V.

Design Review of Technical Options for Reducing Excess Material in the Cycle

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METHODOLOGY

The second major class of waste is the use of excess materials in the materials cycle. This chapter identifies technical options for reducing materials usage in the design, manufacture, and use of products.

Table 22 presents a list of options grouped in six basic classes or categories:

- use of less metal in products,
- substitution for critical metals,
- product rework and reuse,
- extended design life and durability,
- reduced inventories and overproduction, and
- use of less intensive materials systems and products.

Table 22.—Options for Materials Conservation in Product Design, Manufacturing, and Use

Use of less ***metal***
- Reduce size
- Stress optimization
- Better manufacturing techniques
- Eliminate unessential components
- Functional changes in product
- Standardization of components
- Design for recycle
- Decreased scrap generation
- Powder metallurgy manufacture

Substitution for critical materials
- Use of less critical materials
- Use of renewable resources
- Recyclable materials for nonrecyclable

Extended life through rework and reuse
- Product rework
- Reuse of components
- Remanufacture of components

Extended design life and durability
- Reduced obsolescence
- Failure avoidance
- I reproved maintenance procedures
- I reproved corrosion and wear resistance

Reduced inventories and production
- Combined inventories
- Production control

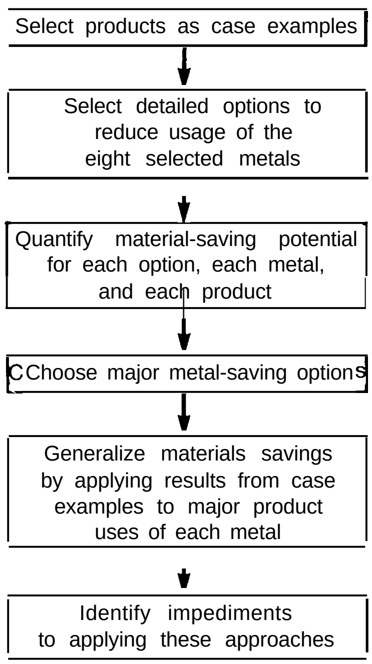
Use **of less-intensive materials systems and products**
- Use of coatings for alloys
- Reduction of alloy content
- Combined usage of products

SOURCE: OTA, based on Working Paper Three

These are technical options that, if implemented, would reduce metal usage. The list does not include implementation options such as education, increased R&D, and regulations, which could be used as a means of implementing a given technical option. Implementation options are considered in chapter VII.

The overall approach of this chapter's analysis is shown in figure 23. For selected products, the potential material saving for each option was estimated by conducting a design review. The design review was carried out on a product-by-product and component-by-component basis for each of the eight metals studied in chapter IV.

Figure 23.— Methodology for Evaluating Options for Reducing Excess Material in the Cycle



SOURCE: OTA

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Estimated material savings were then generalized to a whole range of products that contained the metals under evaluation. For example, if 10 percent of steel used in automobiles could be saved by a stress-optimized design, that percentage was applied to all transportation products containing a given amount of steel.

Because of the great variety of products and the large variations in material usage in each product, only a few products could be selected for review of their design, manufacture, usage, and disposal. The products are listed in table 23. These products were selected because they are typical of the specific industries indicated and because each product uses a relatively large amount of metal.

Table 23.—Products Selected as Case Examples

Industry	Product
Transportation	Automobile
Appliances	Refrigerator
Construction	Buildings Bridges
Machinery	Lathes Tractors
Fabricated metal products	Cans

SOURCE: OTA.

DESIGN REVIEW OF SELECTED PRODUCTS

In order to quantify the amount of material that could be saved using the technical options listed in table 22, a design review of each of the products listed in table 23 was carried out. The details of the methodology are described in the *Working Papers* (vol. II-C); an example of the methodology for refrigeration is given in chapter VI. Basically, each product and component were reviewed for alternative designs that would use less metal. The metal savings would be the difference in metal usage between the present and the proposed design.

The potential metal savings of every option is shown by product in table 24, The numbers in the table represent the percentage of the total weight of the product that could be saved or substituted for. For substitution options, the numbers represent the percentage saved of the second metal by substituting the first. A hyphen (dashed line) in the table indicates the savings are small but that no quantitative estimate has been made. NA indicates an option is not applicable to the product.

