American Plastics Council

Plastics

Key Materials for Innovation and Productivity in Major Appliances

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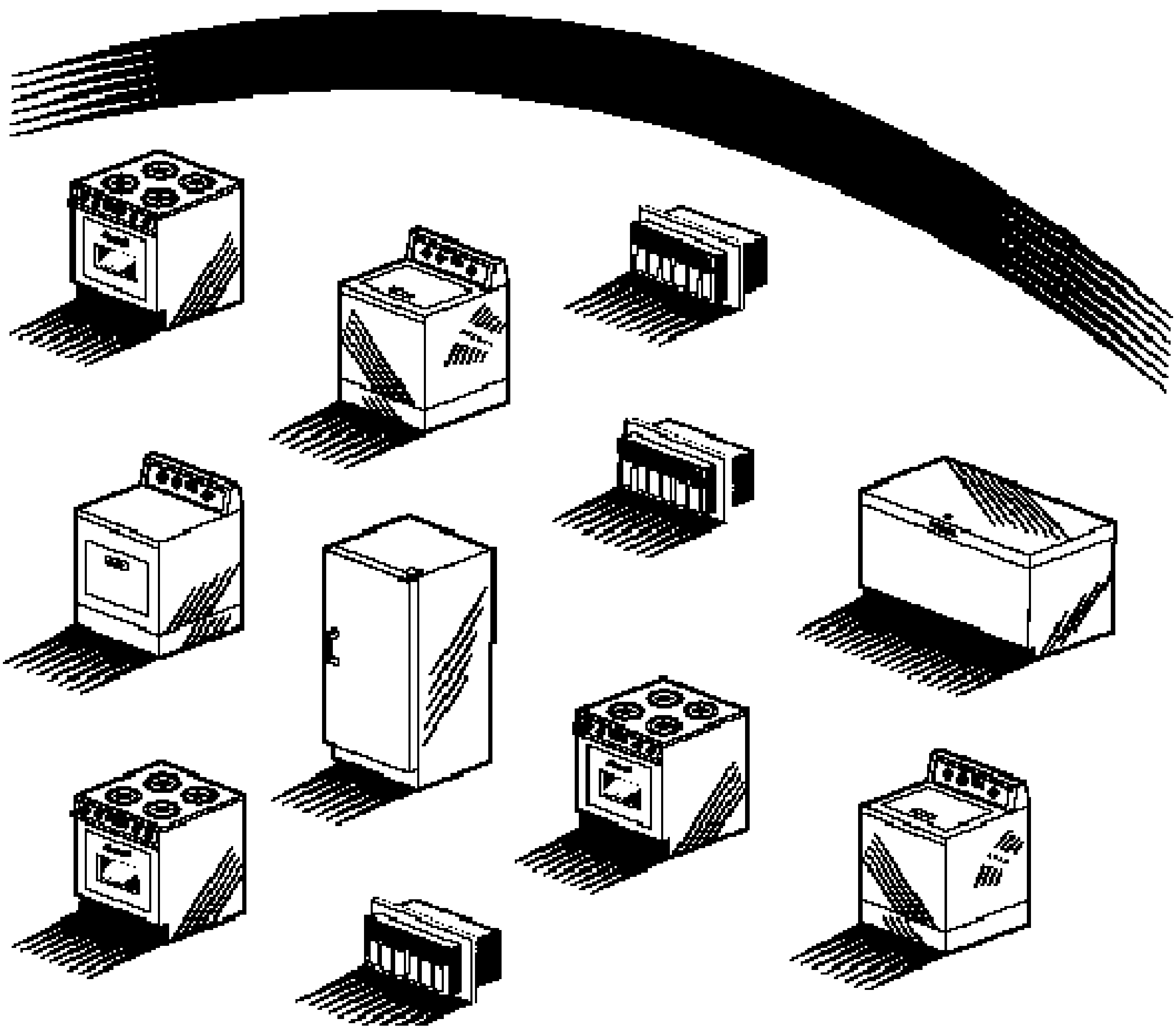

