

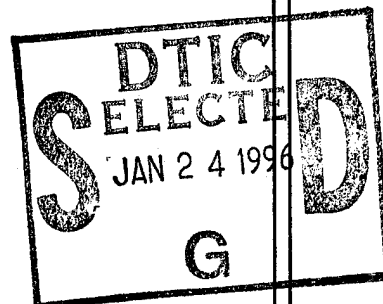
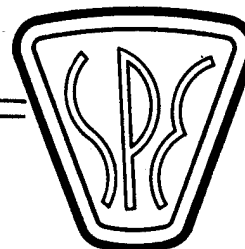
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REGIONAL
TECHNICAL CONFERENCE

*"Plastics in the Automotive
Industry"*

May 14, 1963

Rackham Building
Detroit, Michigan



SOCIETY OF PLASTICS ENGINEERS, INC.

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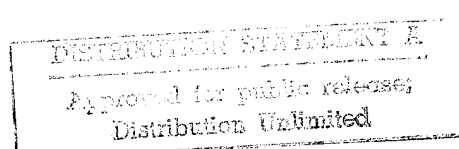
Regional Technical Conference

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Detroit Section

Society of Plastics Engineers, Inc.

May 14, 1963



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DETROIT SECTION

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IS THE U. S. PLASTICS INDUSTRY ASLEEP?

David L. Dennison

Product Sales Manager

du Pont International, S. A.

Geneva, Switzerland

Although the foregoing title may seem facetious or purposely provocative, it is not. It stems from the rhetorical question so often put to me and my similarly displaced U. S. colleagues, by the many Europeans with whom we work. I have tried to assemble pertinent viewpoints and facts on this subject recognizing that many of you may be more familiar with certain aspects of it than am I.

In this paper, the following will be discussed

- A. Europe
- B. European automobile industry
- C. Role of plastics in European automobile with emphasis on recent developments
- D. Generalization of the differences between the U. S. and Europe

EUROPE

First, let us look at Europe. The Europe being discussed starts with Finland, includes the EFTA or outer 6 countries, the EEC, plus Spain and the Eastern end of Europe, Yugoslavia, Greece and Turkey. In this area, there are 353MM people, nearly twice as many as in the U. S. There are manufactured products as shown in Table I amounting to only 75% that produced in the U. S. The people in Europe are just like Americans in the sense that they too want the automobiles, appliances and other modern conveniences. People are Spartan by necessity, not by inclination. This means a tremendous potential market opens up as these people obtain increased purchasing power.

AUTOMOTIVE INDUSTRY

Accordingly, with booming economic conditions in Europe, there has been and continues to be a terrific demand for products. This is best illustrated by the automotive industry as shown in Figure 1. From a level of 1.5 MM/year in 1950, European production of vehicles rose to about 6.5 MM/year in 1962, a truly phenomenal increase during which period U. S. production showed no sustained increase.

Even with this increase, there are only 35MM vehicles on European roads as compared with over 75MM in the U. S. Obviously, with twice as many people, the saturation is only 1/4 that of the U. S. This means continued expansion and inconceivably greater problems for the European highway network than the U. S. network.

The Europeans scene is characterized by the large number of manufacturers. In Table II are shown the 15 companies that make more than 100M units. There are numerous other small companies.

Of this group, only Volkswagen make 1MM vehicles. Fiat is next with 3/4MM, BMC 630M, Renault make 1/2MM, down to Volvo who make 100M. It is evident that this means shorter production runs and reduced funds for investment in tooling versus the U. S. This fact, plus the division of Europe into many small local markets, are responsible for many of the differences that we see reflected not only in the automotive industry, but also in all industries that consume injection molded plastics.

USE OF PLASTICS IN EUROPEAN AUTOMOBILES

Let's first review those applications in which European practice is similar to the U. S. and from country to country within Europe. It is my impression that France and Italy use significantly larger quantities of plastics in their automobiles than do England and Germany.

In the electrical systems, phenolics are used for distributor caps, PVC for distributor spark-plug leads and for general wiring by nearly every manufacturer.

Tail lights and parking lights are normally methyl methacrylate although an acrylonitrile-styrene copolymer has limited usage for these lenses.

PVC is used throughout the interior of the cars for roof liners, seat upholstery, door panels and miscellaneous trim.

As in the U. S., steering wheels are painted hard rubber on the economy models and cellulose acetate butyrate on the deLuxe models. Exceptions are Fiat who use acetate butyrate on all models and Citroën who use a PVC tape overwrapped on a steel core for their ID and DS to obtain an unusual and useful effect. Wooden steering wheels are still used on some sport cars.

Miscellaneous knobs and handles such as the gear shift knob, horn button, window crank and instrument panel knobs are usually acetate butyrate. Phenolics, ABS and polystyrene are used but less than butyrate. Volkswagen use melamine quite extensively for this purpose.

Instrument housings are non-load bearing decorative bezels for the most part and ABS is used with occasional exceptions.

Upholstery has been largely changed from sponge rubber to polyurethanes. Most constructions involve metal springs, a vegetable

fibre mat followed by shaped urethane foam and a PVC surface. Full depth flexible foam seats have been molded for the Morris 1100 by BMC and are under investigation by other companies.

Mechanical parts such as door-lock wedges, brake and clutch pedal bushings, speedometer gearing, steering linkage bearings and windshield wiper gears, are of nylons or acetal resin.

Now, let us look at some interesting points of differences between the various manufacturers.

A. Hardware

As in the U.S., European manufacturers use chrome-plated zinc on the deluxe models, but they have adopted plastics for many of the utility models, such as the polyamide parts used on the Citroën ID, the ABS hardware with metal insert used by Simca (Figure 2), the door-latches on the Ford Zodiac and the new Renault R-S which uses black acetal resin (Figure 3). This last handle (Figure 3A), uses imaginatively a strip of bright aluminum tape recessed in a groove to give a contrasting sparkle to the black acetal. It seems obvious that plastics usage in this area will increase as the pressure to decrease costs mounts and the public demonstrates they will accept plastics without prejudice as has been the case. Mercedes are using plastics in their hardware, having combined a strip of vinyl with a conventional chrome-plated window crank to give added style.

B. Lighting

Peugeot have an interesting development in tail-lights. The chrome-plated zinc-die-cast reflector unit has been replaced by a metallized methacrylate reflector (Figure 4) so that the whole unit is now in methacrylate. Opel are using a similar part on their Kadett. An auxiliary wire is attached to the chassis to provide grounding.

The license plate lamp on Renault R-4 uses a lens of polycarbonate because of the high temperature caused by the bulb located very near the lens.

C. Rear Windows

Methyl methacrylate is used for the rear windows in the Citroën ID (Figure 5), in certain Alpha Romeo's and the Simca 900. Fiat are experimenting with it for their 1300 and 1500.

D. Reinforced Plastics

In general, European usage of polyesters corresponds to the U.S. practice. They are mainly used for parts having a geometry difficult to reproduce in steel, low volume specialties and chemical tank trucks. The most notable

items are the roofs for the Citroën ID and more recently their Ami-6 (Figure 6). Renault, too, make a roof from polyester-glass for their Estavette delivery truck (Figure 7). This would require a difficult and deep-draw in steel and is reported to be cost competitive with a steel top.

E. Fluid Reservoirs

On practically all models, the windshield washing fluid is stored in a high density polyethylene container. Fiat is an exception using the PVC bag used on many U.S. models (Figure 8).

The windshield washer system for the Volvo Amazon as pictured, utilizes several plastics. The motor housing is in high impact polystyrene, the pump housing in acrylonitrile-styrene copolymer, acetal resin is used for the fastening cap, gearing and impeller and high density polyethylene for the water container (Figure 9).

In contrast to the U.S. practice, the brake fluid reservoir is made from plastics in Europe. Volkswagen use high density polyethylene, Opel, Fiat and others use a polyamide container as shown in Figure 10.

F. Crash Pads

In this regard, there appears to be little difference between U.S. and European practice. Most European models above 1300cc displacement have a crash pad consisting of an acrylonitrile-butadiene-styrene film over a polyurethane foam (Figure 11). Figure 12 shows the great variety of such constructions that are used.

G. Fans and Blowers

Much experimental work is being carried out in Europe with various plastics for engine cooling fans and blowers and a number of different materials are used commercially. Of interest are a glass-filled nylon fan reported to have been adopted by DKW in place of their nylon fan to get added stiffness, an acetal heater blower and the first cooling fan introduced in a plastics, the Citroën nylon fan (Figure 13).

Also relatively new are a heater blower for trucks and buses made in Sweden from acetal (Figure 14), and the cooling fan for the Fiat 1500 made from polypropylene (Figure 15). Practically all manufacturers have a program underway aimed at replacing the metal cooling fans and heater blowers with a plastics.

H. Heater Bodies

The heater body in Figure 16 is for the Peugeot and is in phenolic. Fiat, Simca, Renault and possibly others use

phenolics. There appears to be very little usage of polyester-sisal fibre molding compositions in Europe in contrast to the U.S. practice.

I. Applications in Contact with Fuel

Plastics fuel lines are very much in evidence in European cars, particularly from the fuel pump to the carburetor. In the composite Figure 17 are shown vinyl tubing used by Fiat and nylon fittings used in the Citroen system. Opel in their new Kadett have made extensive use of nylon tubing including the line from the tank to the fuel pump (Figure 18). Joints are by means of a fabric covered rubber coupling. In the Citroën, about 150ft. are used for conveying fuel and in the low pressure lines of the hydraulic suspension system. Rover and Jaguar both use a nylon line from the tank to fuel pump. Numerous carburetor parts in contact with fuel including a float are made of acetal resin by Villiers and the connecting union on an electrical fuel pump manufactured by S.U. Carburetor is also in acetal. There are numerous developments afoot in this area.

Other applications worth noting are the bezel (Figure 19) for the DKW which is in polycarbonate, the reasons given for this choice being its ability to be metallized and the good resistance to high temperatures.