These numbers are engineering judgments of the overall conservation potential for the listed options. The numbers are interdependent in that implementation of one option will reduce the saving possible with another option. Also, the percentages shown indicate the savings that are technically possible. Economic and other factors may severely limit the actual savings. Finally, the purpose of these numbers is only to identify the most promising options, not the practicalities of implementation.

As shown in table 24, the potential metal savings are generally small for options that would use less metal. Removing excess metal through improved manufacturing techniques shows significant potential for metal cans, but not for other products. Stress optimization or “design to stress” is generally applicable and could save up to 30 percent of the metal depending c n the product. Other options save insignificant amounts of metal either because they represent the current practice or because they cannot be implemented. Design for recycling is not an effective strategy at present because it is not the design that limits the recycling, but rather ineffective methods of disposal and metal separation. This situation may improve in the future, but the net effect on material savings cannot be ascertained at this time (as indicated by an “X” in table 24).

Initially, standardization of components appeared to be a desirable option for saving metal through a reduction of inventory. However, this investigation showed that standardization could lead to increased, rather than decreased, use of metals because all components would have to be designed for the maximum usage condition. To be effective, standardization would have to be combined with component recycling so that the built-in excess durability could be fully utilized.

Substitution as a general option has the widest applicability and offers the largest potential savings. A substitution of one metal for another does not reduce the overall use of metal nor would substitution be an effective option if all materials, in-

Table 24.—Potential Metal Savings of Conservation Options for Selected Products

	Product					
	Cars	Refrigerators	Tractors	Lathes	Cans and containers	Fabricated metal structures
Use of less metal						
Reduce size	3-45	**10**	1	NA	NA	NA
Better manufacturing techniques	**1-6**	< 1	2	8	{23-33}	NA
Stress optimization	5-16	*30*	*2*	8		NA
Eliminate unessential components	< 1	—	—		NA	
Functional change	< 1	—	—		—	—
Standardization of components	< 1	—	—		NA	**10**
Design for recycle	< 1	x	—	—	x	**x**
Decrease scrap in manufacturing	2	1-2	< 1	1-2	—	—
Powder metallurgy	3-5	1-2	< 1	1-2	**100**	
Product recycling						
Product rework	15	80	NA	NA	NA	NA
Reuse of products or components	NA	NA	NA	NA	0-80	10-80
Remanufacture of components	15	1	50	5	NA	NA
Substitution’						
Al/steel	68	74	< 1	2	**100**	*40*
Plastic/steel	17-20	31-85	< 1	2	*40*	NA
Al/Cu	100	100	100	100	NA	100
HSLA/St	6	NA	2	1	NA	30
Steel/Al	100	75	NA	NA	100	100
Wood/steel	NA	NA	NA	NA	NA	< 30
Concrete/steel	NA	NA	NA	*50*	NA	*< 30*
Composites	*0-90*	*0-84*	< 1	4	NA	NA
Glass/St	NA	NA	NA	NA	40	NA
Glass/Al	NA	NA	NA	NA	91	NA
Lead/steel	NA	NA	30	NA	NA	NA
Plastic/Al	NA	NA	NA	NA	91	NA
Increase product life						
Increase component life	50-60	60	3	3	NA	—

Numbers indicate percentage of metal, by weight, that could be saved for each option and product studied A dash means negligible metal could be saved. NA means that option is nonapplicable X means savings cannot be determined at thls time

.The substitutions should be interpreted as follows, for example

Al/steel = substitution of aluminum for steel.

Al/Cu = substitution of aluminum for copper

HSLA/St = substitution of high-strength low-alloy steel for steel.

SOURCE: Working Paper Three.

eluding plastics, were in short supply. However, where a supply crisis develops with a particular metal (or material), substitution would be the most effective option if there were sufficient time to implement it.

Product recycling appears to be an effective option. A product reaching the end of its life (as defined by its owner) maybe returned to useful life in a variety of ways. It may be used again in its current state (reuse). Either the whole product or its individual components can be repaired, reworked, or remanufactured. Repaired means that the product is made operable. Reworked means that the product is returned to its orginal state or close to it by adding new parts, repairing parts, painting, etc. (overhaul). Remanufacture means essentially the same thing as rework except that in remanufacturing the original parts are not reassembled (see glossary, appendix D).