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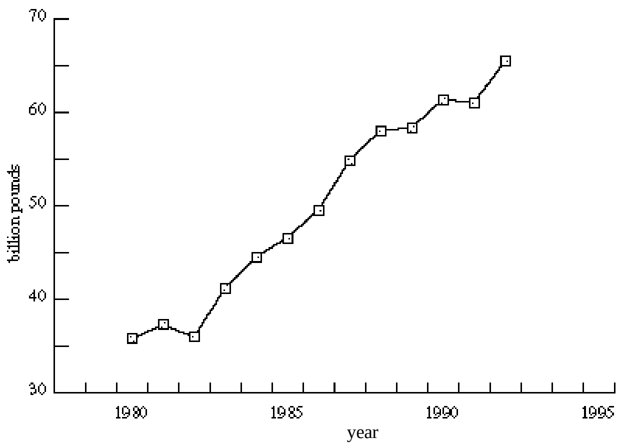
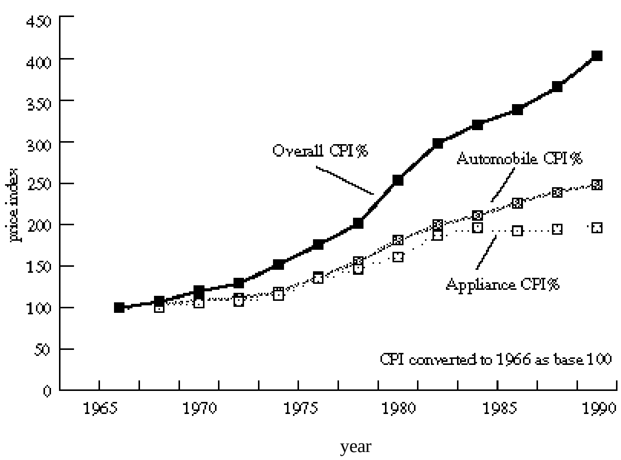


Figure 2: Overall CPI versus CPI for appliances and automobiles.



Highly versatile plastic materials have experienced rapid growth in the United States (Figure 1). In major appliance applications, they have grown from less than 1 percent of material content in the early 1960s, to almost 25 percent by weight today. This equates to over 60 percent of total material volume.

Plastics' ease of fabrication into complex shapes through melt injection molding and thermoforming processes and the thousands of possibilities for specific compounds, each with a uniquely tailored set of properties, has made possible many new product features, improved product performance and significant reductions in product cost.

Plastics have allowed the creation of such features as refrigerator inner door storage, through-the-door ice service, clear lightweight storage pans and covers and soft touch handles. Plastics have also made possible aesthetically appealing, legible and highly functional electronic control panels. Molded complex shape clothes washer agitators have greatly increased energy efficiency and washing performance. Urethane foam thermal insulation has improved the energy efficiency of refrigerators by more than 50 percent. Chip-resistant molded dishwasher tubs and corrosion resistant dishwasher and clothes washer pumps and valves have greatly extended product life. Molded plastic double-wall shock resistant electrical enclosures have enhanced product safety.

The major appliance industry is highly competitive and has an outstanding track record for increased productivity and cost containment. A 13.5 cu. ft. refrigerator with porcelain enameled steel door liner, cabinet liner, storage pans and fiberglass insulation cost $525 in 1940. Today, an 18 cu. ft. refrigerator with automatic defrost, automatic ice maker, plastic inner door storage, plastic cabinet liner, clear plastic pans, and urethane foam insulation uses 50 percent less energy and costs less than $500. Indexed for inflation, the 1940 refrigerator would cost well over $5000 today.

The overall Consumer Price Index (CPI) has increased over 300 percent since 1966, while the CPI for major appliances has increased only 96 percent (Figure 2, page 1).

The overall Producer Price Index (PPI) and the PPI for major appliances and plastics are shown in Figure 3.

Parts consolidation and integration, molded complex functional shapes and ease of fabrication through the use of plastics result in a 15 to 20 percent savings per application in product cost and often as much as 50 percent less manufacturing investment to fabricate major structures.

The application of plastics with outstanding thermal insulation and moldability characteristics has significantly reduced energy usage and operating costs for major appliances. Since 1972, product energy consumption has been reduced 30 to 40 percent and operating costs have decreased 30 to 60 percent (Figure 4).

