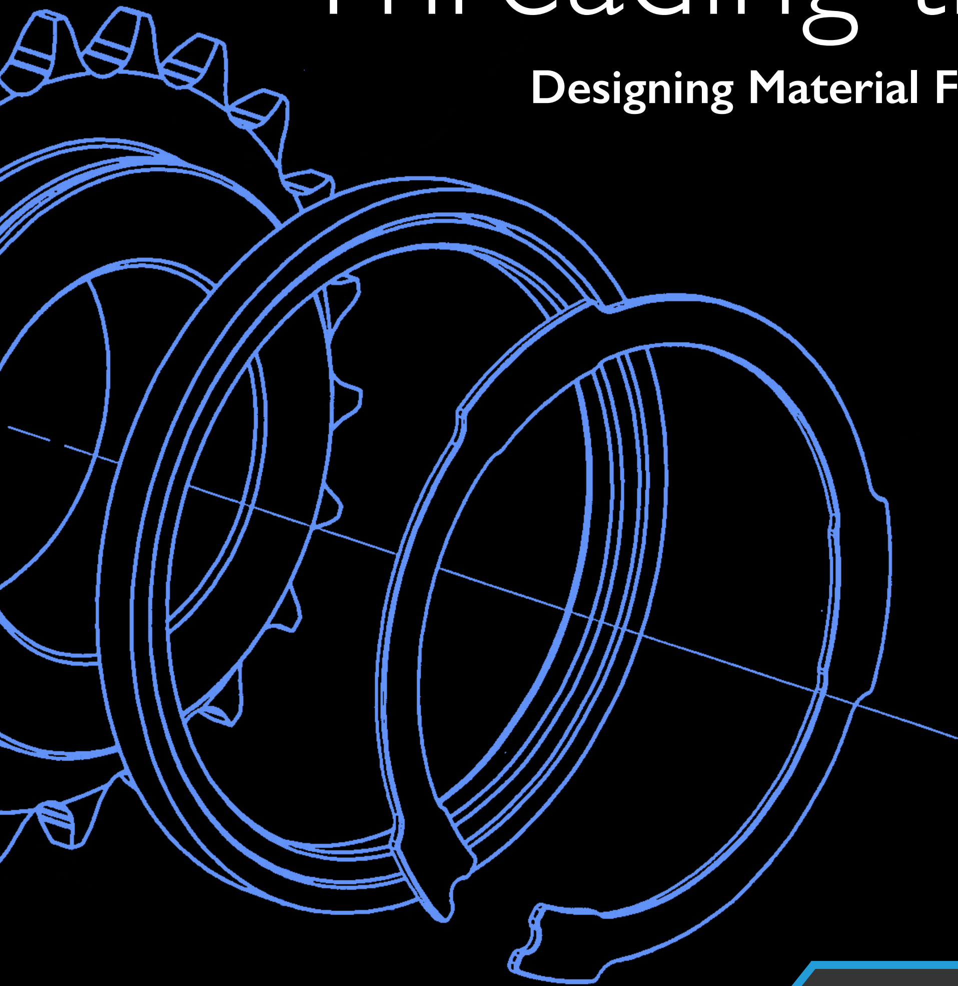
Threading the Needle

Designing Material Flows from Beginning to End



Executive Summary

Design for Disassembly is a design strategy that considers the future need to disassemble a product for repair, refurbish or recycle. Can the product be reclaimed, refurbished, and resold? If it must be discarded, how can we facilitate its disassembly into easily recyclable components? The Design for Disassembly method increases the effectiveness of a product both during and after its life.

Reduction of Labor Costs

Products that **disassemble easily** often assemble easily, saving the company time and money on labor. Also, if products need to be repaired or refurbished, quick disassembly will save time and effort for the company and keep the customer satisfied.

Reduction of Material Costs

DfD solutions emphasize simplicity. By closely examining the anatomy of a product, designers are often able to find components that can be **combined or deleted** altogether, saving material and production costs. In addition, when products can be refurbished, the material and production costs are greatly reduced—as with disposable cameras or printer cartridges.