Product rework appears to be technically possible for most products except cans (which only have one life) and structures. The potential of this option is limited for automobiles since most of the automobile is now effectively recycled, but would amount to about 80 percent (the same as refrigerators) if this were not the case. The rework option does not apply to tractors and equipment that are already used almost to the limit of their useful lives.

Reuse of products or components offers some potential savings for containers and fabricated metal structures. The amount of metal saved would depend on the amount of metal used. Finally, remanufacturing of components is already extensively used for automobiles and could be applied to a wide variety of other products.

Increasing product life by increasing the lifetime of life-limiting components would save considerable metal, but only for certain products. A more detailed analysis is necessary to determine if enough products are involved to realize a substantial savings.

In sum, based on these selected products, the technical options that offer the greatest potential for saving metal are the following:

- substitution,
- stress-optimized designs,
- rework and reuse of products and components, and
- extended product life.

The following section presents estimates of the total savings possible if each of these options was applied to all products, not just the ones listed in table 24.

In table 25, the results from the specific case examples presented in table 24 are generalized to the industry as a whole. The numbers in table 25 are the percent of 1974 domestic shipments that could be saved by each option listed. The detailed methodology used to develop these percentages is described in volume II-C of the *Working Papers.* In brief, the percentages derived for the individual products were applied to all o the products within a given industry.

More specifically, the flows of materials were disaggregate into all major end-use products for each of the eight selected metals. Then each of the end-use products was placed in one of the following categories:

- transportation,
- electrical equipment,
- building and construction,
- industrial machinery and equipment,
- off-the-road equipment,
- commercial equipment,
- domestic equipment, and
- cans and containers.

Based on the data from table 24 and engineering judgments as to their applicability, the following metal-saving percentages were applied to the end-use products in each category.

1. For substitution, metal savings ranged from 2 to 100 percent with the following rough breakdown: (variations were also made on a metal-by-metal basis)
   - 2 percent for metalworking and manufacturing equipment;
   - 10 percent for tractors and related machinery;
   - 40 to 100 percent for building and construction materials;
   - 40 percent for electrical machinery;
   - 70 percent for appliances;
   - 70 to 100 percent for automotive; and
   - 100 percent for containers.
2. For using less metals, both manufacturing techniques and stress optimization were con-

Table 25.—Potential Metal Savings of Conservation Options[a]

Metal	Substitution	Substitution in construction industry[b]	Use of less metal[c]	Increase product life	Remanufacture of components	Reuse of products or components	Product rework
Aluminum	60	6	8	5	1	15	30
Copper	59	23	6	6	4	32	
Iron and steel	29	6	9	8	3	11	30
Chromium	16	—	4	5	2	6	12
Nickel	20	—	8	9	2	15	12

aNumbers indicate percent of total 1974 end use of each metal, generalized from product to industry.
bIncluded in substitution.
cBy better manufacturing techniques and stress optimization.
SOURCE: OTA, based on Working Paper Three.

sidered together. Where appropriate, the following numerical values were applied:

- 8 percent for machinery and manufacturing equipment;
- 10 percent for electrical machinery; and
- 10 to 20 percent for appliances, construction, containers, and automotive.

3. For increased product life, computations were carried out as follows: A factor of 50 percent was applied to automobiles, some appliances, household products, domestic and office furniture, and air-conditioners. Three percent was applied to some industrial equipment.

4. For remanufacture of components:
   - 15 percent for automotive, appliances, watches, clocks, motors, generators, transformers, and air-conditioners;
   - 50 percent for locomotives, tractors, and agricultural machinery; and
   - 5 percent for industrial materials-handling equipment.

5. For reuse of products and components:
   - 50 to 80 percent for architectural products such as windows, doors, screens, awnings, canopies, plumbing, and other builders' hardware; reusable containers such as barrels, pails, domestic and office furniture; wire and cable;
   - 10 percent for limited other categories such as cabinet sheet stock; and
   - The percentages shown for product rework were based on an independent study of the products for which rework was made possible and a determination of the amount of metal contained in these products.

For each technical option and metal, the total potential metal savings as a percentage of end usage is given in table 25.