In Italy, the foremost electrical equipment manufacturer has introduced the cover and base of the voltage regulator in acetal resin in a geometry it would be difficult to reproduce in steel. Fiat have replaced their speedometer frame, previously assembled from six pieces of a nickel-plated steel, by the single acetal molding shown in Figure 20. Even the pinions of this speedometer are in acetal. Ingenious use of acetal resin has been made in using it to hold metal "nails" in place in a tire to provide traction on the icy roads found in Northern Europe (Figure 21).

SUMMATION

Generalizations are always dangerous but it is evident to me that the conclusion of my colleague, Dr. Burk, as presented to the Detroit SPE Section in June of 1959 is still valid. European manufacturers make significantly greater use of plastics when allowance is made for the relative weight of the vehicles. I must acknowledge that the opportunity to use plastics is not directly proportional to the weight of the vehicle because of the larger relative importance of the motor in a large car, but a bigger car certainly presents a greater opportunity. (See Table III)

In addition, the numbers in Table III are supported by a listing of important differences in U.S. and European automotive practice.

In the use of laminated glass, polyester-sisal fibre compositions (commonly termed: gunk moldings) and polyethylene for carpet backing, the U. S. has not yet been imitated by Europe. However, in using plastics for door hardware, cooling fans, heater blowers, fuel lines and brake fluid containers, Europe has not been content to follow a U. S. example, but have moved ahead independently. Earlier, I commented on the large number of manufacturers in Europe. The small production series of many of these manufacturers result in a different economic picture than prevails in Detroit. Injection molded plastics parts are excellently suited to modestly sized production runs since the new investment money is substantially less than that required for an extensive metal stamping-forming, assembly and finishing operation. This is true not only in automotive but in other fields as well. Conspicuous examples are the extensive use of plastics, nylon in particular, in housings for European mixers and vacuum cleaners. With several manufacturers of these products in each country, individual series tend to be small and nearly all turn to injection molding as the most economical production method. Since the prices of the finished products are usually higher and less competitive in Europe than in the U.S., material selection is not as critical. A manufacturer will frequently select a better quality material rather than spend time working out the problems associated with the use of a less expensive but somewhat limited material.

Eight of us from the duPont Company who previously worked in the U.S. plastics industry have been in Europe for periods ranging upwards of three years. To a man, we have been impressed with the speed and skill with which our plastics have been adopted for injection molded component parts. An excellent example is the complicated automatic shut-off valve in Figure 22, used to prevent overflow of an oil tank. This ingenious device was designed, executed and code approvals obtained in Switzerland in under two years. I believe it is safe to generalize that in the utilization of the injection molding technique, Europe is ahead of the U.S. in the variety and originality of the component parts produced. This does not mean the molders are better. They are not. The same range of competency exists in Europe as does in the U.S. However, they are working under conditions of economic development which make it easier to give full play to creativeness due to markedly less severe price competition from well established metal products made in very large quantities. To know that European prices are higher, you have only to ask one of the many transplanted American housewives located in Europe.

It is my impression that in the other areas of plastics usage, we get a mixed picture showing the U.S. to be superior in certain aspects but with Europe close behind.

In packaging, for instance, the U.S. is clearly well ahead of Europe but here, polyamides appear to be more widely used in Europe than in the U.S.

The U.S. refrigeration industry with their very large freezer compartments and complicated door liners have, I believe, led the U.S. to greater sophistication in vacuum-forming than current in Europe. Similarly, the use of foamed-in-place polyurethane for refrigerator insulation is a U.S. first.

Melamine dishware sold in the U.S. is unequalled in cost and quality. In Germany for example, dishware of polycarbonate (Figure 23) is sold in quantity at prices at least 50% above the U.S. level. The items shown cost over \$2.00 and do not have the surface hardness, rigidity or decorative patterns available with even the cheapest U.S. melamine sets.

My impression is that the U.S. is clearly ahead in the use of plastics for attractive and economical luggage.

In wire and cable, the U.S. aircraft and missile experience has led to constructions utilizing fluorocarbon resins, silicones and nylons to an extent unknown in Europe. On the other hand, there are a myriad of PVC constructions in Europe with extremely wide usage.

In the chemical industry, PVC took a big hold in Europe during the war and this has spread to the extensive use of PVC piping for use in drainage systems and gas and water distribution. However, the U.S. appears to have more sophistication and wider usage of the fluorocarbon resins.

Molding machinery has been a hot topic for some time. It is my impression that the models of screw machines introduced recently by U.S. manufacturers more or less equalize the situation on both sides of the Atlantic. You may be interested to know that we find that practically all our European customers purchase screw injection equipment when replacing old machines.

Generalizations are extremely dangerous in a field as complex as plastics. However, I believe, that when all phases of plastics usage are included, the U.S. is slightly ahead of Europe. However, there is absolutely no room for complacency. We have seen the following characteristics which lead us to predict that the U.S. cannot sit back and long retain a lead in any field.

- A. Development work by small to medium sized companies by U.S. standards progresses very rapidly. Test programs are thorough but not drawn-out interminably. Decision points are centralized.
- B. European consumers accept plastics with more open-mindedness as evidenced by automotive experience.
- C. Design and injection molding skills are fully equal to U.S. standards.
- D. European producers seem more prone to gamble on a new product.
- E. There are fewer dominant companies with a large vested state in metal fabricating equipment which they are reluctant to part with.

Accordingly, in planning for the even more competitive days ahead, U. S. manufacturers will do well to ask themselves by what route they would make their products, if they were starting from scratch today. Only through this logic can obsolete methods be shown in their true perspective and replaced by newer methods which can lead to better and less costly products.

TABLE I

	Population, MM	Industrial Output, (1) \$ MMM
Europe	353	135
United States	182	183
(1) Industrial output at factory cost		

TABLE II

MAJOR EUROPEAN MOTOR MANUFACTURERS

Volkswagen	Citroën	Vauxhall
Fiat	Opel	Mercedes
BMC	Ford Company	Rootes
Renault	Peugeot	Auto-Union
Ford U.K.	Simca	Volvo

TABLE III

USE OF PLASTICS IN EUROPEAN CARS

Vehicle	Total Weight, lbs.	Lbs. of Plastics	% of Total
Citroën ID	2530	66	2.5
Fiat 1300	2112	26	1.2
Renault(average)	1500	20	1.3
Volkswagen (1959)	1430	23	2
Chevrolet II	3750	30	<1

TABLE IV

DIFFERENCES IN PLASTICS USAGE IN AUTOMOBILES

Item	United States	Europe
Heater housing	Polyester-sisal or others	Phenolics or others
Carpeting	Polyethylene-backed fabric Rubber	Rubber
Door hardware	Chrome-plated zinc	Nylon Acetal Chrome ABS
Fans and blowers	Steel	Polyamide Polypropylene Acetal Steel
Windshields	Laminated	Laminated Tempered
Fuel lines	Steel	Nylon, PVC, Steel
Brake fluid containers	Steel	Nylon

