This is a reproduction of a library book that was digitized by Google as part of an ongoing effort to preserve the information in books and make it universally accessible.

Google™ books

https://books.google.com

TL 154 D4
UNIVERSITY OF CALIFORNIA, SAN DIEGO E
3 1822 01289 8755
UC SOUTHERN REGIONAL LIBRARY FACILITY
DD 000 016 059 8
TL
154
.D4
S&E

University of California, San Diego
Please Note: This item is subject to recall.
Date Due

5 1992

CI 39a (4/91) UCSD Lib.

Digitized by Google

TL 154 D4
UNIVERSITY OF CALIFORNIA, SAN DIEGO E
3 1822 01289 8755

May 1974 • TPR 79

Solid Waste Program

BUREAU OF MINES TECHNICAL PROGRESS REPORT

EFFECT OF INCREASING PLASTICS CONTENT ON RECYCLING OF AUTOMOBILES

Digitized by Google

Digitized by Google

I 28.26/6:79

EFFECT OF INCREASING PLASTICS CONTENT ON RECYCLING OF AUTOMOBILES

by

K. C. Dean, J. W. Sterner, and E. G. Valdez

Salt Lake City Metallurgy Research Center,
Salt Lake City, Utah

Bureau of Mines Solid Waste Program

Technical Progress Report 79

May 1974

U.S. DEPARTMENT OF THE INTERIOR

The work upon which this report is based was done under a cooperative agreement between the Bureau of Mines, U.S. Department of the Interior, and the Ford Motor Co.

Digitized by Google

Digitized by Google

S & F
TL
154
.D4

CONTENTS

ILLUSTRATIONS

TABLES

Digitized by Google

Digitized by Google

EFFECT OF INCREASING PLASTICS CONTENT ON RECYCLING OF AUTOMOBILES

by

K. C. Dean,[1] J. W. Sterner,[2] and E. G. Valdez[2]

ABSTRACT

Changes in the types of materials used for the construction of recent automobile models have occasioned a review of the continued applicability of current recycling techniques. Plastics are being used increasingly in late model cars. To evaluate the changes occurring, a 1972 Mercury Montego, furnished by the Ford Motor Co., was completely dismantled and analyzed, and the composition was compared with that of a composite automobile from 15 vehicles ranging in date of manufacture from 1954 to 1965 and designated as a circa 1960 model. The composite vehicle contained about 26 pounds of plastics, while the 1972 model contained over four times that quantity. The increasing use of plastics in automobiles suggests that research to improve the economic potentiality of plastics recycling is warranted.

INTRODUCTION

In 1957 the abandoned auto was not a major problem in this country. The demand for automotive scrap was high, and the national price for No. 2 automotive steel bundles was about $37 per ton. Many of the accumulated cars were in auto salvage yards where they were held for sale of usable parts before being processed as scrap. Practically all of the steel in 1957 was made in open-hearth furnaces from an average charge of 52 percent molten pig iron and 48 percent scrap. Since then the basic oxygen furnace, which takes only about 25 percent scrap in the charge, has gradually supplanted many of the open-hearth furnaces, and the demand for scrap has lessened. Auto scrap, because it contains copper, zinc, lead, aluminum, nickel, and chromium, which are impurities in steel, was the first scrap to be reduced in furnace charges. By 1963 the price for No. 2 bundle scrap had fallen to $19.85 per ton and accumulations of junked automobiles started to become a national problem.

In 1965, the Bureau of Mines expanded its research on mineral- and metal-bearing wastes to include studies on the problems involved in producing better quality steel scrap and in recovering nonferrous metals from junked automobiles.

---

[1] Metallurgist.
[2] Chemical engineer.

Digitized by Google

An assessment of potential recycling methods indicated that two methods, (1) shredding plus magnetic separation and (2) smokeless incineration plus hand-stripping of the nonferrous metals and baling or shearing of the cleaned steel, offered the most promise for recycling of the junked autos. Subsequent research by the Bureau of Mines and industry has resulted in development of a smokeless incinerator for low-cost burning of the combustibles from junked autos (2).[3] Research has also led to the development of air and water classifiers plus auxiliary methods, such as cryogenic treatment and heavy media separation for the recovery of nonferrous metals from the nonmagnetic rejects produced in the shredding system (1, 5-6). Use of these techniques can increase the recovery of nonferrous metals from the average 20 percent attained by handpicking, such as is practiced at many shredder installations, to over 90 percent, thus aiding mineral conservation considerably.

One problem which may arise in the development of recycling techniques is the change in materials of construction in use or contemplated for use by the automotive industry. The industry, in its efforts to meet more stringent automobile safety standards and to develop lighter weight automobiles, has tested many materials, including lighter weight metals such as aluminum and magnesium and many different types of plastics. Plastics, offering on the average a 50- to 60-percent decrease in weight over comparable metal parts, appear to have a leading position in supplanting heavier metals for automotive construction. Evidence of the present leading position of plastics is the increase in usage by the automobile industry from 120 and 300 million pounds in 1960 and 1965, respectively, to an estimated 1,200 million pounds in 1972 (7). This marked increase in total plastic use between 1965 and 1972 is even more noteworthy for individual plastics such as polyurethane foam which shows an eightfold increase in usage from 30 million pounds in 1965 to about 240 million in 1972. All this lends credence to the statement by various industry sources that by 1980 approximately 1,000 pounds of metals would be replaced in an auto by 450 to 480 pounds of plastics. Such a decrease in recyclable metal values over the years would adversely affect the economics of auto scrap processing unless means could be developed for recycling of plastics that are substituted for the metallic portions of the cars. In addition, the disposal of the much bulkier nonbiodegradable plastic materials, such as polyurethane foam, could create a major problem in municipal landfills, if means are not developed for reuse of such materials (3). Hence, cooperative research was initiated between the Ford Motor Co. and the Federal Bureau of Mines to determine the changes taking place in automotive materials of construction and to determine the potentiality of plastics recycling. This report compares changes in construction materials between a circa 1960 composite automobile and a 1972 Mercury Montego. A later report will summarize research on the separation and recycling of plastics with specific attention to polyurethane foam; Ford Motor Co. has developed a procedure for the fractionation of polyurethane into the individual recyclable components of diamines and polyethers.