In summary, plastics contribute significant value in the manufacture of major appliances. Many of the work saving and convenience features we take for granted were made possible only by the unique application of plastics. In addition, plastic materials and processes have increased manufacturing productivity and contained escalating costs and significantly reduced energy usage. As a result, major appliances are one of the best values among today's consumer products.

Figure: 3: Overall PPI versus PPI for major appliances and plastics

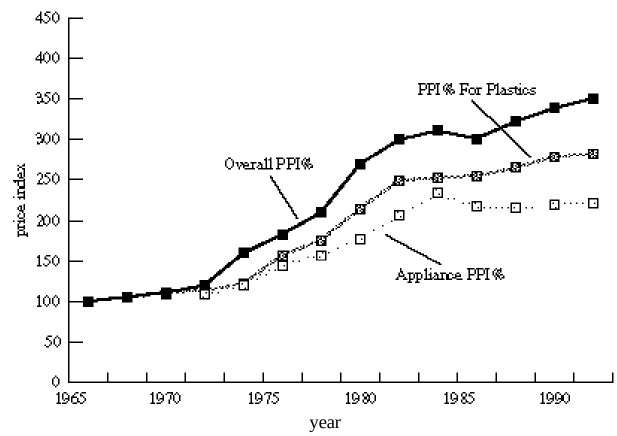
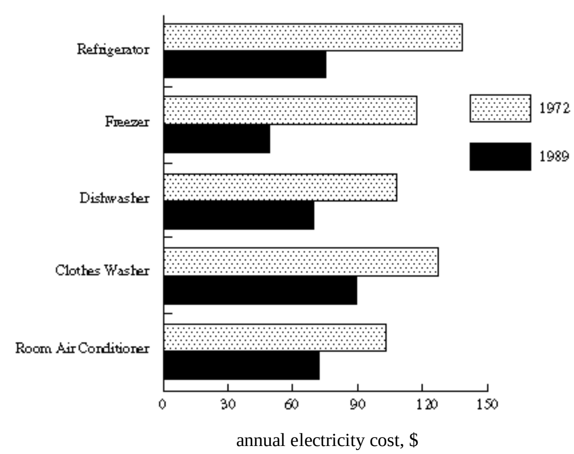


Figure 4: Costs to operate appliances



In 1981, in an early cradle-to-grave look at total energy savings, Franklin Associates, Ltd. reported a total energy savings of over 30 trillion British Thermal Units (Btu) per year in appliance manufacturing and use.

Without plastics, today's major appliances would cost at least 25 percent more and use 30 percent more energy. Refrigerators would use 50 percent more energy and lose 20 percent of their storage capacity. Corrosion would reduce product life for clothes washers and dishwashers by roughly 50 percent and truly portable room air conditioners would not exist.

Introduction

Major appliances, those workhorses of the home kitchen and laundry, are an integral part of the American lifestyle, providing convenience and high quality performance for preserving and preparing food and for washing and drying dishes and clothes. Major appliances save time, sanitize, and contribute to safety and conservation in the course of many daily chores.

The United States' major appliance industry manufactures products such as home refrigerators and freezers, cooktop ranges and ovens, clothes washers and dryers, dishwashers and room air conditioners. It is one of the larger consumer product industries with annual sales of over $12 billion, production of over 38 million units, annual investment of over $300 million and employment of nearly 100,000 people.

In 1990, the major home appliance industry spent over $7.6 billion for components and materials such as steel, porcelain enamel, plastics, paint, wires, fasteners, controls, motors and gaskets. Over $1 billion of this amount was spent on plastic materials that emerged from World War II technology. Modern plastic materials are lightweight, tough, corrosion-resistant, and provide myriad specific compounds and property profiles. Plastics are highly versatile materials that are easily molded and formed into complex shapes and geometries. These materials grew from 1 percent of major appliance material content by weight in the early 1960s to more than 20 percent by weight (more than 60 percent by volume) today.

This growth occurred because plastics have been major contributors to the continuing innovation of features and convenience and to continuous improvement engineering that has been standard operating procedure in the major appliance industry over the past 25 years.

It is interesting that both the U.S. major appliance and plastics industries have maintained world class technological and competitive leadership and have helped keep manufacturing in the United States strong and healthy. Comparisons shown in Figures 2 and 3 for CPI and PPI data illustrate that the indices for major appliances and plastics have increased much less than those for the overall marketplace and for automobiles.