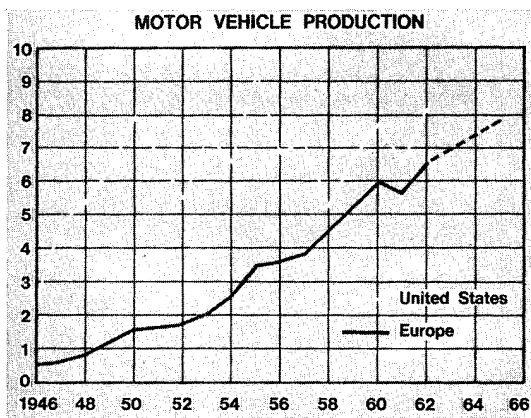


FIGURE 1

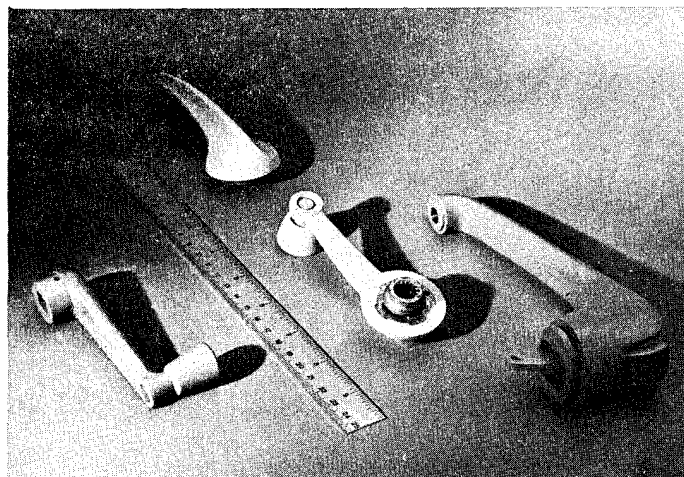


FIGURE 2: Citroen and Simca Hardware

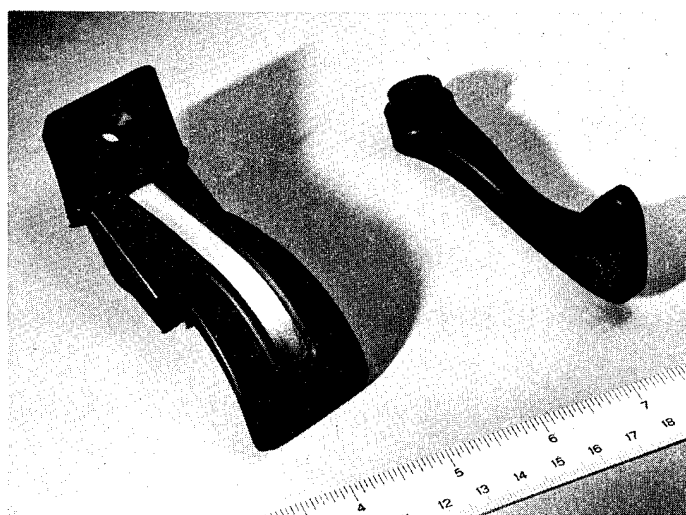


FIGURE 3: Hardware from Acetal Resin

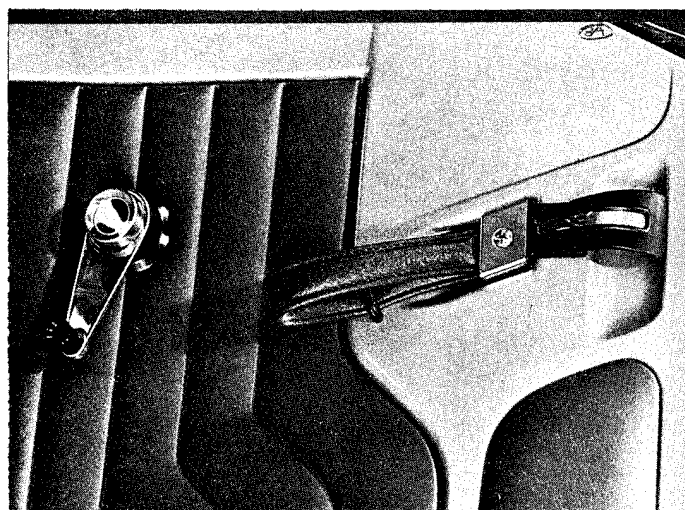


FIGURE 3A: Acetal Door Latch on Renault R-8

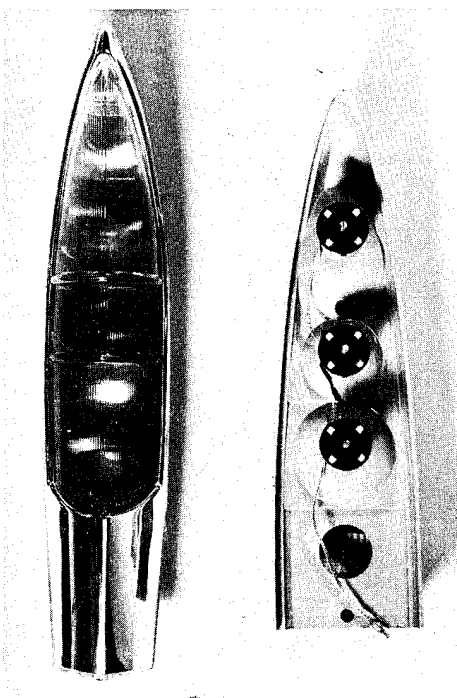


FIGURE 4: Peugeot Tail Lights



FIGURE 5: Methacrylate Window in Citroen ID

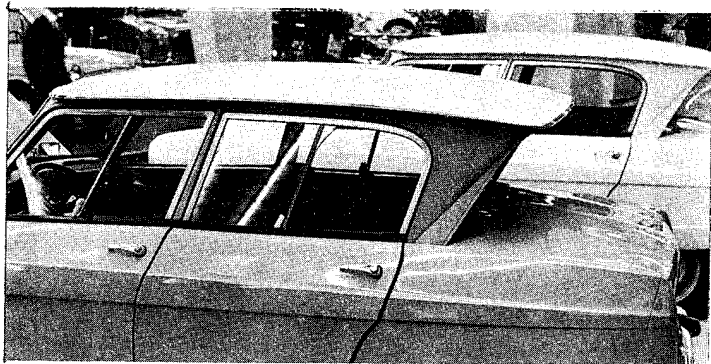


FIGURE 6: Roof of Citroen Ami-6 in Polyester Glass



FIGURE 7: Reinforced Plastics Roof of Renault Estavette

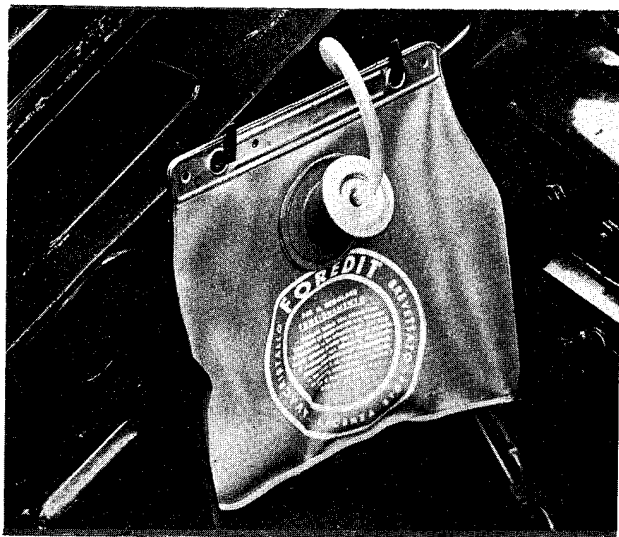


FIGURE 8: PVC Bag for Windshield Washer Fluid

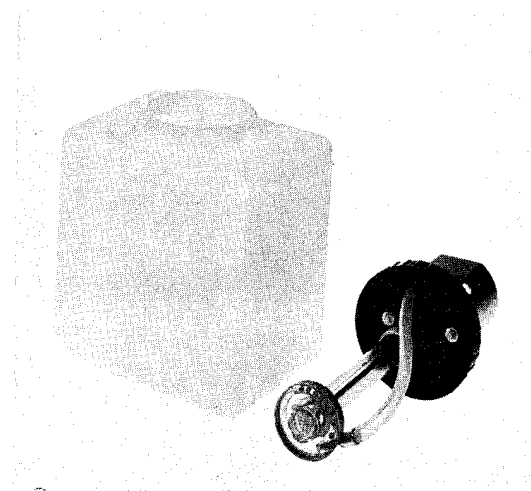


FIGURE 9: Volvo Windshield Washer System

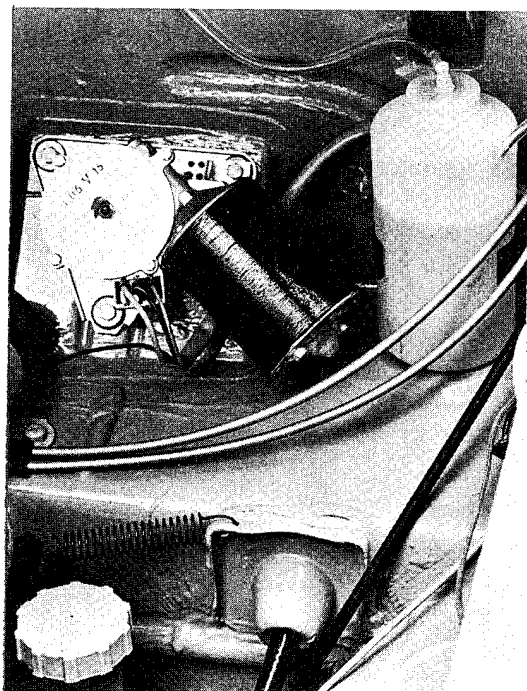


FIGURE 10: Opel Kadett Polyamide Brake Fluid Container (lower left)