---

[3] Underlined numbers in parentheses refer to items in the list of references at the end of this report.

Digitized by Google

ACKNOWLEDGMENT

The authors and the Bureau of Mines acknowledge with grateful appreciation the cooperation of the Ford Motor Co. in furnishing vehicles which permitted proper characterization of the materials of construction. Specific acknowledgment is also given to Terry Cole and Lee Mahoney of the Ford Motor Co. for guidance on identifying plastics and furnishing information on the recycling potential of reclaimed materials.

DESCRIPTION OF 1972 AUTOMOBILE

The Ford Motor Co. donated three 1972 Mercury Montegos to the research project as being fairly representative of a medium-class automobile being manufactured in 1972. Two of the Montegos were fragmentized in a commercial shredder to produce nonmagnetic rejects suitable for feasibility testing on the separation of plastics. The third Montego was subjected to hand-dismantling for characterization of components; this vehicle was a two-door hardtop sedan, Brougham series, with vinyl top. The dismantled car had automatic tranmission, power steering and brakes, air conditioning, and radio. It was complete except for a spare tire and handtools. The total gross weight of 3,923.4 pounds included gasoline, oil, coolant, and other liquids. The car weighed 3,808 pounds after draining all liquids. A picture of the car before disassembly is presented in figure 1.

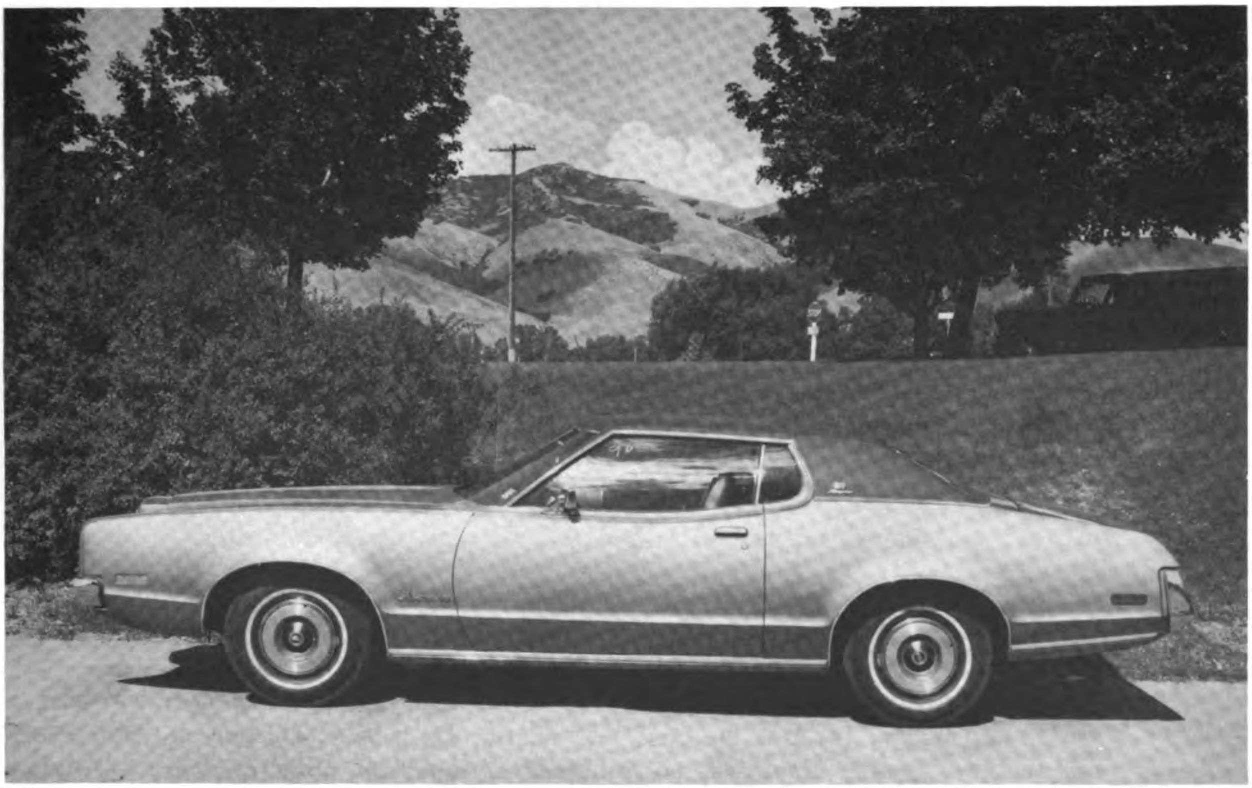

FIGURE 1. - 1972 Mercury Montego before disassembly.