The purpose of this paper is to document the tremendous advantages that plastic materials bring to major appliances. Without plastics we would not have many product features such as refrigerator inner door storage, washing machine agitators and Mini Baskets®, dishwasher automatic dispensing detergent cups, attractive multi-functional control panels and lightweight portable room air conditioners with over 5000 Btu capacity.

In addition, plastics have made possible energy-saving foam insulation, double wall shock-resistant electrical enclosures, and highly functional touch pad electronic control panels that depend on back-printed clear plastic films for graphics and on flexibility for tactile control switches.

Plastics' high strength-to-weight ratio, corrosion resistance, molded-in color and ease of fabrication into complex shapes have resulted in greatly reduced product costs. Production savings have come from parts consolidation, reduced manufacturing costs and reduced paint pollution. Plastics have also greatly increased product life and durability in the hostile environments where major appliances must operate.

Plastics applications in major appliances

Plastics technology led to the emergence of lower cost, large volume commercial materials following World War II. Rapid technological advances in the identification of new polymers and the chemical and physical modifications of these polymers employing copolymers, terpolymers and others have resulted in a wide array of versatile resins for use by product manufacturers. In addition, mechanical blending and the addition of fillers, reinforcers and other additives have made a wide array of engineered plastics available. With enhancements in fabrication processes, the use of plastics mushroomed. Nowhere was the increased consumption more pronounced than in appliances where usage soared from 10 million pounds in 1959 to over 700 million pounds by the early 1980s. Today, plastics usage in appliances totals more than 1.3 billion pounds annually.

Early applications of plastic capitalized on its unique properties of low thermal and electrical conductivity. Refrigerator breaker strips that connected the outer flanges of the steel cabinet to the steel inner liner are an example. The low thermal conductivity of the plastic prevented excessive heat leakage from the exterior metal surface to the refrigerator interior. Isolation of electrical current carrying parts requiring materials having good dielectric properties, such as wiring and motor insulation, provides another example. Finally, polymeric gaskets provide the desired compressibility under load to seal case/ door assemblies.

During the 1960s, the rapid growth in plastics usage, technology and processes drove the price of plastics down from year to year. In this period, many direct substitutions of plastics for metal were made to reduce costs.

Plastics application technologies subsequently matured. Tailored materials, parts consolidation, and unique new processes became part of total systems design concepts that integrated material, process and design. Successful field history in the use of plastics increased engineering confidence, and plastics soon became employed in more and more structural designs.

A review of the major applications of plastics and their advantages in different appliances follows:

Refrigerators

As cited previously, the first applications of plastics in refrigerators were thermal breaker strips and electrical insulation. In the early 1950s, a metal divider with fiberglass insulation was used to separate the fresh food compartment (38° – 42° F) from the freezer compartment (0° F). Moisture would often soak the fiberglass causing the material to become soggy and lose its insulation effectiveness. The binders, necessary to protect the fiberglass during handling and assembly, also gave off offensive odors when wet. In 1956, expanded polystyrene bead foam was molded into one-piece dividers for this application, improving product quality and reducing cost. This one-piece molded part served as both insulation and divider.

Inner Door

By the mid-1950s, many new low-cost plastics were commercially available. One of these was high-impact polystyrene (HIPS). To produce HIPS, polystyrene, a clear, inexpensive and brittle plastic was combined with styrene butadiene rubber to form a tough, opaque, pigmentable, rigid thermoplastic that was lightweight, inexpensive and easily formed into complex shapes. Engineering creativity developed refrigerator inner doors out of HIPS that were no longer just flat panels but had complex shapes that included shelves and compartments for food storage inside the inner panel of the refrigerator door. The HIPS material was extruded into flat sheets and these were then heated and formed over complex molds in a process called thermoforming. The formed part contained the geometry that provided increased storage capacity.

Later, acrylonitrile was combined into the material to make acrylonitrile butadiene styrene (ABS). This engineering polymer provided improved chemical and stress-cracking resistance in the presence of food and was chosen by many refrigerator manufacturers to make the inner door. Today, virtually all refrigerators have functional inner doors made of ABS or HIPS. This plastic innovation improves overall energy efficiency and adds 2 to 3 cu. ft. of storage capacity to the refrigerator. Modern refrigerators now have inner doors with shelves wide enough to store gallon milk containers. The high performance of plastics in these engineering applications has given design engineers the confidence and creativity to use plastic in more and more load-bearing and structural applications. The plastics industry continues to create higher performance grades of ABS and HIPS.