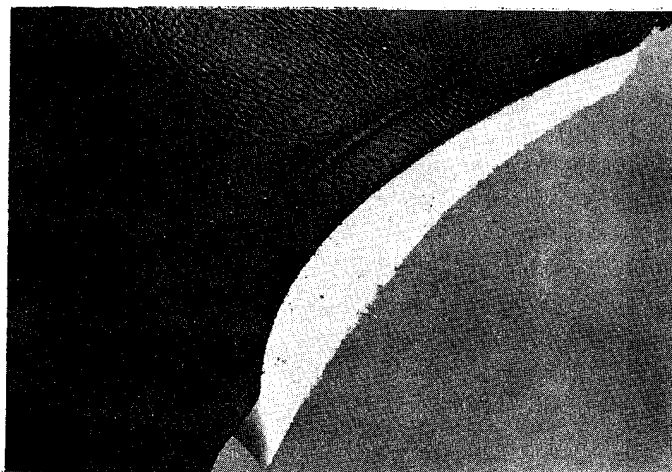


FIGURE 11: Cross Section of Volvo Crash Pad

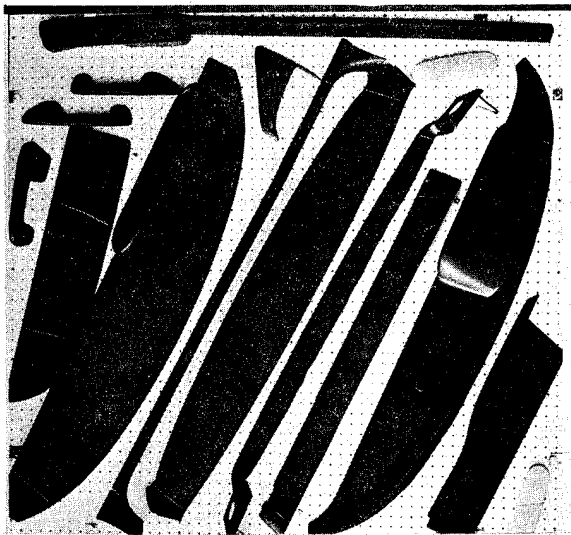


FIGURE 12: Various European Crash Pads

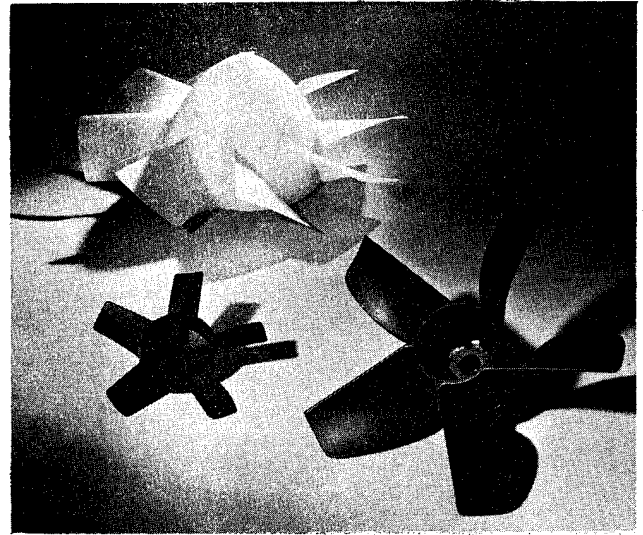


FIGURE 13: European Fans and Blowers

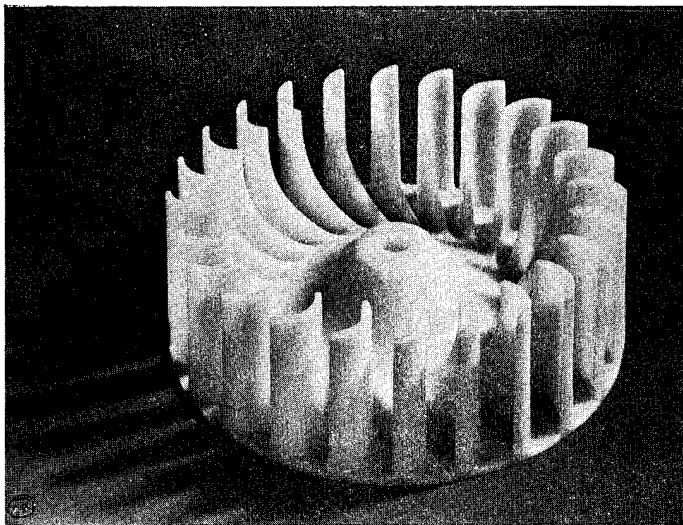


FIGURE 14: Acetal Heater Blower

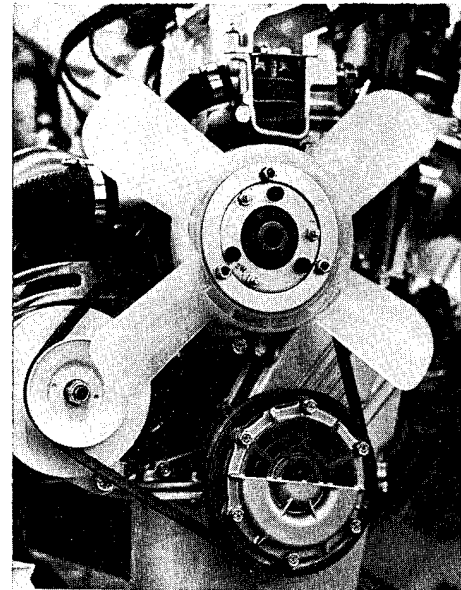


FIGURE 15: Fiat 1500 Engine Cooling Fan

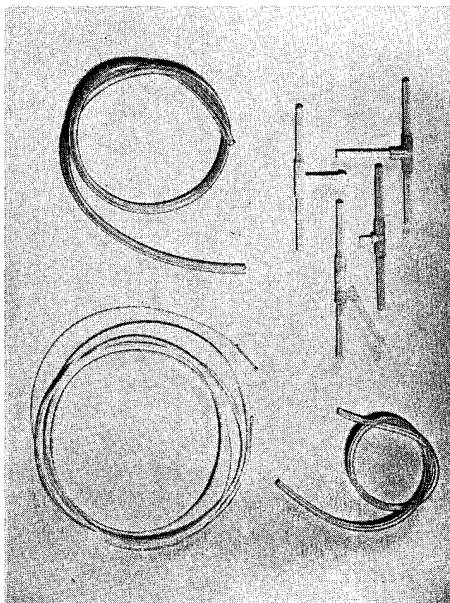


FIGURE 17: Vinyl Fuel Lines and Polyamide Fittings

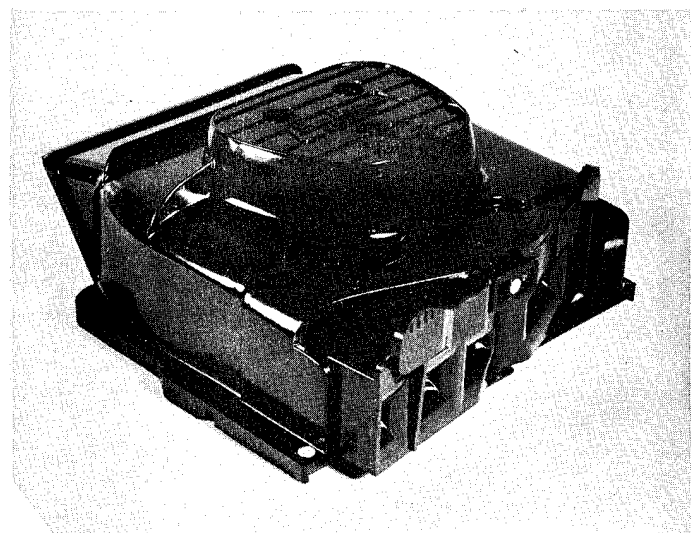


FIGURE 16: Peugeot Heater Body

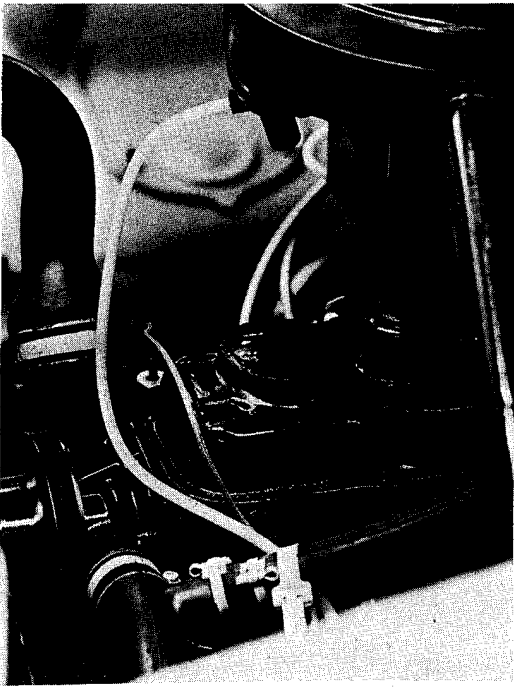


FIGURE 18: Polyamide Fuel Lines

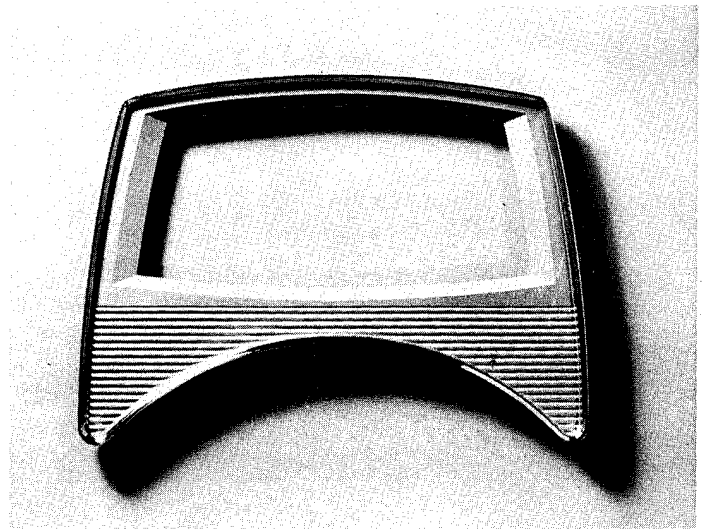


FIGURE 19: Polycarbonate Bezel

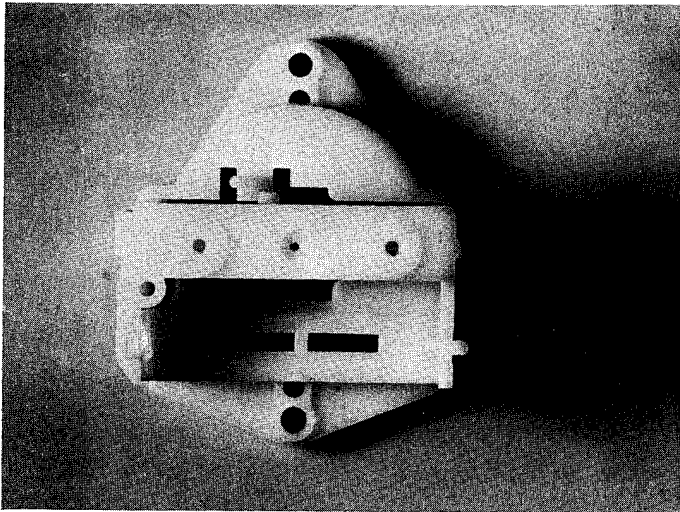


FIGURE 20: Speedometer Frame in Acetal

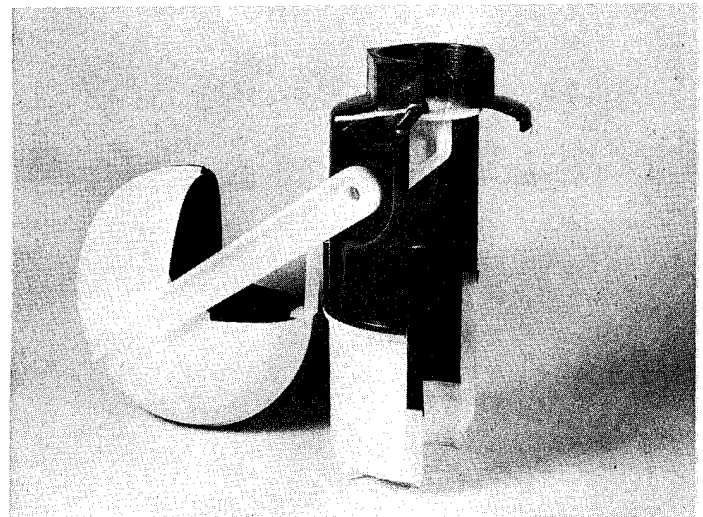


FIGURE 22: Automatic Oil Shut-off Valve

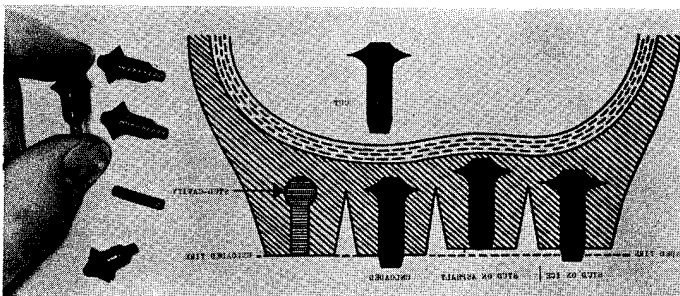


FIGURE 21: Tire Nails used to Replace Chains

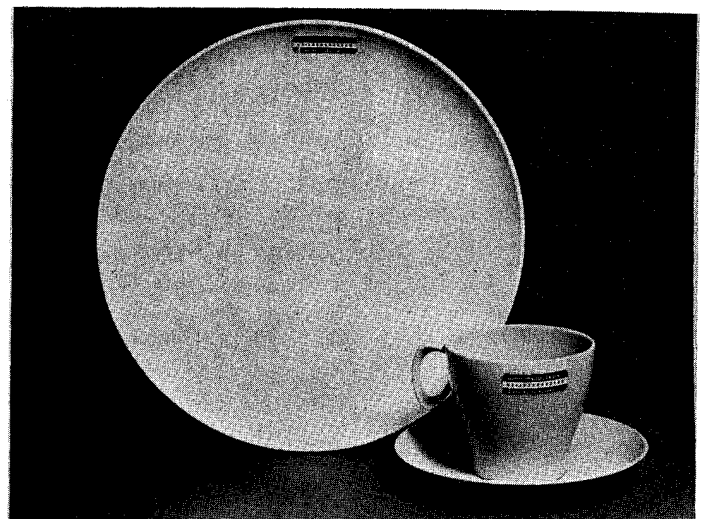


FIGURE 23: German Polycarbonate Dishware

PLASTICS ACCELERATOR PEDAL WITH INTEGRAL HINGE

Robert F. Sale

and

James H. Junkin

Materials Application Dept.

Ford Motor Co.

Dearborn, Mich.

5188

This is the case history of the development of a plastics part to replace an equivalent part that had been manufactured from other materials for many years.

The plastics part is an accelerator pedal, injection molded in one piece from polypropylene, the low-cost, light weight thermoplastic with a unique ability in thin sections to act as a hinge with excellent flex-life. This feature has been incorporated into the design of the pedal, eliminating the need for a mechanical hinge (Figure 1).

The advantages of this plastics pedal over the conventional rubber and steel pedal are a one-half pound weight savings, approximately one-half pound reduction in pedal effort, better abrasion resistance and considerable cost savings.

The Ford plastics pedal was designed in October, 1959, as a direct replacement for the rubber-and-steel pedal, and it maintained the appearance, method of attachment and function of the original. A single-cavity experimental mold was made shortly thereafter and sample pedals were molded. Several of these pedals were installed in durability test cars, and others were put on a flexing machine to evaluate flex-life. These latter pedals completed over one million cycles under rigorous conditions with no hinge failures.

In January, 1960, samples of a polypropylene pedal with an integral hinge were shown to the automotive industry by a supplier. These samples were subjected to rigorous lab testing, including 850,000 cycles through a 30 degree arc with the hinge submerged in sand and water. They showed no deleterious effects on the hinge.

The Ford pedal is hinged at the floor and operates against the accelerator lever at the tip. In order to simulate car conditions, a durability test was developed with the pedal loaded 6.5" above the hinge and 0.38" off center; the pedal was cycled through its normal travel at various temperatures, with the applied load increasing from 6 to 30 lbs. This load exceeded normal requirements and included a "passing-gear" down shift every cycle. The test involved

100,000 cycles at -40°F, 100,000 cycles at 150°F and 800,000 cycles at room temperature.

In addition, a fixture was built to flex several hinges simultaneously through a 90-degree arc (Figure 2). The hinges were flexed until they showed signs of impending failure. A minimum of two million cycles is the base line, but it is not unusual to have hinges flex well over four million cycles.

In order to correct an unacceptable "set" in bending and a twist due to the off-center loading that developed while cycling at 150°F, the initial mold was modified to deepen the ribs (Figure 3). This modification provided a noticeable improvement in the "set" in bending, but the twist due to the off-center loading was still unacceptable. A second revision was made to the mold to improve the resistance to twisting. This revision consisted of a new half-mold to the underside of the pedal, with a cross-rib design to put the ribs in direct tension and compression during a torsional load (Figure 3). It was also determined that the high temperature of 150°F was not realistic on the basis of a vehicle temperature survey, and 125°F was selected for further testing. These revised pedals exhibited a good resistance to twisting under the off-center loading and high temperature test conditions.

Results of comparative testing in cantilever bending, beam loading and torsional stiffness at room temperature are shown in Figures 4, 5 and 6.

Deepening the ribs gave a considerable increase in cantilever bending strength, and the change to a cross-rib design lost none of the cantilever strength but increased the torsional strength considerably.

The originally designed pedal weighed 0.125 lbs.; the deeper ribbed version weighed 0.175 lbs. and the cross-rib design weighed 0.170 lbs. Though the final cross-rib design had more ribs, through a reduction in wall thickness from 0.100 to 0.080", it provided a lighter pedal than the previous design, with no sacrifice in strength.