Open New Markets

When companies make smart choices, people notice. Honda, a leader in fuel-efficient vehicles, has developed a reputation for building cars that minimize their impact on the environment.

Systems Thinking

"Having designers understand how they can affect the different groups in the organization is fundamental to designing more sustainable products," notes Phil Berry, President of Sustainable Product Works, and former Director of Footwear Sustainability at Nike. By seeing that products can be **reclaimed**, designers are changing the way things are constructed, so those materials can be re-integrated into the production cycle.

Sharing Goals with Strategic Suppliers

By working closely with manufacturers, Honda developed recyclable faux leather. Not only can the material re-enter the resource stream, it also eliminates the toxic chemicals found in leather production such as chromium. Suppliers are experts in their field and can provide better alternatives if the design team communicates their objectives.

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The Industrial Ecosystem

Integrating Design and Process

As the green game is played out in corporate boardrooms, the shop floor, in the home, and in the community, it is clear that technology and engineering will continue to play a critical role in reducing many environmental impacts of production and consumption.

Neither technology nor technological know-how are in short supply. The primary opportunities come from the continued, sustained application of existing technology to identified problems. The primary need is to **create the incentives and techniques** for companies to use technology and knowledge to improve environmental quality.

Human economic activity has been characterized by an open and linear system of materials flows, where materials are taken in, transformed, used, and thrown out. As human populations grow, discarding waste material is becoming increasingly problematic.

Momentum for Change

Regulatory pressures and shifting public opinion have spurred the industrial and engineering community to initiate efforts aimed at closing the materials loops more effectively and improving energy-use efficiencies.

One way for industry to be more self-sufficient and less wasteful is to improve the efficiency of materials use. It seems worthwhile to **examine both production processes and product designs** to see if the use of materials (and energy) can be improved. Currently, when products wear out or are replaced by newer models, they are usually thrown away.

Case Study: Volkswagen

Closing the Lifecycle Loop

A Million Little Pieces

Automobile manufacturers such as BMW and Volkswagen have designed cars for easy disassembly and recycling. These companies are designing new products with reuse, remanufacture, and recycling in mind. The industrial ecology perspective is beginning to influence designers of manufacturing processes.

Launched in 2010, Volvo's Project MiniBug has reduced the number of parts in the VW Beetle from 14,528 to 12,302, decreasing assembly time by 10% and leading toward approximately $1,700 in saving per Beetle sold.

Streamlining Reuse

Material Stewardship by Design

Designing a product as a temporary provider of a service, to be used later in the creation of another product, is a novel idea in modern manufacturing and raises a new set of issues. If the manufacturer thinks about taking it back for remanufacturing, the length of time the product spends in the customer's hands becomes an adjustable design variable.

The maker may not want the product to wear out by being used for an indefinite time and so might choose to reclaim it at an optimum time for remanufacture. The manufacturer may increasingly want to choose materials and designs that take into account the product's eventual "de-manufacture" and reuse.