Pans and covers

Plastics replaced porcelain enameled steel used for meat and vegetable storage pans. Initially, the first plastic pans were, like their metal counterparts, opaque. However, the plastic alternative was much lighter weight and much lower cost. During the application's evolution, clear lids were made of polystyrene, but brittleness prevented its use in the pan and required customer care in handling of the lids. Today, the introduction of partially clear high impact acrylic plastics has resulted in smoky clear pans and lids that are impact resistant and tough. Top-of-the-line refrigerators use polycarbonate, a relatively new, clear and very tough engineering plastic. These plastics are also used for storage module covers in the inner doors, lending a bright, crystal clear and attractive appearance. The use of plastics in storage pans has also made it possible to hot stamp decorative trim and identification information directly onto the pan fronts, further enhancing their appearance and functionality. The pan slides and rails are also plastic, which allows for low-friction movement.

Urethane foam insulation

In the late 1950s and early 1960s, another plastics innovation led to a major application in refrigerators that would have substantial impact on their energy efficiency and method of construction. The innovation was cellular polyurethane foam that was expanded by Refrigerant 11 (R-11), a gaseous blowing agent today more commonly referred to as Chlorofluorocarbon-11 (CFC-11). The heavy gas, CFC-11, in the closed-cell foam improved its thermal insulation properties by a factor of two. Cellular polyurethane foam has a thermal conductivity K-factor of 0.12 Btu-inch per Hr-sq. ft. - °F compared with 0.23 for fiberglass insulation.

The material was adapted to a pour-in-place manufacturing process that injects liquid polymer and CFC-11 blowing agent into the refrigerator cavity between the outer case and inner liner. The wall space is then filled as the liquid expands into a cellular foam that is cured into a rigid thermosetting ultra-small-cell-size foam by the heat created from the chemical reaction. In one step, a thermally superior insulation is formed that also serves as a rigid separator for the refrigerator walls and provides a very strong sandwich construction much like that used for aircraft structures today. Most refrigerators use this form of insulation and construction. The high strength of the sandwich structure makes it possible to reduce material of the outer case and inner liner by as much as 50 percent and makes possible the use of thin prepainted steel that can be formed without cracking the polymeric surface coating.

Relationships between energy usage, wall thickness, internal volume and external dimensions are illustrated in Figure 5 on page 10. Replacing polyurethane foam insulation with fiberglass, all other parameters being equal, increases refrigerator energy consumption by more than 60 percent. (Figure 5, Models A and B). If a fiberglass-insulated refrigerator were required to use the same amount of energy as an 18 cu. ft. refrigerator with foam insulation, its thicker walls would reduce the internal volume to just over 12 cu. ft. (Figure 5, Model C). If the 18 cu. ft. volume was maintained, the thicker walls would increase exterior cabinet dimensions by 3.6 inches in height, depth and width (Figure 5, Model D). These increased dimensions would preclude use in many kitchens.

Model E in Figure 5 is a refrigerator insulated with foam in combination with a new form of insulation, plastic vacuum panels, which are currently under development. These panels have a K factor as low as 0.04 Btu - inch per Hr-sq. ft. - °F, compared with 0.12 for foam and 0.23 for fiberglass. Their long-term viability in use and their suitability to modern manufacturing methods must still be established.

Improvements in product energy efficiency resulting from plastic applications in today's refrigerators, freezers, dishwashers and clothes washers saves over 53 billion kilowatt hours (kwh) of electricity annually, significantly reduces America's dependence on foreign oil and is a substantial contribution to energy conservation. The energy saved, equivalent to over 85 million barrels of oil, is sufficient to provide the annual energy needs of 4 million homes.

Because of the predicted adverse effects on the upper atmosphere's ozone layer by the currently used chlorofluorocarbon R-11 blowing agent in polyurethane foam, a major effort is underway to develop environmentally compatible substitutes. The conversion to alternative blowing agents is already in progress. A very slight decrease in insulation capability is expected. Longer term, future systems will probably incorporate plastic vacuum panels in conjunction with modified foam systems to maintain or improve energy efficiency. Plastics have provided, and will continue to provide, enormous advantages for reducing energy consumption throughout the life cycle of major appliances.