Digitized by Google

DISMANTLING PROCEDURE AND RESULTS

The weights and types of metals and nonmetals within the 1972 Montego were determined by selective dismantling and chemical analysis of samples of the engine, transmission, body, chassis, and accessories. These samples were obtained in the form of drill shavings, lathe turnings, and saw filings from the part removed. Homogeneous materials were sampled directly, while heterogeneous metals were melted to form a uniform alloy before sampling. Most of the plastics were visually identified by a Ford Motor Co. representative, and

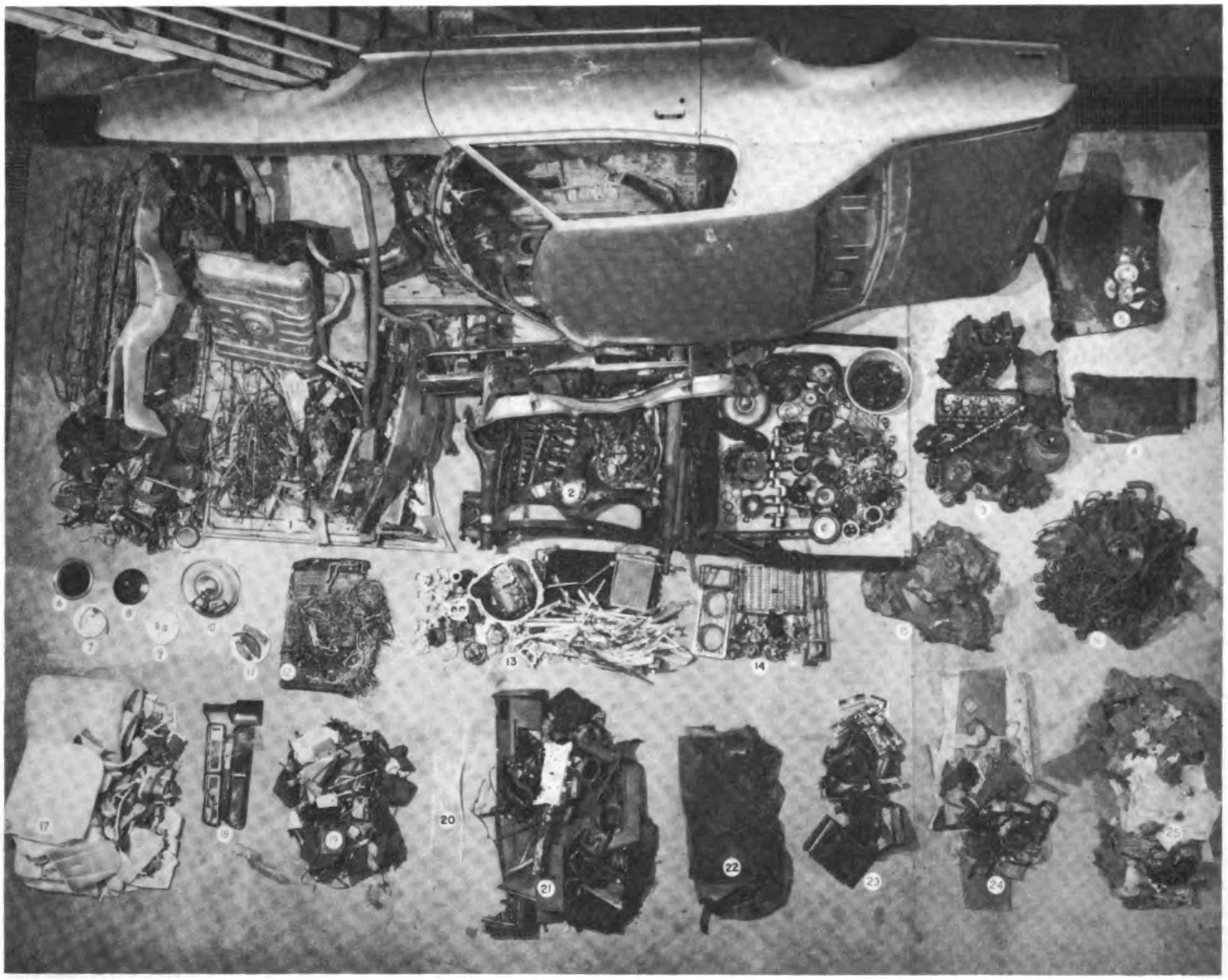

FIGURE 2. - Components of 1972 Mercury automobile. 1, Light steel, less than 1/8-inch thickness; 2, heavy iron and steel, more than 1/8-inch thickness; 3, cast iron; 4, mineral wool; 5, glass and ceramic; 6, carbon, activated; 7, molded nylon; 8, Bakelite; 9, lead; 10, stainless steel; 11, asbestos; 12, copper and brass; 13, aluminum; 14, zinc die-cast; 15, mastic; 16, rubber; 17, polyurethane foam; 18, acrylic; 19, vinyl; 20, polyethylene styrene; 21, polypropylene; 22, nylon fabrics; 23, acrylonitrile-butadiene-styrene (ABS); 24, paper, fiberboard, and padding; and 25, cotton, jute, etc. (textiles).

Digitized by Google

those of which he was doubtful were sent to Ford Motor Co. and identified by plastics experts.