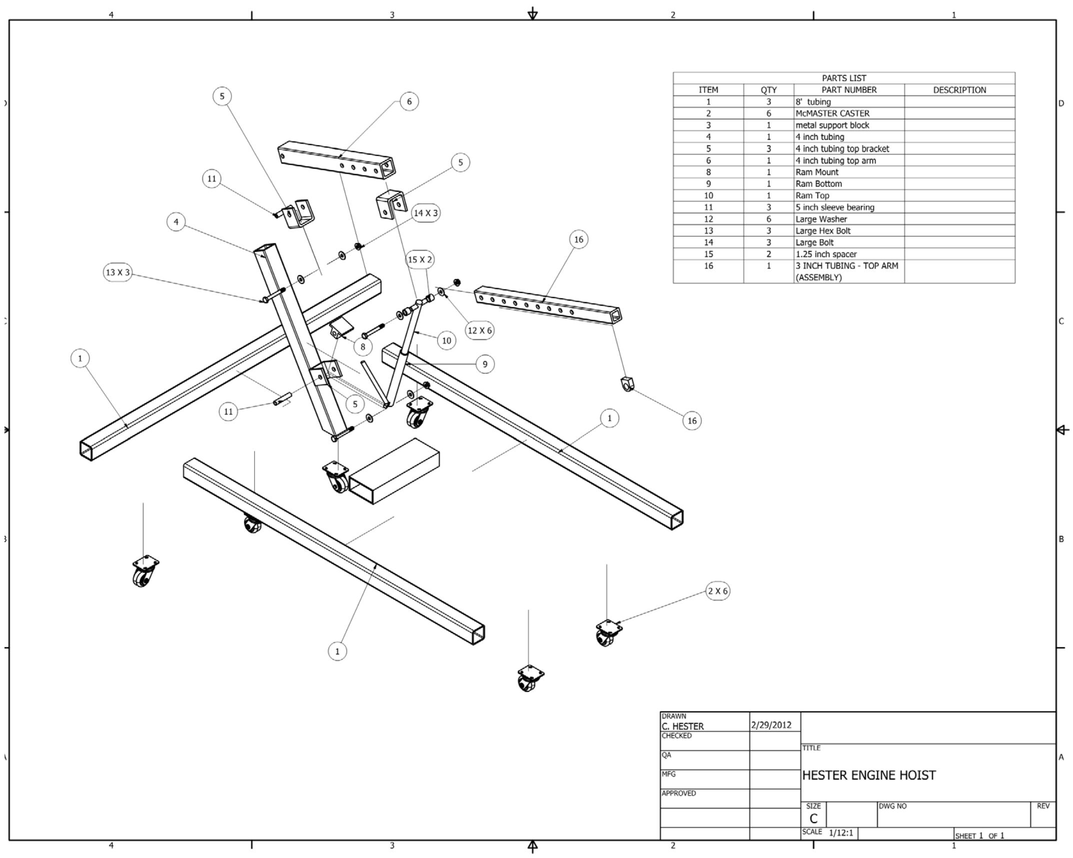
Designers of products are beginning to view their creations as transient embodiments of matter and energy. In a lease-based system, the manufacturer controls and therefore is responsible for the end of the product's life and is always prepared to take it back for recycling, reuse, or refurbishment. Products and the materials they contain are being designed so that they can be reused at the end of their lives.

Caring for our Materials

The whole industrial process can be thought of as a closed cycle in which the manufacturer has overall custody for the material used. In this system, the manufacturer must consider the entire material and energy stream, from materials input and manufacturing through the life of the product and its eventual reuse or disposal. This concept has begun to be embodied in law (as in Germany), making manufacturers responsible for their products through to final disposition.

Keeping Materials Separate

The manufacturing process tends to mix materials that are further mixed in the process of waste disposal. In remanufacturing, one generally wants to separate things into their original components and materials. There are costs involved in collecting, sorting, and transporting used-up products, scrap, and waste. Such separation requires information, effort, and energy, which must all be paid for. These costs must be compared with the costs of new materials.



Examining Existing Schematics

Sharing existing product schematics and tooling specifications with industrial designers builds shared understanding and helps identify how future designs can be streamlined.

Using Recyclable Materials

The suitability of a material for an intended reuse is a key technical concern. Metals, metal compounds, and organic materials make up a large fraction of industrial products. The metals are relatively easy to reprocess and reuse. In many cases, however, organic materials are best thought of as energy stored in chemical bonds rather than as reusable materials.

Design engineers may not know of the real costs to the company of the materials they choose. Automobiles, their components, and other metal products, especially those made of iron and steel, have a long history of being recycled without regulatory prodding.

For other metal products and materials, progress has come later and been much slower. Why is there so much waste, especially of iron, steel, and precious metals, in the metal industry, which has such a long tradition of recycling?

Tooling Costs

Adapting Existing Processes

Managing Tooling Inertia

Heavy capital investment in existing systems may prevent a company from securing an easy source of new investment to start over. This obstacle may introduce a time lag, postponing the decision to recycle until it is suitable to make a capital investment, such as when the machinery requires change for some other reason.