Figure 5: Energy usage, storage volume and external dimensions as functions of appliance insulation.

	Model A	*Model B*	*Model C*	*Model D*	*Model E*
Type insulation	FOAM	FG	FG	FG	VIP/FOAM
R value/inch	R9	R4	R4	R4	R25/R9
Cabinet dimensions (inches)					
Height	64.00	64.00	64.00	67.60	64.00
Width	29.30	29.30	29.30	32.90	29.30
Depth	28.80	28.80	28.80	32.40	28.80
Internal volume (cu. ft.)	18.03	18.03	12.18	18.03	18.03
Wall thickness (inches)					
Freezer top	2.10	2.10	3.90	3.90	2.10
Freezer sides	2.10	2.10	3.90	3.90	2.10
Freezer back	2.30	2.30	4.10	4.10	2.30
Freezer door	1.50	1.50	3.30	3.30	1.50
Freezer bottom	1.80	1.80	3.60	3.60	1.80
FF sides	1.60	1.60	3.40	3.40	1.60
FF back	1.80	1.80	3.60	3.60	1.80
FF door	1.50	1.50	3.30	3.30	1.50
kwh/day	2.37	3.88	2.39	2.39	2.02

Notes:

Model A: 1991 base-line 18 cubic foot with foam insulation.

Model B: Model A with fiberglass insulation.

Model C: Expand Model B wall thickness to reduce energy to Model A level and hold external cabinet dimensions.

Model D: Expand Model B wall thickness to reduce energy to Model A level and hold internal volume to 18 cubic feet.

Model E: Model A with plastic vacuum panel and foam insulation.

Plastics Inner Liner

In the 1970s, plastics again had a major impact on the design and manufacture of refrigerators. The extruded sheet thermoforming process was applied to make one-piece cabinet liners. Most of these had evolved from porcelain enameled steel to painted steel. The successful development of plastic liners using ABS or HIPS material reduced refrigerator cost and improved performance. An important advantage of the one-piece plastic liner was lowered thermal conductivity. This provided the desired thermal break between the warm outer case and the cool interior liner and eliminated the need for breaker strips. The end result was improved cleanliness and significantly improved energy utilization.

Another major step toward improving energy efficiency resulted from the formability of the plastic liner. This allowed a one-piece, stepped-wall configuration that produced thicker wall sections and insulation in the freezer than in the fresh food compartment. The simple, smooth, one-piece construction vastly improved cleaning, and the plastic liner allowed parts consolidation by forming components into the liner. For example, the freezer/fresh food separator could be formed as part of the liner.

Refrigerators and freezers are one of the largest users of plastic materials among the major appliances. The major applications discussed above combined with numerous others such as control housings, ice-maker containers, handles, trim, electrical enclosures, fan housings and blades, butter dishes, snack packs, leftover trays and many more, result in plastics comprising as much as 25 percent of the total refrigerator content by weight — over 60 percent by volume.

Plastic handles are a recent innovation that evolved from solid, angular die-cast metal, to molded plastic, to the new warm, soft-touch handles made of plastic and flexible urethane foam. These handles are both aesthetically and tactually pleasing.

Clothes Washers

Early applications of plastics in clothes washers utilized plastics' electrical insulation characteristics for improved durability and safety. This was followed by the application of thermosetting phenolics in pumps and other water distribution parts to improve corrosion resistance over die-cast metal parts. The agitators that oscillated back and forth for movement of clothes — imparting mechanical energy and clothes turnover to improve the washing process — were first made of molded phenolic. They were heavy, subject to breakage and, of course, black. The molded shape, though somewhat limited, did improve washing performance.

The Mini Basket® and Filter Flow® innovations of washers of the 1960s were molded of ABS plastic. They upgraded product quality, increased load size versatility, and provided an energy saving alternative for small or delicate fabric loads. ABS's lightweight, moldability and built-in color made all of these new product features possible.