The dismantling equipment consisted of an electric impact wrench and handtools. Neither a cutting torch nor a metal cutting saw was used in this study as had been used in previous dismantling work. Time and motion studies were made on the removal of each part from the hulk but are not considered significant except for a specific study on seat removal and separation for which the use of available dismantling tools was limited. Figure 2 depicts the light steel hulk of the Montego and the materials removed from it. The accompanying numbered list corresponds with the numbers in the figure and lists all different types of materials removed except for the liquid components. Figure 3 and accompanying list show the materials making up the engine

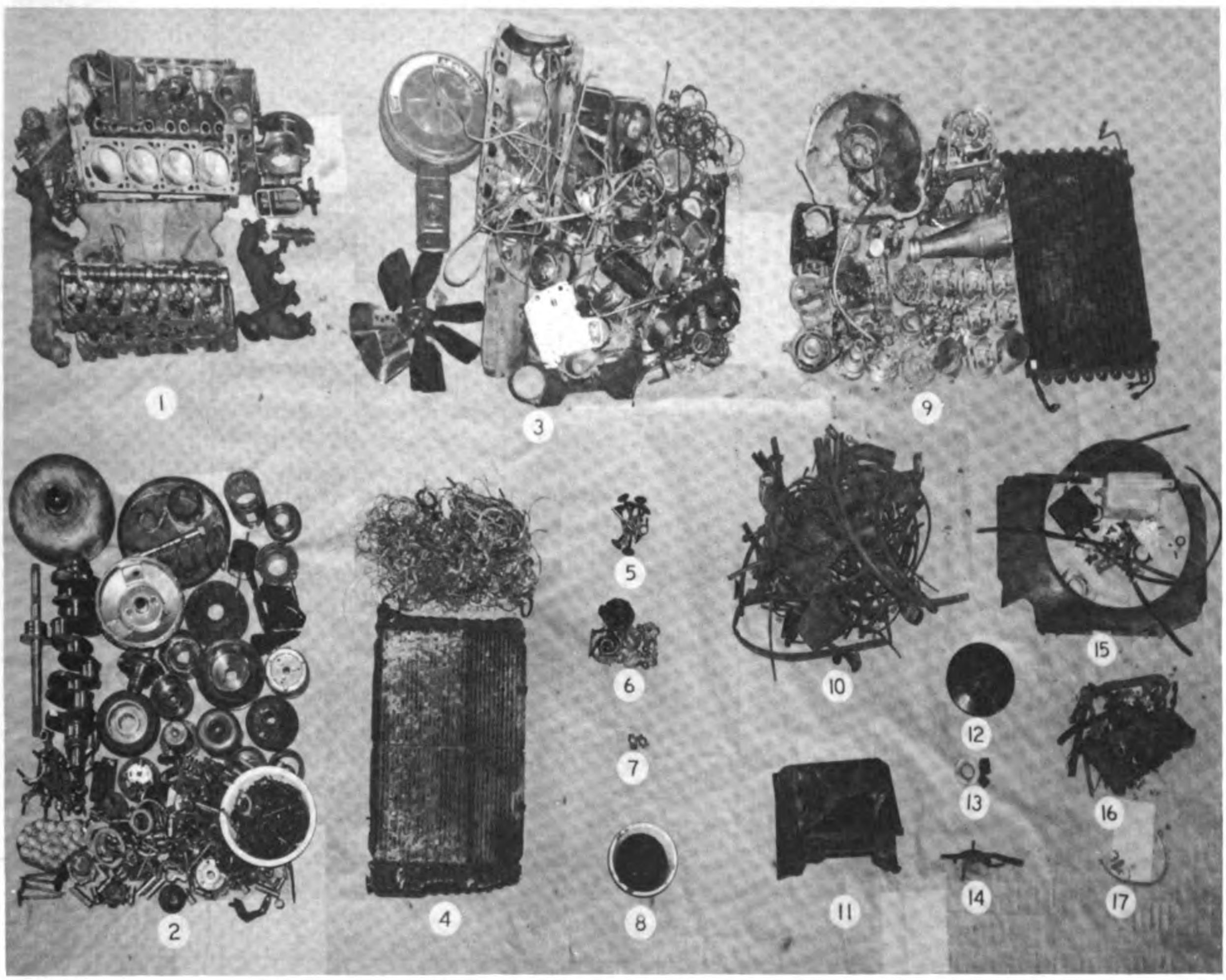

FIGURE 3. - Components of 1972 Mercury engine compartment. 1, Cast iron; 2, heavy metal, less than 1/8-inch thickness; 3, light metal, more than 1/8-inch thickness; 4, copper; 5, stainless steel; 6, zinc die-cast; 7, lead; 8, carbon; 9, aluminum; 10, rubber; 11, polyester; 12, Bakelite; 13, polyvinyl; 14, cotton fabric; 15, polypropylene; 16, paper products; and 17, nylon.

Digitized by Google

of the automobile. Table 1 provides a listing of the combustible and noncombustibile components in the 1972 Mercury Montego.

TABLE 1. - Combustible and noncombustible components in a 1972 Mercury Montego

Material	Combustibles, pounds	Noncombustibles, pounds	Distribution, weight-percent
Polypropylene	31.1	-	0.8
Vinyl	22.6	-	.6
Nylon	14.7	-	.4
Acrylic	4.3	-	.1
Polyurethane foam	19.1	-	.5
Acrylonitrile-butadiene-styrene (ABS)	8.3	-	.2
Polyethylene	5.1	-	.1
Bakelite and thermosetting plastics	1.9	-	.05
Rubber	162.2	-	4.1
Mastic	75.6	-	1.9
Paper	4.2	-	.1
Fiberboard	10.9	-	.3
Fiber padding	.1	-	-
Jute padding	2.8	-	.07
Burlap	1.4	-	.03
Cotton cloth	2.2	-	.05
Cotton padding	9.7	-	.2
Ceramic	-	0.1	-
Glass	-	95.8	2.4
Mineral wool	-	4.8	.1
Asbestos	-	1.8	.04
Carbon	-	.7	-
Light steel	-	1,417.8	36.1
Heavy steel	-	1,277.2	32.6
Cast iron	-	425.3	10.8
Stainless steel	-	20.2	.5
Aluminum[1]	-	85.7	2.2
Copper and brass[2]	-	39.6	1.0
Zinc[3]	-	28.5	.7
Lead[4]	-	27.8	.7
Oils, grease, gasoline	88.8	-	2.2
Motor coolant, electrolyte	-	33.5	.8
Total	-	3,458.8	99.6
Combined combustibles and noncombustibles	-	3,923.8	-

[1]As scrap sheet and cast aluminum.
[2]Including copper and brass, but not in solid solution in steel.
[3]Exclusively on zinc-base die-cast.
[4]Includes battery lead.

