum. Since the production of recycled aluminum alloy requires approximately 5% as much energy as primary aluminum production, there is a dramatic conservation of non-renewable energy resources.

Die castings, as opposed to forgings or extrusions, for example, can make far greater use of recycled material.

Process and Material Selection for Product Recyclability

The typical life cycle for die cast components is shown in Fig. 1-2. While the recycling circle for aluminum, copper, magnesium and zinc die cast parts is very similar, each will differ in the extent to which internally reclaimed alloy at the die casting plant will be reused directly or will move to a secondary smelter or primary producer for remelting and reprocessing.

When a die cast product is reclaimed at the end of its useful life, it enters the nonferrous alloy reclamation stream. Nonferrous alloy parts can be readily separated from ferrous components by long-established magnetic means.

Large assemblies with a high proportion of metal parts, such as automotive vehicles, are the easiest scrap to be recycled and a well-established infrastructure exists.

High-value components are usually dismantled from vehicles and enter the used parts or remanufactured parts distribution channel. The remaining automobiles are then shredded, with 75% of the weight of a typical car yielding recycled material, virtually all metal. An average vehicle in 1998 produced over 168 lbs of aluminum alone for recycling. Though aluminum makes about 9% or slightly more than 300 pounds of today's car, it can add up to 30% of its recyclable value.

Unlike plastic, there is no necessity to segregate various types of aluminum scrap for remelting and reprocessing. Reclaimed aluminum from siding, trailers, major appliances, and automobiles — produced by a variety of metal forming processes in a range of alloy types — can be recovered by the aluminum smelter using selective thermal processing. Carefully engineered and analytically controlled chemical composition result in precise specification ingot for each of the commonly used die casting alloys.

As product engineers seek to design their new products for optimum servicing, reuse and recycling, aluminum, copper, magnesium and zinc die castings are available to meet their needs. With an infrastructure in place for reclaimed die casting alloys, and a proven ability to capitalize on parts consolidation principles, die castings can be respecified for a wide variety of parts originally conceived as molded plastic.

Where lightest weight is an important product criteria, selected die casting alloys can offer excellent strength-to-weight ratios, with total part weight virtually identical to the plastic component being replaced. In selecting materials and manufacturing processes which meet environmental concerns, the product designer should ask these questions:

- *Does the material allow for efficient and economical maintenance, repair, refurbishing or remanufacturing of the product to extend its life, where this is a design benefit?*
- *Is the material readily recyclable at the end of its useful life?*
- *Can the material be recovered and reused in high performance applications?*
- *Is the necessary infrastructure in place to make recycling of the reclaimed material a practical reality?*

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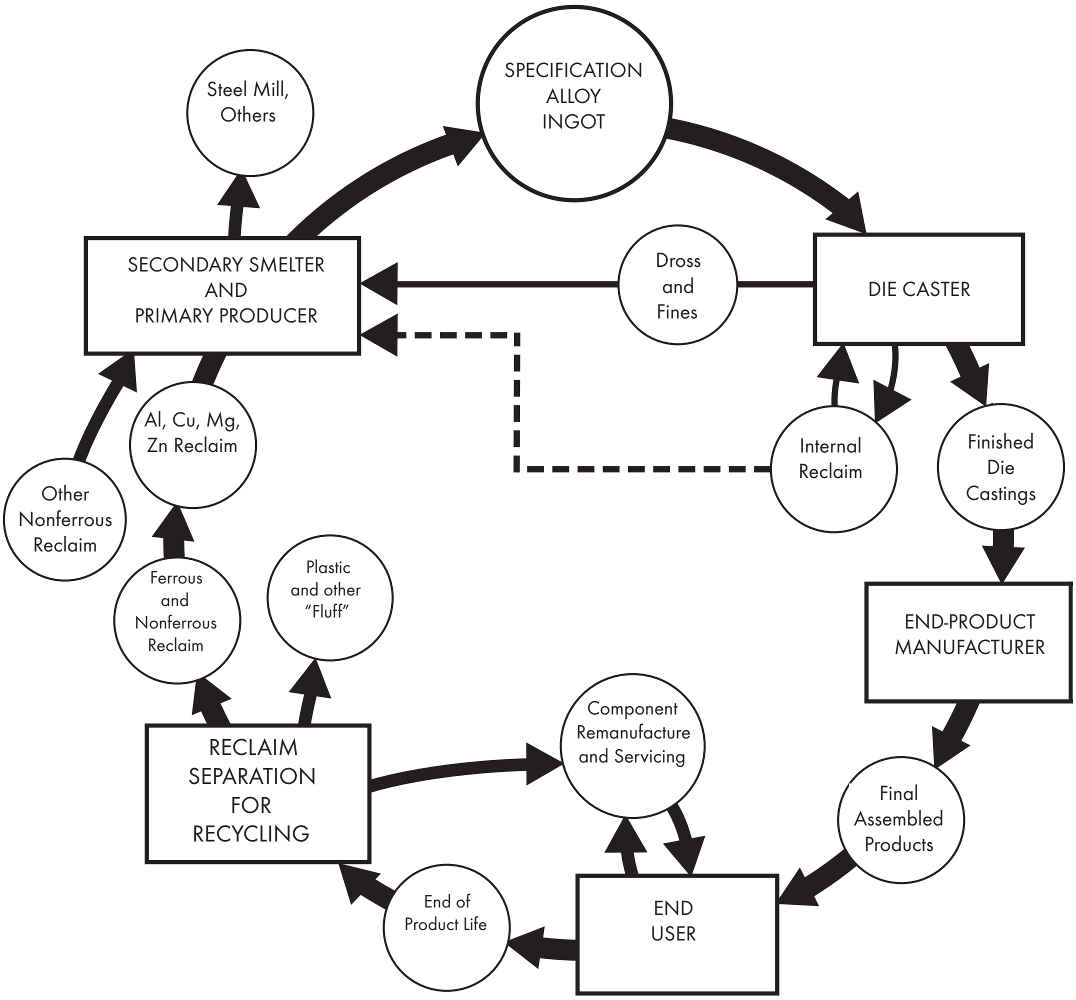

Figure 1-2 The Die Casting Recycling Circle – The die casting alloy recycling stream, illustrated above, is based on an existing worldwide metal reclamation infrastructure that has been operative for more than 40 years. This basic recycling pattern, with variations based on the amount of reclaimed alloy going to secondary and primary producers, applies to the majority of die castings being currently specified.

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