Flexing the hinge after soaking at -40°F revealed the importance of initial flexing while the pedal is still hot from the mold. New pedals, as molded; new pedals, hot flexed; and used pedals were cold-soaked to -40°F and flexed by hand upon removal from the cold box. Used pedals and new pedals that had been initially flexed while still hot from the mold were unaffected by this treatment, while new, unflexed pedals were brittle. It was assumed that the initial hot-flex orients the molecular structure of the plastics and gives it good resistance to brittleness at low temperatures.

During this laboratory test period, pedals were also operated in over twenty test cars. These tests included hot weather testing in Death Valley, cold weather tests in northern Minnesota, rough-road durability and general durability tests and totaled over one-quarter million miles of test operation. In all this preliminary road testing, there was not a single pedal failure; therefore, it was decided to make a four-cavity production mold for final testing.

Shortly after this decision, problems developed. A pedal broke at the hinge on a car running on a rough road durability test, and a month later a pedal broke on a car that had been in the cold room for several days. Also, the "Noise-Vibration and Harshness" engineers felt that the pedal had an undesirable buzz at critical periods on a prototype car then under development. These events, coupled with an understandable caution, almost eliminated the program at this point. It was obvious that a close quality control method would have to be developed; and it would also have to be a rapid method, since flexing pedals to destruction is very time consuming.

Test results of preliminary work at a supplier laboratory indicated a possible correlation between hinge elongation, which is easily measured, and flex life. This principle appeared worth investigating; so the mold was shipped to the supplier's laboratories, where a new molding machine with laboratory instrumentation was available. Nineteen molding runs were made under varying conditions of melt flow, method of coloring, melt temperature and fill time. These variations were made to determine optimum molding conditions.

An investigation was then made to develop a test procedure. Hinges were elongated at various rates of separation to determine the speed that would give the most consistent results, and 0.2"/min. was ultimately selected. The time interval between molding and testing was varied, and a five-hour stabilization period produced results that were relatively consistent, showing little change with increasing time (Figure 7). In order to evaluate the effect of coloring on the physical properties, sections of pedals molded from pre-colored material and from concentrated color were subjected to a microscopic inspection. The pre-colored material showed an even texture, while samples from concentrated color had several flecks of undispersed pigment. These flecks could act as weak spots in the hinge area, even though the pedal appeared satisfactory to the unaided eye. This fact indicated that the use of concentrated color might be satisfactory in decorative items but would be questionable in functional components of this type.

Melt flow, a measure of flow rate through an orifice under specified conditions, provides a means for determining thermal degradation. The more extensive the thermal degradation in molding, the higher the ratio of melt flow of the finished piece to the original material.

A material grade with a nominal melt flow of 5.0 gave the best physical properties of the materials then available. Tests of this grade showed that a melt index ratio of 1.7 is about the highest that could be tolerated, giving a final melt flow not over 8.0.

The usual cause of excessive degradation is too long an exposure to high heat or "hot spots" during the molding cycle. Since it is necessary to mold this pedal at a relatively high and even melt heat to provide the fast cavity fill time for optimum hinge properties, care must be exercised to prevent the undesirable conditions of excessive heating and hot spots.

This degradation was found to have a more noticeable effect on fatigue life than on strain behavior. Therefore, to assure a

satisfactory hinge, it is necessary to perform both an elongation test on the hinge and a melt-flow test.

The graph shown as Figure 8 illustrates part of the data establishing the correlation between flex life and hinge elongation. Selected molding runs covering most of the variable conditions are listed in descending order of elongation, with concomitant flex-life and molding data. As indicated, there is a strong tendency toward increased flex-life with increased hinge elongation.

Various hinge profiles were examined (Figure 9). A fairly sharp "V" hinge was tried with reasonable success, but the flexing loads were quite concentrated. A strap hinge was also evaluated with good flex life results, but control of the actual hinge line was lost, and a sag occurred. The profile that gave best results was a 60 degree "V" with a 0.03" radius at the apex and a thickness of 0.02". The data on elongation and flex life, shown in Figure 8, is based on this optimum hinge configuration.

Typical stress-strain curves are shown in Figure 10. An elongation of 0.25" to "failure point" is considered minimum. The "failure point" is defined as the point on the curve where a significant loss of load occurs. About three thousand hinges were tested in this manner to establish these quality standards.