Digitized by Google

TIME AND MOTION STUDY ON SEAT REMOVAL

Of all the plastics used in newer automobiles, polyurethane presents the greatest challenge for recycling. Effective reuse of this material would eliminate landfill problems occasioned by the low bulk density of 2.1 pounds per cubic foot. If all of the 240 million pounds used by the automotive industry in 1972 were to be discarded to landfill, without prior compaction, it would require over 114 million cubic feet of space. Recycling would not only eliminate this major waste of landfill area, but would also eliminate an appreciable usage of petroleum feed stocks at a critical time of energy source shortage.

Automobile seats are generally removed from hulks to be shredded because the contained spring steel forms tangled masses with other materials in the shredder. Since in recent model cars the seats contain appreciable quantities of polyurethane foam, removing them also insures a cleaner nonmagnetic reject.

The front bucket and rear seats of the 1972 Montego contained 15.7 of the total 19.1 pounds of polyurethane foam in the automobile. (Most of the remainder was in the dashboard and firewall.) A time and motion study was made to determine the labor necessary to remove the seats using hand methods. The time for removal of the seats from the hulk was 12.5 minutes. The time for a one-man separation of all the seat components was 57.5 minutes for a total of 70 minutes. Based upon labor costs of $3.20 per hour plus an additional 15, 40, and 40 percent for supervision, maintenance, and overhead, respectively, this would amount to $7.60 for labor costs. Repetitive operations by an operator with practice in removing and stripping seats would probably be substantially lower in cost. Table 2 lists the quantities of materials separated from the seats, the value per pound ascribed, and the total material value. Figures 4 and 5 and accompanying material lists show the composition of the seats.

TABLE 2. - Economic value of seat materials in a 1972 Mercury Montego

Materials separated	Pounds	Value per pound[1]	Total value
Cotton fabric and padding[2]	8.4	-	-
Paper[2]	.1	-	-
Fiber[2]	1.4	-	-
Iron	96.4	$0.0105	$1.01
Plastics:			
Vinyl	1.0	.15	.15
Polyurethane foam	15.7	.20	3.14
Nylon	2.8	.85	2.38
Polypropylene	7.0	.50	3.50
Polyethylene	4.4	.15	.66
Total	137.2	-	10.84

[1] The values per pound were ascribed by Ford Motor Co. and represent only hypothetical values rather than true market values in that there are at present only limited markets for these materials.

[2] No value was ascribed to the cotton, paper, and fiber although some value probably does exist.