The application of plastics into control backsplashes on panels was an inevitable evolutionary process. Moldability combined several parts into one, electrical insulation properties eliminated parts and provided shock resistance. Built-in color and technology for decorating and printing on the plastic made for attractive, ergonomically superior products. Molded plastic knobs presented easier to use, safe controls for the consumer.

The development of polypropylene, an inexpensive, relatively tough, rigid, semi-crystalline thermoplastic with outstanding chemical and corrosion resistance, and the ability to withstand hot water temperatures better than HIPS and ABS, revolutionized many washer applications. Pumps, valves, agitators and filters were all designed to use this new lightweight plastic. Innovative shapes, lighter weight and long life upgraded the performance of the washer. Copolymer modifications of polypropylene and the addition of fillers and fibers helped create a broad range of compounds of widely varying properties that could be tailored to specific applications and helped increase polypropylene's versatility. Even washer hoses have been upgraded to provide longer life through the use of materials based on polypropylene chemistry. Molded polypropylene agitators have shape and flexing characteristics that increase energy translation from the motor to the clothes by 24 percent.

Today, plastics comprise as much as 20 percent by weight of the material in washers. Recent applications include tubs, baskets and lids. Plastics' versatility, durability and ease of processing into complex shapes are advantages that drive the use of plastics in clothes washers.

Clothes Dryers

Plastics make up a small percentage of the material content in clothes dryers primarily because of the high temperatures involved. Plastics that can withstand continuous temperatures well above 250°F are still relatively expensive and find application where their light weight is a key factor — in aircraft for example. Nevertheless, plastics usage in dryers has grown in recent years. Applications include front rub rings, blower ducts and scrolls, drum paddles and blower blades. The complex shapes that can be molded improve air distribution, temperature uniformity and drying efficiency.

Dishwashers

As much as 25 pounds, or over 30 percent, of today's modern dishwasher is plastic. Control knobs and electronic touch pad control panels are common to most of the major appliances. Pumps evolved from die-cast aluminum to molded thermoset plastic to today's corrosion-proof, lightweight, injection molded versions made of thermoplastics based on polypropylene resins. In fact, most of the water distribution systems, valves, pumps, pump housings, impellers and spray arms are now made of plastics. Plastics allow a high degree of parts consolidation, the development of complex shapes to optimize water distribution and energy usage and virtually total resistance to the highly corrosive dishwasher environment. Molded polypropylene silverware baskets replaced plastisol-coated steel that was easily cut and subject to rusting.

Product quality problems occurred from tub corrosion of porcelain enameled steel that chips and plastisol-coated steel that easily cuts and results in rusted tubs. These deficiencies led to extensive engineering development programs to design and produce an all plastic tub, building on polypropylene copolymer technology, research in filled and reinforced systems and new technology for large part injection molding. After nine years of development and exhaustive testing to ensure long-term reliability, 12-pound injection molded tubs were produced in a one-shot molding operation.

This major development utilized the newest materials formulation technology using unique stabilizers to provide long life, and new fillers to provide dimensional stability. It also used the newest manufacturing technology for large part injection molding. First introduced in the mid-1970s with a 10-year warranty, injection molded polypropylene-based tubs are now the standard of dishwasher manufacturers. Parts consolidation included a molded-in sump and rack supports. The smooth contour, seamless one-piece design allows superior sanitized water drainage paths because there are no cracks or crevices.

Simultaneously, similar plastic materials were used to produce the dishwasher inner door, virtually eliminating corrosion of this part. Other innovations allowed parts consolidation for vents and gasket assembly grooves and permitted the development of an automatically dispensing detergent cup.

Parts consolidation, functional integration, and improved product quality brought about savings of 15 to 20 percent in product cost and substantially lowered manufacturing investment costs.

The dishwasher also contains the typical generic plastic applications for decorative trim, timer cams, and electrical insulation components, all of which upgrade quality and enhance product safety.

A key advantage of plastic applications in these appliances lies in the production of highly accurate and reproducible dimensions. This results in very low scrap production and high material utilization in the manufacturing process. Good plastics processes often are 99 percent or higher in efficiency. Metal-forming equipment often requires frequent maintenance and adjustments to ensure dimensional stability. Paint and enamel finishing operations require precise control, discharge pollutants, and often generate fairly high numbers of rejects and scrap.