The conclusion reached after this series of molding runs and subsequent testing indicated that optimum molding conditions were:

1. Melt temperature - 580-590°F
2. Mold temperature - 70-120°F
3. Cavity fill time under three seconds
4. Hinge to be hot-flexed
5. Polypropylene to be pre-colored
6. Melt-flow 4.5 to 5.5

The problem of noise also had to be solved. The source of the noise was engine vibrations transmitted through the accelerator linkage, causing the accelerator lever to vibrate against the underside of the pedal during critical engine periods. Several approaches were tried; a soft rubber tube slipped over the end of the lever produced a scrubbing action during pedal motion. A rubber dip, applied to the lever end required too much preparation and handling to be feasible. The best solution found was a felt pad with a Mylar coating, attached to the pedal in the area of contact with the accelerator linkage.

After considerable additional laboratory and vehicle testing with very satisfactory results, the decision was made to put the pedal into production, and two more four-cavity molds were made. New screw presses were purchased to provide for production capacity.

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After considerable additional laboratory and vehicle testing with very satisfactory results, the decision was made to put the pedal into production, and two more four-cavity molds were made. New screw presses were purchased to provide for production capacity.

It would be very satisfying to be able to say that all problems had been solved at this point, but there were still lessons to be learned. Polypropylene is quite notch-sensitive, and particular care must be given to the detail finishing of production molds, especially in highly stressed areas of the part. There is also the problem, in automotive applications, of selecting a grade of material that will give acceptable low temperature impact strength with sufficient rigidity at elevated temperatures. New, improved grades are constantly being evaluated as they become available. Then, there is the problem of differences in installation practices in an assembly plant as compared with those in an experimental garage.

This case history demonstrates that when a product is to be developed in plastics as a direct replacement for another material that has been long established, the new part must be appreciably better and less expensive than its predecessor. It is also necessary to anticipate the customer's performance requirements; and, finally, one must have a molder, who, understanding what is at stake, will conscientiously produce quality parts.

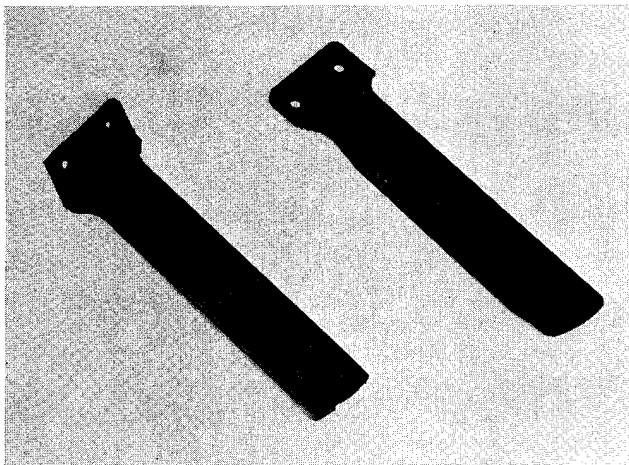


FIGURE 1: Rubber vs. Plastic Pedal

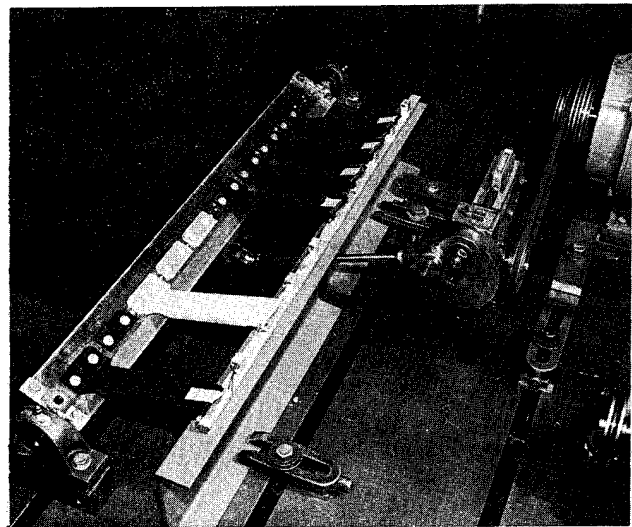


FIGURE 2: 90° Flex-life Fixture

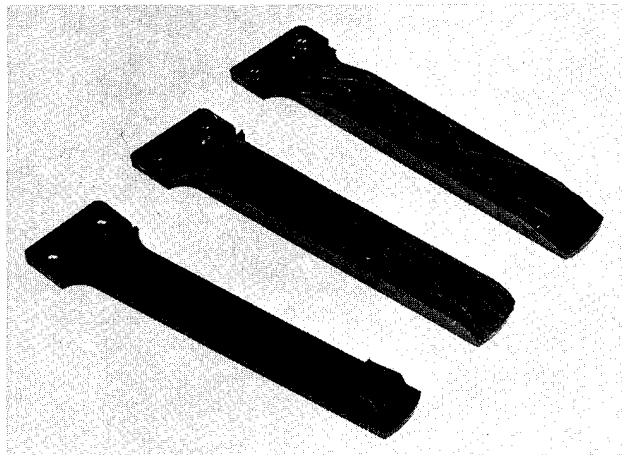


FIGURE 3: Three Revisions

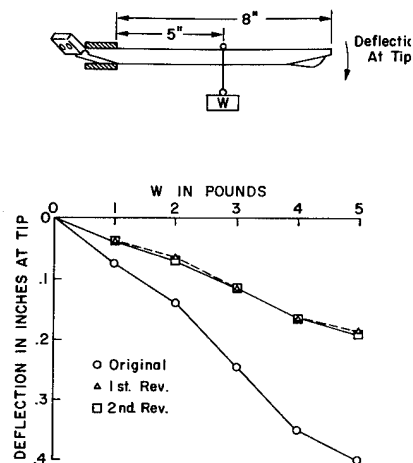


FIGURE 4: Cantilever Bending

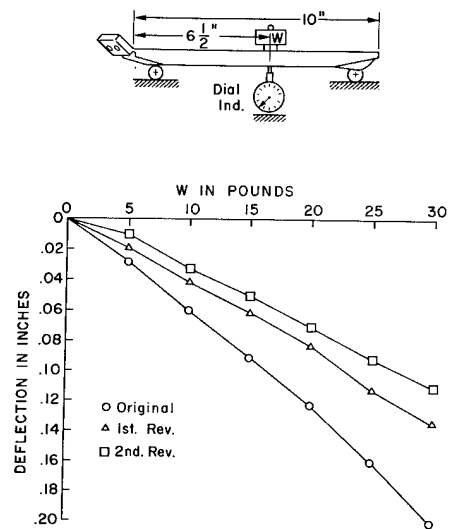


FIGURE 5: Beam Loading

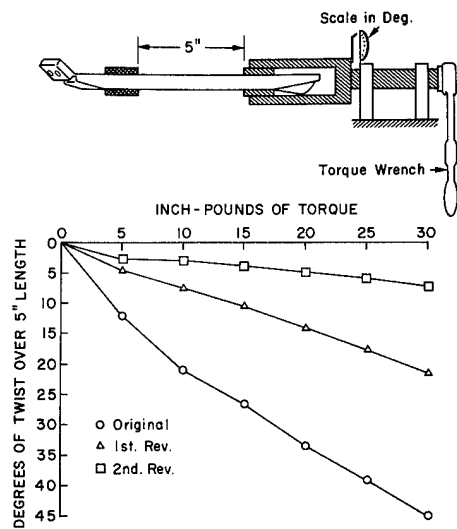


FIGURE 6: Torsional Stiffness

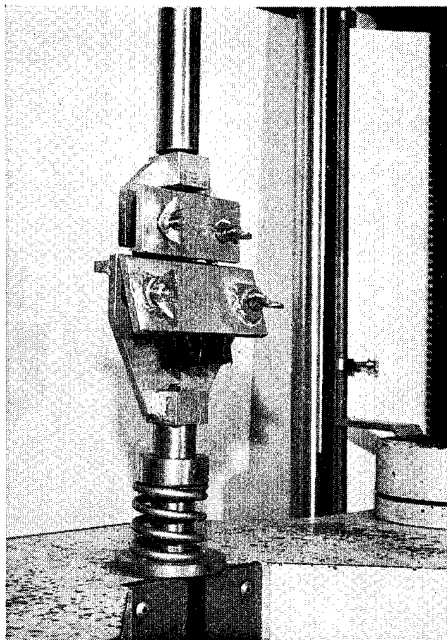


FIGURE 7: Elongation Test Illustrating Special Jaws

RUN	ELONGATION	TEMP	MOLD F	M	RAM TIME	MATL	FLEX	M.I.	FLEX CYCLES 90° NO LOAD (135° 25 LBS (520 PSI))
11	296	590	72	91	2 1/4	THRU	YES	6.9	
3	283	580	104	122	2 1/4	THRU	NO	5.9	
7	273	590	104	122	2 1/4	THRU	YES	6.8	
10	268	590	72	91	2 1/4	THRU	NO	6.9	
4	258	580	104	122	2 1/4	THRU	YES	5.8	
6	250	578	104	122	8 1/2	THRU	YES	5.8	
2	229	580	104	122	2 1/4	CONC	YES	9.0	
5	221	590	104	122	8	THRU	YES	6.0	
8	208	500	100	111	2 1/4	THRU	YES	5.4	
14	174	590	72	91	3	THRU	NO	7.2	
1	183	530	100	112	8	CONC	NO	7.9	

FIGURE 8: Elongation vs. Flex-life Chart

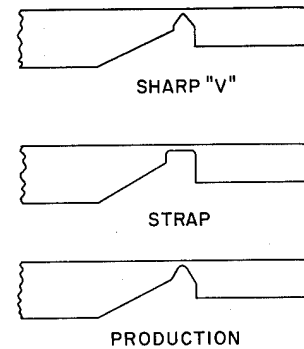


FIGURE 9: Hinge Profiles

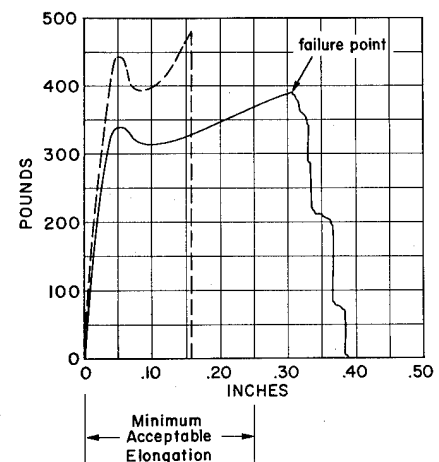


FIGURE 10: Typical Stress-Strain Curves

RIGID URETHANE FOAM - A NEW DESIGN TOOL FOR THE AUTOMOTIVE INDUSTRY

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INTRODUCTION

Rigid urethane foams are a unique type of plastics insulating and structural material. They are another step toward lightweight structures with rigidity equaling, or surpassing, current methods of fabrication. By the employment of rigid urethane foams in sandwich structures, less reinforcement and thinner metal skins are being used with no sacrifice in strength or design.