Digitized by Google

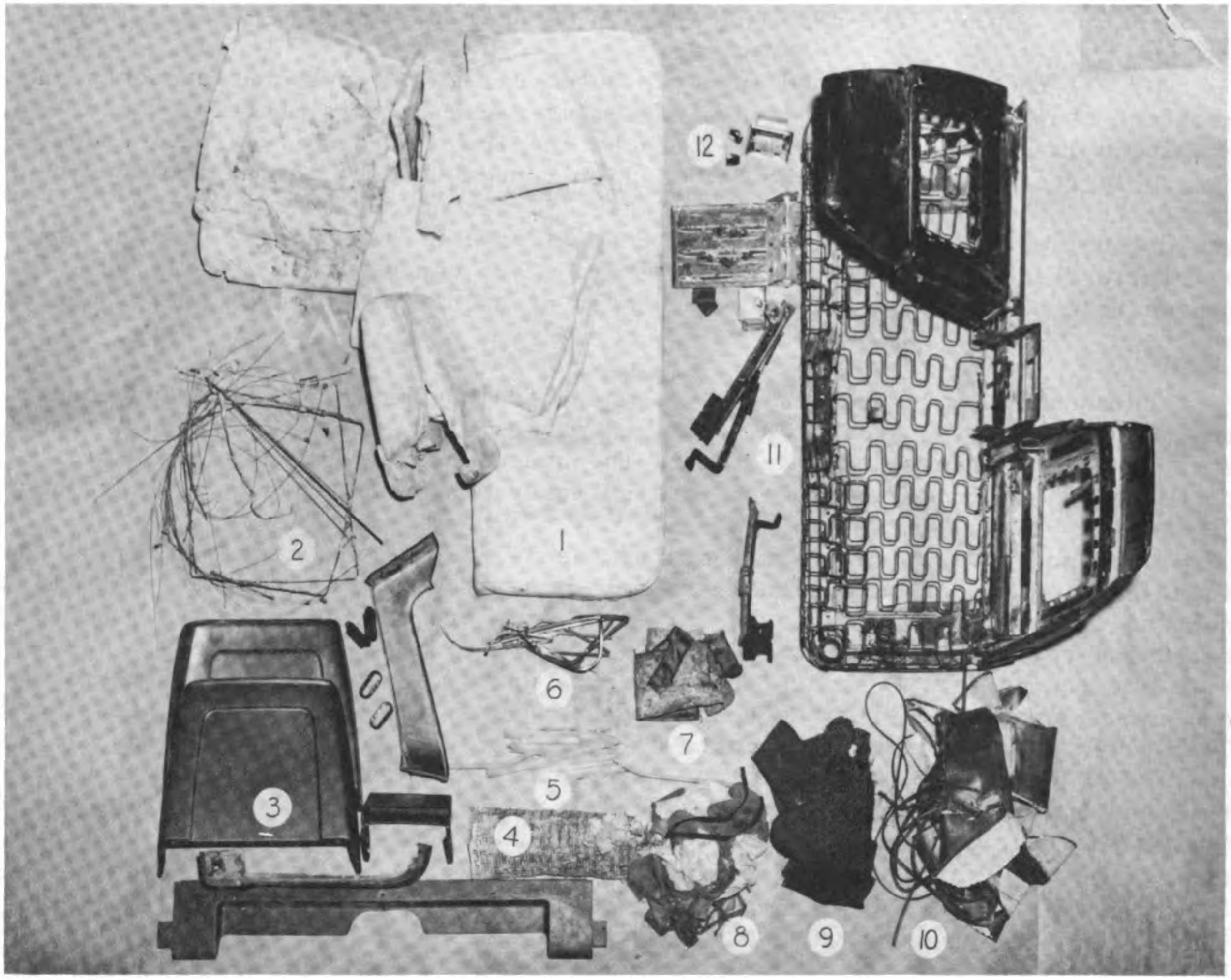

FIGURE 4. - Components of 1972 Mercury front seat. 1, Polyurethane foam; 2, wire and light steel; 3, polypropylene; 4, fabric mesh; 5, polyvinyl chloride (PVC); 6, plated PVC; 7, vinyl; 8, burlap and cotton cloth; 9, nylon cloth; 10, backed vinyl; 11, spring and light steel; and 12, Ni/Cr-plated die cast.

If the values assigned to labor and materials are substantially correct, and the plastics can actually be sold for the assigned values, this evaluation indicates that hand removal and material separations of modern car seats could be economically feasible. The clean materials are immediately available for recycle, and removal would facilitate subsequent separations of the nonmagnetic reject components and eliminate plugging of shredder dust removal systems by the lightweight foam.

Conversely, the practice of incineration, hand dismantling, and baling or shearing (now the dominant method of recycling in small scrap-processing yards) would be complicated. Removal of the seats would eliminate the bulk of the flammable materials in the passenger compartment of an automobile. Sustaining combustion sufficiently to eliminate other combustibles and to melt the zinc

Digitized by Google

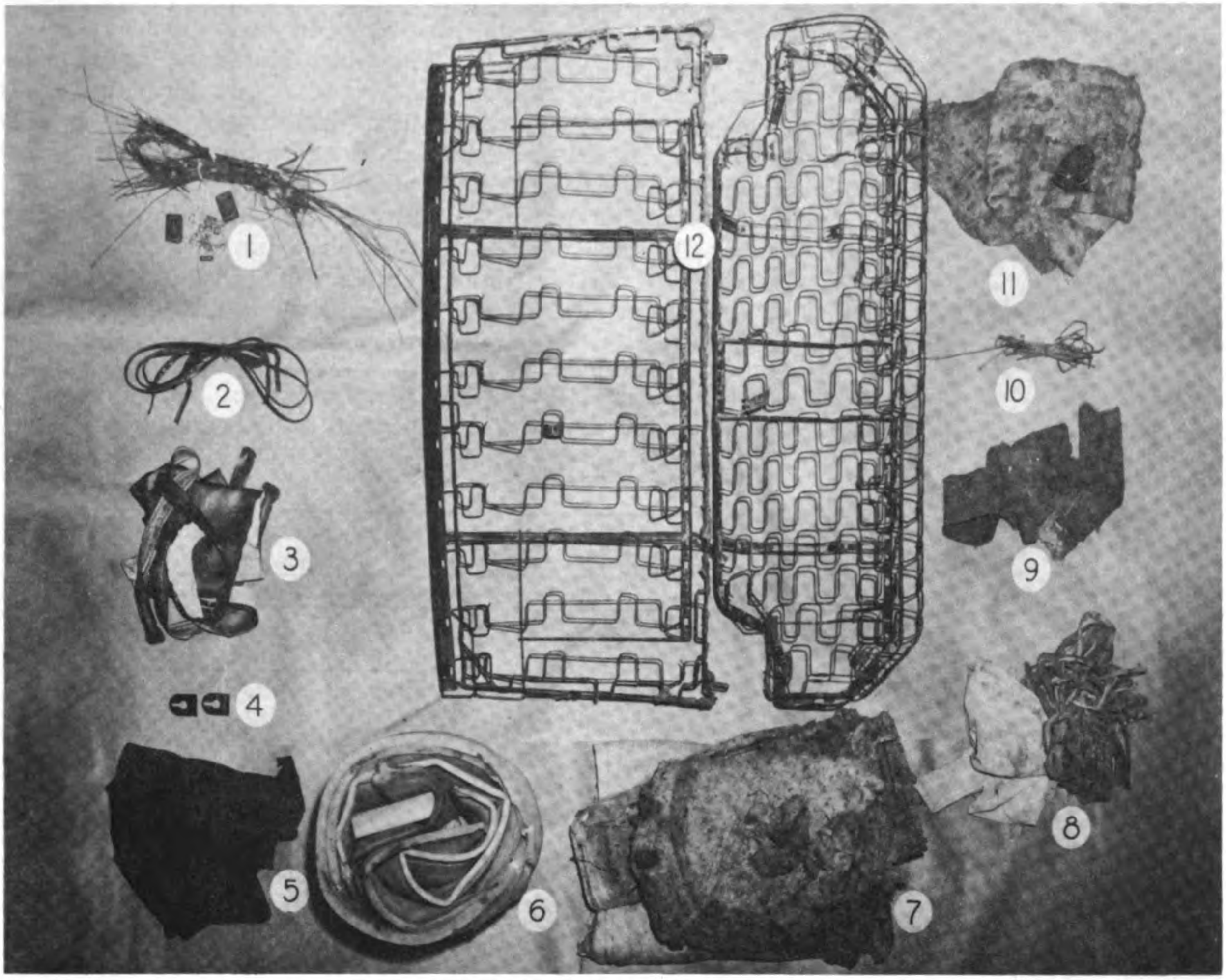

FIGURE 5. - Components of 1972 Mercury rear seat. 1, Light steel and wire; 2, backed vinyl with cording; 3, backed vinyl; 4, polypropylene; 5, nylon cloth; 6, polyurethane foam; 7, cotton mat; 8, cotton fabric; 9, cotton fiber mat (jute); 10, paper rope; 11, burlap; and 12, spring and light steel.