Range Cooktops and Ovens

Because of the high temperatures involved, most of the plastic applications in ranges are thermoset phenolics or glass-reinforced polyesters. Recent developments in high temperature thermoplastics such as polysulfones and polyimides have led to applications like the mode stirrer shaft in microwave ovens that improves uniformity of energy distribution. Door handles and knobs for shape/

functionality and insulating thermal breaker strips are also made of plastic. Plastic microwave oven doors provide parts consolidation and seamless cavity liners improve hygiene and cleanliness.

Room Air Conditioners

Plastics have found wide applications in room air conditioners, ranging from molded air flow grills that do not sweat to an integral barrier and base pan for the Carry Cool® air conditioner that combines 17 metal parts into a one-piece molded thermoset plastic. This one plastic part provides a handle, the separator between the outdoors and the home interior, the drip pan for condensate and the support for the blower fan.

The Carry Cool® has a plastic barrier and base pan, a plastic case, fan, grille and air deflector. Because it is essentially made of lightweight plastics, it is truly portable, weighing only 40 pounds and generating 5000 Btu for cooling. These plastic applications provide superior resistance to corrosion and outdoor weathering, thereby prolonging product life.

Summary of Plastics' Advantages

This paper has documented many key applications of plastics in major appliances. Plastics provide valuable advantages to the major appliance industry, as witnessed by the dramatic increase in its use — almost a hundredfold since 1960. Today, more than 1 billion pounds of plastic are used by the industry.

Plastics provide the following advantages:

- Ease of fabrication into complex shapes through injection molding, thermoforming and functional integration provides a 10 to 20 percent savings in product cost.

- Highly efficient manufacturing processes (up to 99 percent efficiency) increase productivity by 20 to 30 percent and reduce capital expenditures by as much as 50 percent.

- A versatile range of tailored compounds from a wide variety of compositions gives an almost unlimited array of property profiles that can be tailored to fit specific applications.

- Good characteristics of electrical insulation, light weight and toughness enhance product safety.

- Outstanding thermal insulation characteristics and shape optimization reduce product energy consumption. Plastics have allowed major appliances to make significant improvements in this area. Since 1972, product energy consumption has been reduced 30 to 40 percent, product efficiency has increased 50 to 100 percent and the cost to operate major appliances has actually decreased 30 to 60 percent.

- Energy conservation from the manufacture and use of today's major appliances equates to an annual savings of 85 million barrels of imported oil.

- Built-in-color production eliminates the need for finishing processes that are energy intensive, air polluting and produce large volumes of scrap.

- Molded complex geometries with integrated functions make possible inner door storage in refrigerators, agitators in clothes washers, energy distributors in microwave ovens and portable, lightweight room air conditioners.

- Finally, high resistance to corrosive environments greatly improves product performance and prolongs life.

Without the contribution that plastics provide to increased manufacturing productivity and superior product performance, we would not have the major appliance industry as we know it today. In all likelihood, these products would have gone the way of many other manufacturing-intensive products — they would be manufactured offshore. Capitalizing on an increasing use of plastics and leading edge technology, the industry continues to be one that successfully manufactures products in the United States. Without plastics, product costs would be at least 50 percent higher, energy consumption would be 40 to 50 percent higher, and efficiency would be reduced 30 to 50 percent. Product durability and life would be shortened 30 to 40 percent and many convenience features and advantages would not be possible.

This paper has defined and quantified the many benefits that plastics bring during manufacture and use in the appliance industry. These benefits are indeed significant. But today, the value that materials provide society is also being judged over the entire product life cycle. To this end, increasing attention is being given to the fate of appliances after their useful life has ended. Discarded appliances are being collected in increasing numbers for recycling. Recycling has the potential to save valuable resources. The technical challenges associated with the recovery and recycling of the major plastic components of refrigerators and freezers are being addressed by the plastics industry, original equipment manufacturers (OEMs) and an emerging appliance recycling industry. A widespread recovery of valuable plastics from discarded appliances is in the early stages of development and eventually will provide even greater life cycle benefits.

In conclusion, plastics have revolutionized the major appliance industry by significantly enhancing productivity, product features and product value. As a result, this industry continues to be a highly competitive, very viable business providing the consumer with outstanding values.

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