Some companies that face competitive forces of ever-shorter product lifespans, particularly those in the electronics industry, have introduced "design for the environment" techniques as a major impetus for reengineering their products and processes.

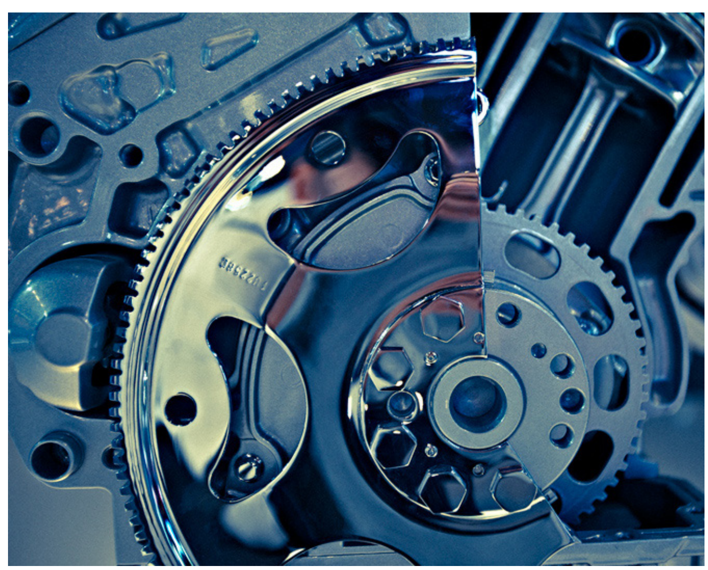
The U.S. regulatory system for industrial wastes has been designed around disposal, and the rules treat recycling and reuse as forms of disposal. The designation of a material as waste, as distinguished from scrap or hazardous material, can be crucial.

Stronger through Material Integrity

Working through the constraints of minimizing material mixing and part reduction can often have other benefits as well. Switching wheel locks from zinc-coated steel to titanium increased their lifespan by 140% for an increased cost of only 28%.

"Tramp" Elements

Waste and product materials sometimes contain unwanted "tramp" elements. These contaminants can **ruin the reuse potential** of the materials or make handling difficult or dangerous, and purification is often problematic. As products are redesigned for newer more cyclical material use, some of the material problems may be eliminated through smarter design. However, it will not always be possible to "design out" problematic materials. For example, zinc is often used to coat steel to prevent corrosion. It can interfere with the desirable properties of new steel forged from melted recycled scrap steel.



Finding Your Counterpart

Design and Production have often lived in independent silos, but the reality is that each step in the design process has a complementary tooling process.

Understanding the practical constraints of the production side is crucial to producing effective product design. Likewise, understanding design trends will better help facility managers plan for the future.