APPLICATIONS

One recent automotive application has employed a vinyl coated steel and foam sandwich structure in the floor of station wagons. It replaced a steel channel reinforced panel which not only weighed more but also required a greater number of operations to fabricate. A bonus property of decreased sound transmission was gained by the new design.

Refrigerated cargo van manufacturers are using foam to decrease wall thickness and thereby increase the cargo-carrying volume of their vans. Rigid urethane foam has made possible thinner metal walls but with increased strength overall.

As an insulating material, urethane foam has been used in railroad tankcars carrying materials which must be kept above ambient temperatures to facilitate flow. Normally the car had been shipped about a thousand miles and at the end of that time steam was put through its coils to melt the material before unloading. With foam insulation, enough heat was retained for immediate unloading, permitting considerably reduced demurrage.

Truck cabs are being insulated with rigid urethane foam for better temperature control and greater quietness to improve working conditions for drivers. By reducing fatigue, safety is increased.

The building industry uses rigid foam in panels for curtain-wall construction. Erection costs are reduced considerably by prefabrication techniques of prefinishing both the interior and exterior of the panels before assembly as well as by simplifying construction in the field.

FOAM FORMATION

Rigid urethane foams are made up of two liquid chemicals which are reactive when blended together. A blowing agent which boils at room temperature is included in the system to expand the material until it can set to a rigid, closed cell foam. The final product is more than 30 times the volume of the starting materials resulting in reduced densities. The actual density of the foam may be adjusted from 1.5-30.0 lbs./cu.ft. but normally it is in the 2.0-2.5 lbs./cu.ft. range where properties and costs are best balanced for most applications. Other properties such as elevated temperature stability, physical strength and fire-retardance can be built into a foam by the proper selection of raw materials for the foam system.

PHYSICAL STRENGTH

A wide range of physical properties is possible by changing the density of a foam. Figure 1 plots the range of compressive strength that can be expected at various foam densities. The lower densities are used where insulation is the major factor and where skin materials add to the strength of the structure. Medium density foam in the 6-10 lbs./cu.ft. range is being used in the fabrication of foam radomes which have no supporting members other than the foam itself. These are strong enough to withstand Arctic winds of over 100 mi./hr. Very high density foams often find application as a potting and encapsulating material or a low density type of molding compound.

INSULATION

The excellent insulating properties of rigid urethane foams are achieved by the use of trichlorofluoromethane, commonly called R-11, as the blowing agent. As indicated in Table I, foams made by this method have a k-factor of 0.11 (Btu/hr/sqft/°F/in) which is one-half that of the second most efficient insulating material in common use. Foams, by their chemical composition, are resistant to moisture and will retain their insulating efficiency over much longer periods of time than insulating materials which had previously been used. They do not pick up water and are not damaged by shock and vibration. This low, stable k-factor has also opened up new fields of low temperature operation which were not practical with previous insulating materials.

With the proper selection of raw materials, foams can be made to withstand elevated temperature and high humidity conditions. When heat is applied from one side, as is normal for insulating applications, rigid urethane foams can be made to retain their integrity even after one thousand continuous hours at 350°F.

CHEMICAL RESISTANCE

Rigid urethane foams will also resist attack by many chemicals, some of which are listed in Table II. These tests were performed on 2" cubes submerged in the chemical for one week and at the end of

that time a volume measurement was taken. In the case of the more active solvents such as acetone, methyl ethyl ketone, alcohol and the chlorinated solvents, the resistance would be satisfactory for short periods of time but the foam would be attacked and softened by extended exposure.

FIRE RETARDANCE

Rigid urethane foams can be either nonfire-retardant, self-extinguishing or nonburning. The demand for the latter types is increasing because of the need for safety during storage of the foam and in the finished product. The more fire retardant a foam is, the more it will localize a fire preventing it from traveling away from the immediate source.

Fire-retardance in foams can be achieved by the chemical design of the raw materials or by adding compounds during fabrication, which will limit flammability. The first method is always preferable since the foam produced by it would not only be permanently fire-retardant but also its physical properties and elevated temperature stability would not be deteriorated by additives. An example of a foam which offers maximum fire-retardance by virtue of its chemical composition is the system using HETROFOAM 250*, a polyol produced by the Durez Plastics Division of Hooker Chemical Corporation, and a commercially available polyisocyanate. This system is rated as "non-burning" by the ASTM D-1692 fire test, and has excellent physical properties and elevated temperature stability.

PROCESSING

Rigid urethane foam may be processed either by fitting pre-foamed boards, called slab stock, into a void or by pouring the liquid components into a cavity and allowing them to rise and cure.

The slab stock method of fabrication most closely approximates processes using fiberglass or similar types of insulation. The foam is available in many shapes from flat board stock to curved sections for pipe insulation. It can be easily shaped with conventional cutting equipment and often is resilient enough to be wrapped around objects such as large storage tanks. The use of slab stock offers a simplified control of foam density and quality. It is most widely available in the 1.5-2.0 lbs./cu.ft. density range with nearly isotropic cell structure, that is, the strength of the foam in all three directions is almost equal. A minimum investment in equipment is needed to use slab stock making it suitable for low volume applications.

The foam-in-place method consists of blending one liquid, called a polyol or resin, with another called an isocyanate, under controlled conditions. The R-11 blowing agent, catalyst and cell controller are usually included with these components. Equipment is available which will meter each component accurately and then blend

*Registered Trademark

them thoroughly. Foam-in-place is normally used in the plant where a product is being manufactured. The liquid prefoam is poured into preheated molds and allowed to rise to completely fill the cavity. Foam-in-place production of rigid urethanes offers freedom of design in that the liquids can be made to flow around complex shapes and will bond to most materials without the use of a primer or adhesive. It provides a continuous insulation leaving no openings for air leakage. This processing technique offers the lowest ultimate cost of any method of foam application, especially where the volume is large. An additional advantage of foam-in-place is that the raw materials are stored in an unexpanded state thereby reducing warehousing requirements.

A variation of the foam-in-place process sprays the foam onto a surface rather than pouring it into a cavity. The materials, once mixed and sprayed onto the item being insulated, rise rapidly and set to a rigid state. This can be trimmed as needed and the assembly completed. Both of these variations produce satisfactory foam; the choice being determined by the requirements of the item being foamed and the process manufacturing it, for example, the pressure limitations of the cavity, the mobility of the product during manufacture and the space and equipment available for foaming.

The success of a urethane foam process is largely dependent upon three factors:

1. The raw materials must have the capabilities required by the end product. Inadequate starting materials can yield only poor quality foam and an inferior product.
2. The product should take advantage of all the benefits urethane foam can offer. A redesign will often bring about considerable cost savings while mere substitution of urethane foam for other insulating materials will overlook these economies.
3. The processing equipment should be selected carefully, making certain that it can handle the demands to be made of it and keep doing it with a minimum of maintenance and repair.

CONCLUSION

Rigid urethanes, because of their versatility in processing and molecular design, offer unique opportunities to the automotive and transportation industries where rigidity and lightness play such an important role. Although they are primarily insulating materials they will undoubtedly find many varied applications where they can improve a product physically, and at a lower cost.

TABLE I

INSULATION VALUES FOR VARIOUS INSULATING MATERIALS

<u>Insulating Material</u>	<u>K-factor @ 75°F (Btu/hr/sq ft/°F/in)</u>	<u>Inches to equal 1 inch of urethane foam</u>
Rigid urethane foam	.11	1.0
Glass fibers	.25	2.3
Mineral wool	.27	2.4
Cork	.27	2.4
Polystyrene foam	.28	2.5
Flexible urethane foam	.28	2.5
Cellular glass	.39	3.5

TABLE II

CHEMICAL RESISTANCE OF HETROFOAM 250 FOAM

<u>Chemical</u>	<u>Volume Change, %</u>
Hexane	+0.7
Benzene	+0.2
Ethyl acetate	+0.3
Dilute HCl - pH 3	+2.8
Dilute NaOH - pH 11	+0.8
Motor Oil - SAE 20	+0.5
Gasoline	+0.7