would be difficult. In present automobiles the presence of flammable mastics would probably be sufficient to achieve proper burning, but safety proponents are requesting changes to a more fire-retardant mastic than is now in use. Combustible refuse, such as paper and cloth, could potentially serve as a primary ignition material, but the economics of using such materials have not been determined.

COMPARISON OF A CIRCA 1960 COMPOSITE AUTOMOBILE AND A 1972 MERCURY MONTEGO

During 1966-68, 15 automobiles, selected by a computer-based study as representative of those to be discarded within the next few years, were completely dismantled and analyzed as a portion of the automobile recycling

Digitized by Google

program. The cars ranged in date of manufacture from 1954 to 1965, and the composite car derived from the data produced was considered to be a medium-sized car of approximately 1960 vintage (4). The 1960 car could be typified as being equipped with an automatic transmission and a radio but having little auxiliary power equipment. (Only 1 of the 15 cars dismantled had power brakes, power windows, and air conditioning; 3 others had power steering only.) These data from the circa 1960 composite automobile are compared with those of the 1972 model so as to (1) indicate manufacturing trends in the automotive industry, especially with regard to replacement of metallic components with plastics, and (2) determine the extent to which these trends will affect the scrap value and recycling potential of a currently manufactured automobile. Table 3 presents a comparison of materials of construction of the composite 1960 auto and the 1972 Montego.

TABLE 3. - Composition of a circa 1960 composite junk car and a 1972 Mercury Montego

Component	Composite auto circa 1960[1]		Factory new 1972 Mercury Montego	
	Pounds	Percent	Pounds	Percent
Light steel	1,309.5	36.6	1,417.8	36.1
Heavy steel	1,222.4	34.2	1,277.2	32.6
No. 2 bundle steel	2,531.9	70.8	2,695.0	68.7
Cast iron	511.4	14.3	425.3	10.8
Stainless steel	-	-	20.2	.5
Aluminum[2]	50.6	1.4	85.7	2.2
Copper and brass[3]	31.9	.9	39.6	1.0
Zinc[4]	54.2	1.5	28.5	.7
Lead (includes battery)	20.4	.6	27.8	.7
Glass	87.2	2.4	95.8	2.5
Rubber	145.0	4.1	162.2	4.1
Plastics	25.9	.9	[5]107.1	2.7
Other combustibles	[6]101.3	2.7	195.7	5.0
Other noncombustibles	14.8	.4	40.9	1.1
Total	3,574.6	100.0	3,923.8	100.0

[1]Composite auto composed of 15 autos, 1954-65 models (4).
[2]As scrap sheet and cast aluminum.
[3]Including copper in brass but not copper in solid solution in steel.
[4]As zinc-base die-cast exclusively.
[5]Includes 19.1 pounds of polyurethane foam.
[6]Includes gasoline and oils (Mercury contained 58.5 and 29.5 pounds gasoline and oil, respectively). Also includes mastics 6.80 and 75.6 pounds, respectively, for 1960 and 1972 models.

The 1972 car weighed approximately 350 pounds more than the circa 1960 car, which may not be significant in that the 1960 car was a composite vehicle. Of more significance is the change in percentage content of certain materials shown in the following tabulation:

Digitized by Google

Component	Percent in Mercury	
	Decrease	Increase
Cast iron..................	16.8	-
Aluminum...................	-	69.4
Zinc.......................	47.4	-
Plastics...................	-	312.7
Other combustibles[1].........	-	93.0
Other noncombustibles.......	-	175.7

[1]Principally addition of mastic for sound deadening.

The major trend indicated is an increase in weight-saving materials of construction, most noteworthy being the over 300 percent increase in plastics. Table 4 illustrates both the increase in total weight of plastics and the increase in the variety of plastics used.

TABLE 4. - Plastics used in a circa 1960 automobile as compared with a 1972 Mercury Montego

Plastics[1]	Composite auto circa 1960		Factory new 1972 Mercury Montego	
	Pounds	Percent	Pounds	Percent
Polypropylene............................	5.10	19.6	31.1	29.0
Vinyl....................................	19.90	76.5	22.6	21.1
Polyurethane foam........................	-	-	19.1	17.9
Nylon....................................	-	-	14.7	13.8
Acrylonitrile-butadiene-styrene (ABS)....	-	-	8.3	7.7
Polyethylene.............................	-	-	5.1	4.7
Acrylic..................................	.70	2.7	4.3	4.0
Bakelite.................................	.3	1.2	1.4	1.3
Thermosetting group......................	-	-	.5	.5
Total..............................	26.0	100.0	107.1	100.0
Mastic[2]................................	6.8	-	75.6	-
Grand total........................	32.8	-	182.7	-

[1]Plastics as differentiated by sight and knowledge of usage only.
[2]Mastic was included in the plastic weight of the typical junk auto. Current practice is to include it with combustibles.