1. Material Analysis

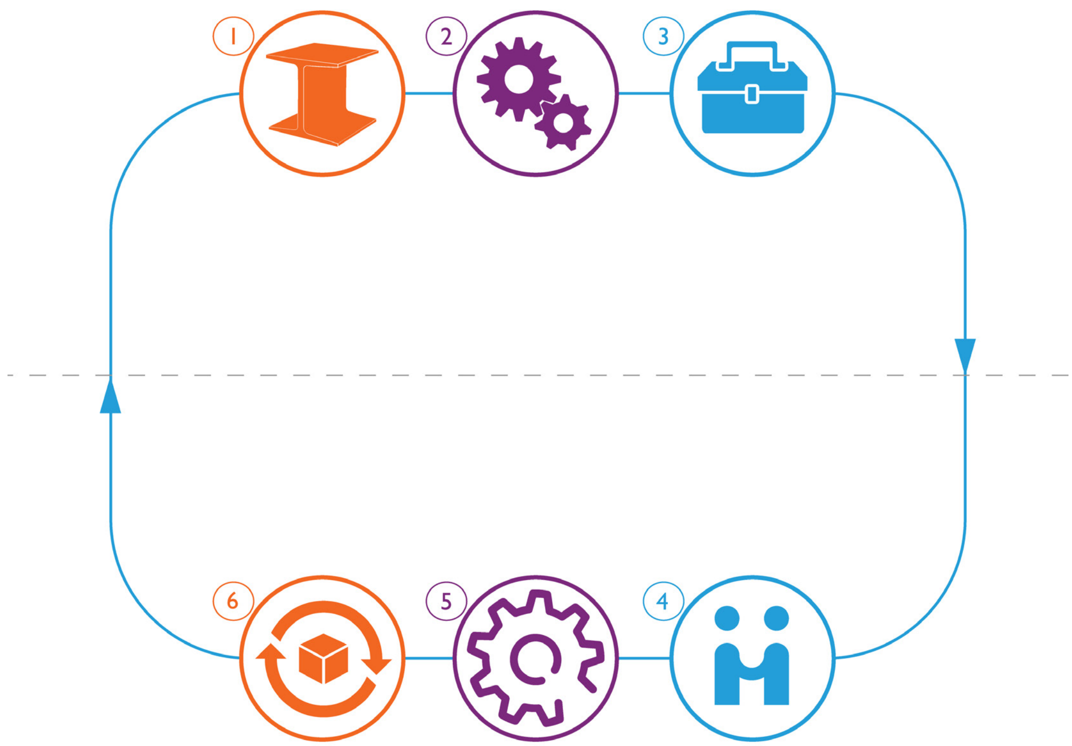
Effective design for disassembly starts by analyzing potential materials. What are the tradeoffs between cost, durability, and reuse? How hard is it for facilities to repross the material?

2. Component Refactoring

Examine existing schematics to identify parts that can be eliminated or standardized. Production plants can be streamlined by sharing parts across product lines.

3. Tooling Preparation

Designers should meet consistently with facility managers throughout the design process so that facilities can be properly tuned.



6. Component Sorting

Sort unusable components by material and direct them to the appropriate recycling or disposal stream.

5. Product Disassembly

Identify any parts that are still usable, perhaps for repair and refurbishing of other products.

4. Reclamation from Customer

Designers should work with facility managers to build reclamation processes that are convenient to the user and allow retrieval of the most valuable materials.

Disposal and Reclamation

A True Silver Lining

The Resource Conservation and Recovery Act

There are many inconsistencies in the Resource Conservation and Recovery Act. Recycling an industrial waste material is likely to require the recycler to become a legal disposer of that material under the regulations. Obtaining a permit has significant time, financial, and bureaucratic costs attached, which are a nontrivial barrier to reuse of industrial waste materials.

New Business Models

Some firms have already begun to design their products and processes with a view to closing material loops as much as possible. However, if a product is the transient embodiment of materials (a plastic water bottle for example), then closing the loop on those value-added materials raises an important question for the firm: Is the product simply the hardware being sold, or is it rather the services that the product can provide?

Obstacles

The barriers to industrial recycling of metals can be classified into six interrelated areas: technical hurdles, economic barriers, information barriers, organizational obstacles, regulatory issues, and legal concerns. When recycling is technically feasible, it may be economically unsound. When it is technically and economically satisfactory, a lack of information may block its adoption. Even when the requisite information is at hand, organizational problems can still stymie implementation. Finally, when all else is satisfactory, a recycling scheme can founder on the rocks of regulatory or other legal barriers.

Takeaways

Pragmatic, Productive, Procedural

Visit Manufacturing and Assembly
Regarding his visits to Nike's Asian suppliers, Phil Berry states "By analyzing the production facilities first hand, we were able to **reclaim roughly 15% of material that would have been scrapped**. We were also able to develop new techniques of how our shoes were built, allowing for future de-construction." By experiencing the manufacturing process, designers are able to identify complications, delays, and waste certain construction methods and material choices make.

Minimize material types
If a design can be made of **fewer parts and material types**, it will be easier to sort and recycle. Take this floss container for example. When it's finished, the entire steel casing can be recycled whole. If the other side was plastic, it would need to be manually separated and sorted for recycling.

Design for easy repair + provide access to parts: If it can be worn out, it will need to be replaced, and the design should support that. Batteries, moving components, contact areas are all examples of parts that will need replacement at some point. The challenge is two-fold: make it easy to replace, and make the parts accessible for purchase through a website or reseller. If these two factors aren't considered, the life of the product is severely limited.

World-changing design doesn't happen overnight. Instead things evolve incrementally to create a higher standard. Design for disassembly is fundamental to improving the cost, quality and longevity of what we produce. Design for disassembly delivers on our promise to provide people with better tools for living for years to come.

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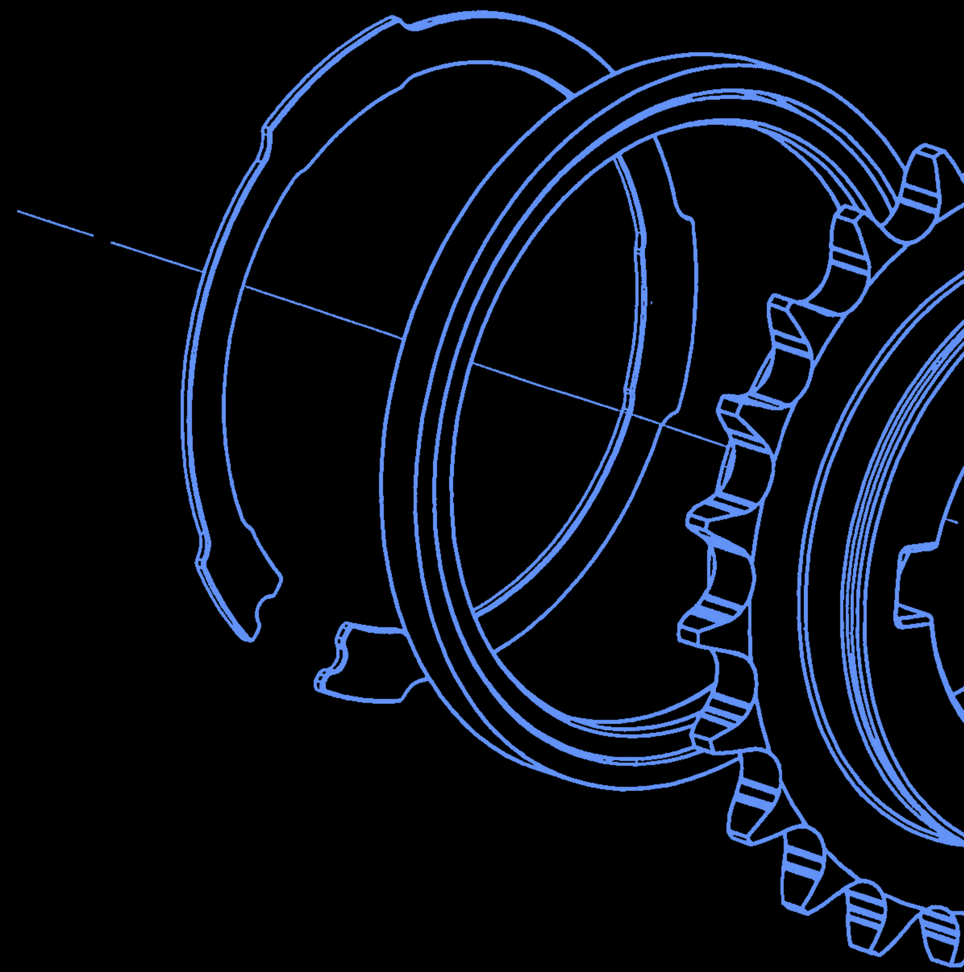
Colophon

Threading the Needle was produced for the Fall 2014 Interaction Design Fundamentals course at Carnegie Mellon University. The typefaces used are Gil Sans and Helvetica Neue.



GE imagination at work