POTENTIAL SCRAP VALUES OF AUTOMOBILES

The circa 1960 composite automobile had a metallic scrap value of about $56 as based on 1969 scrap prices. Updated to conservative 1973 figures, the value of a typical junk auto increased to about $85. The 1972 Montego contained somewhat different contents of steel, cast iron, and nonferrous metals than the 1960 model. Additionally, as noted, the Montego contained almost 107 pounds of plastics. A cost comparison based upon 1973 scrap metal prices is presented in table 5 for the two autos.

Digitized by Google

TABLE 5. - Comparative recoverable scrap metal values in a circa 1960 composite automobile and a 1972 Mercury Montego

Material	1973 scrap value	Composite auto circa 1960		Factory new 1972 Mercury Montego	
		Weight, pounds	Recoverable value	Weight, pounds	Recoverable value
No. 2 bundle steel....	$35.90/ton	2,614	$46.92	2,695	$48.38
Cast iron.............	55.50/ton	[1]429	11.90	425	11.79
Stainless steel.......	.097/lb	-	-	20	1.94
Copper:					
Radiator............	.37/lb	15.4	5.70	23.0	8.51
Wire and heavy......	.54/lb	13.8	7.45	14.5	7.83
Yellow brass........	.34/lb	2.7	.92	2.1	.71
Zinc die-cast.........	.07/lb	54.2	3.79	28.5	2.00
Aluminum..............	.13/lb	50.6	6.58	85.7	11.14
Lead:					
Battery.............	1.40 ea	~20.0	1.40	~20.0	1.40
Metal...............	.11/lb	.4	.04	.3	.03
Total...........	-	3,200.0	84.70	3,314.0	93.73

[1]Only 429 pounds of cast iron were readily recoverable for recycle.

The 1972 automobile contains approximately $9 more in metal scrap value than the circa 1960 car. In addition, the 1972 Montego contains an indeterminate quantity of recoverable plastic that could supply additional value. A future report summarizing laboratory research on the recyclability of the plastics will supply more definitive information on the economic potential of plastic recoveries. For the present the only substantially confirmed recoverable plastic would be that recoverable from the front and rear seats, as reported in table 2, amounting to $10.84. Thus, the total recoverable value of the Montego would increase to $104.57. Comparison of the circa 1960 and 1972 automobiles indicates that the replacement of heavy metal parts by lighter weight materials such as aluminum and plastics has improved the economic potential of recycling junked automobiles. The Montego, if typical, indicates a marked decline in zinc die-cast usage and a marked increase in aluminum and plastics use. From an economic viewpoint only, this is beneficial in that die-cast as of mid-1973 had a value of 7 cents per pound versus 13 cents for aluminum and over 15 cents for most of the plastics. The cost of recovering and separating the plastics and the value of materials replaced by plastics will be the main criteria in determining the economic potentiality of automobile recycling if plastics continue to increase in usage in new automobiles.

CONCLUSIONS

1. Usage of plastics and aluminum in automobiles, as lightweight materials of construction, is increasing rapidly if the 1972 Mercury Montego is considered to be a typical modern automobile. The use of aluminum and plastics, respectively, has increased in the 1972 model by 69 and 313 percent over that in a circa 1960 composite car.

Digitized by Google

2. The apparent recoverable scrap value of a 1972 Montego is about $105 versus approximately $85 for the composite 1960 automobile. The apparent value of the 1972 model potentially can be increased by recovery and separation of plastics additional to those present in the front and rear seats only.

3. A time and motion hand-dismantling study has shown that polyurethane foam can be recovered for recycling on an economic basis. Calculated cost of recovery of an estimated $10.80 in material is $7.60. Removal of seats prior to shredding would be beneficial both economically and in simplifying treatment procedure, but would complicate the incineration and baling recycling procedure.

Digitized by Google

REFERENCES

1. Chindgren, C. J., K. C. Dean, and L. Peterson. Recovery of the Nonferrous Metals From Auto Shredder Rejects by Air Classification. BuMines TPR 31, 1971, 11 pp.

2. Chindgren, C. J., K. C. Dean, and J. W. Sterner. Construction and Testing of a Junk Auto Incinerator. BuMines TPR 21, 1970, 8 pp.

3. Darby, R. T., and A. M. Kaplan. Fungal Susceptibility of Polyurethanes. Applied Microbiology, v. 16, No. 6, 1968, pp. 900-905.

4. Dean, Karl C., and J. W. Sterner. Dismantling a Typical Junk Automobile To Produce Quality Scrap. BuMines RI 7350, 1969, 17 pp.

5. Froisland, L. J., K. C. Dean, and C. J. Chindgren. Upgrading Junk Auto Shredder Rejects. BuMines TPR 53, 1972, 11 pp.

6. Valdez, E. G., K. C. Dean, and W. J. Wilson. Use of Cryogens To Reclaim Nonferrous Scrap Metals. BuMines RI 7716, 1973, 13 pp.

7. Wood, A. S. The Challenges of the Markets--Automotive. Modern Plastics, v. 48, No. 10, 1971, p. 92.

INT.-BU.OF MINES,PGH.,PA. 19463

Digitized by Google

Digitized by Google

SCIENCE AND ENGINEERING LIBRARY
University of California, San Diego

Please Note: This item is subject to RECALL after one week.

DATE DUE

JUN 24 1984
JUN 17 1985

SE 7 (Rev. 7/82) UCSD Libr.

MINERAL INDUSTRIES
BUREAU OF MINES

UNITED STATES DEPARTMENT OF THE INTERIOR

BUREAU OF MINES

Digitized by Google

Digitized by Google
BRO DART
MADE IN U.S.A.