FIGURE I

COMPRESSIVE STRENGTH VS. DENSITY
OF RIGID URETHANE FOAM

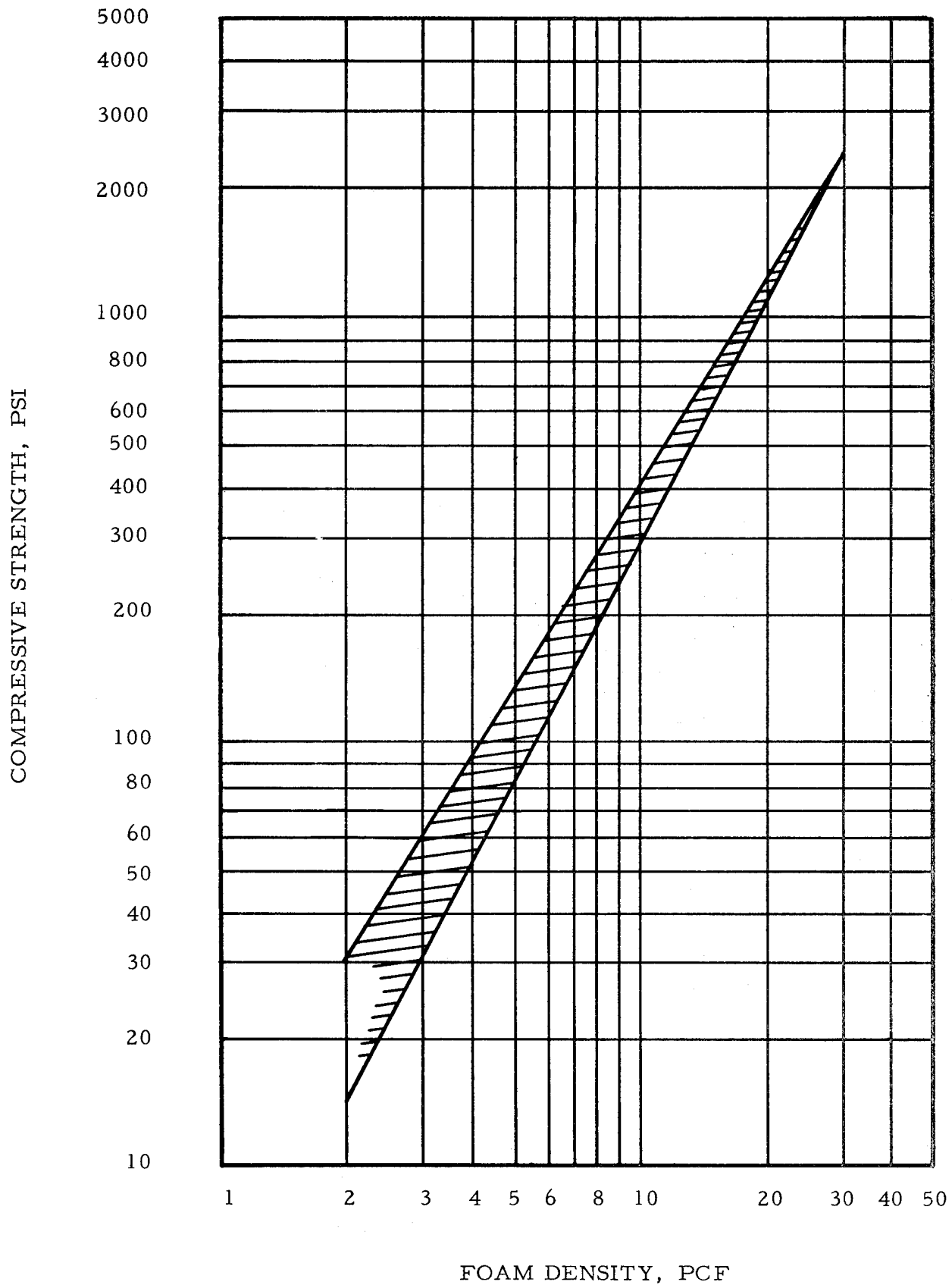


FIGURE 1: Compressive Strength vs. Density of Rigid Urethane Foam

PLASTICS BODY FILLERS FOR AUTOMOTIVE USAGE

Joseph Linder

5190

President

and

Gordon Overbey

Director

Research and Industrial Development

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Since the introduction to the market of the so-called "plastics body fillers", sales have continued to increase at a rather phenomenal pace. This growth is typical of many areas of the plastics industry and accompanied generally by a parallel increase in technology and product development. The rate of increase has slowed because the primary market, automotive repair and body shops, has largely adopted this method of repair. Other markets developed in the past or currently being developed do not represent the volume of automotive repair. However, one area yet to be tapped can create additional volume usage to increase substantially the present figure. Automotive manufacturers present this outstanding potential.

To understand more fully the current status of this field, a look at the background and plans for the future will be useful. Highly filled vinyl or nitrocellulose solutions were on the market for many years with only very limited success, since these products were primarily useful for scratches or very small repairs. Repairs of large areas with plastics became practical only with the advent of relatively low shrinkage, high adhesion thermosetting resins.

In the early 1950's, kits for the do-it-yourself trade were available which consisted of a resin package, a package of milled glass fibers and a container of methyl ethyl ketone peroxide catalyst. People made their own putty by mixing the fibers into the resin. Adhesion was so poor that an epoxy ester primer was required and an impact of low magnitude would cause the patch to crack or completely lose adhesion.

The initial commercial production of any magnitude was in 1957. These early compounded materials were based on general purpose, high reactivity polyester resins, filled and cured with methyl ethyl ketone peroxide. The properties left much to be desired.

Short pot life, drifting gel times, sagging and poor handling qualities, long sand time, hard sanding, poor adhesion, poor flexibility and brittleness, pigment settling and poor shelf life were all typical of the early products. Yet these products met with a degree of success because of the desire of people in the body repair shops to simplify and speed up repairs. An employee no longer needed to be skilled in the art of application of tin-lead solder and the danger of creating undulations in the metal surface by excess heating with a torch was eliminated. Removal of upholstery was also eliminated.

Particularly in the early stages, both polyester and epoxy resins were considered. Although a very excellent body repair product can be formulated from epoxy resins, certain factors were against their general acceptance; namely, cost, more critical curing agent concentration and slowness of cure to sandability, especially in thin sections.

The polyester resin producers became aware of the ultimate potential and began in earnest to assist in methods of improving the products. More stable resins were needed along with less tendency toward drift in gel and cure times and additional information was required for stabilizing additives and cure promoters. Filler pigments and their effect on handling properties, stability, settling, sanding and final properties required evaluation.

Many errors were made, both by resin producers and compounders. Many products were introduced which, for one reason or another, were unsatisfactory. Many saw what they believed to be a golden opportunity to cash in on the necessarily high initial sales price and began to manufacture without adequate background or finances, many with disastrous results for themselves, their customers and the industry. In spite of all the original problems, progress was made.

Methods of testing, many of them improvised and peculiar to the industry, were developed. Indication of product shelf life, involving aging at elevated temperature and checking gel and sand times, along with methods of determining physical properties of the final product, were definite guides before passing improved materials along to the final judge of quality, the consumer.

Filler evaluations resulted largely in the use of talcs. Pre-promoted and pre-stabilized resins became available from the resin producers. Ways to improve settling and handling characteristics were found. Product "brand names" from reputable companies began to be recognized. The use of dimethyl and diethyl aniline, in addition to cobalt naphthenate promotion, allowed a closer spread between gel and sand times. The market continued to grow as products improved and confidence increased.

The next stage of development included the use of the relatively non-toxic benzoyl peroxide paste or "creme" hardener as even more stable resins were produced allowing higher percentages of promoters. Thus another of the objections to plastics body fillers was removed by the marked reduction of flammability and toxicity hazards. Semi-flexible resins were also available which resulted in body fillers with the superior physical properties of better adhesion, impact strength and longer sandability.

At this point, it might be well to discuss very briefly the situation concerning hardeners and their mailability. For many years, there has been a standing Postal regulation stating that the liquid or methyl ethyl ketone peroxide hardeners were non-mailable. When the new benzoyl peroxide paste type hardeners were introduced onto the market, these, too, met with resistance as far as mailability was concerned. Further developments provided fire-resistant hardeners that would no longer fall in the category as set up by the ICC regulations. The Bureau of Explosives tested these materials at the request of Fibre Glass-Evercoat Company and stated that the samples did not fall within the classification. This information was forwarded to the Post Office Department who, in turn, have accepted the fire-resistant catalysts for mailing although responsibility still remains with the sender.

With the availability of increasingly flexible resins, more problems developed. As you are all aware, the more improvements offered, the more are required and demanded. The flexible resins have a tendency to remain in a state of soft gel for longer periods, particularly in areas of low build. During this period, if sanding is initiated, it is an almost impossible task to featheredge the body filler repair section, and blisters may occur through expansion of minute pockets of entrapped air which are heated during the sanding process. The body shops, by this time, were using both sanding and filing as methods of surfacing. To allow filing over any extended period, such as 24 hours, the product must be beyond the soft gel stage but remain in a state of intermediate hardness. An attendant problem occurs with flexible repair materials due to the decreased solvent resistance. Application of paints containing strong solvents sometimes caused blistering, bleed-through or paint color change.

Elimination or minimization of these problems has brought the industry to essentially the current status. Other refinements, such as allowing the use of liquid methyl ethyl ketone peroxide or creme benzoyl peroxide catalyst with the same product, better packaging and colored catalysts which assure the applicator of a correct mix through a final mix color, have been added.

This brings us to the stage to examine the current product. Exceptional shelf storage life, low toxicity, foolproof mixing, excellent application properties, low dusting, good filing and fast sanding are characteristic of the properties of the uncured product. Very low shrinkage, excellent adhesion and resistance to thermal shock, high flexibility and excellent paint base typify the cured product. Shear bond strengths tested on .035" auto body steel are in the range of 450-550 lbs./sq.in. with the break occurring within the compound with no loss of adhesion to the metal. Flexibility varies with the thickness of the cured section but the combination of adhesion and flexibility will allow severe treatment without damage to the repaired area, or low spots may be raised with body tools rather than requiring application of additional repair compound. Aging characteristics have been a question mark but enough time has now elapsed to indicate satisfactory performance.

Technological advances can be expected to continue through even further improved resins and handling characteristics. It is logical

to expect single package, heat-cured products which could be applied by means of an extrusion process. Other resins such as epoxies, polysulfides and polyurethane elastomers will continue to be evaluated.

The automotive industry has with good reason approached this area of interest with care. Before adopting other new materials, a backlog of successful applications following improved technology preceded adoption. For example, there is a large volume of polyurethane foam for cushions and crash pads and very wide use of fabric supported vinyl coverings but this was not always the situation.

Requirements of the automotive industry will vary from those previously established. Application and finishing properties must be optimum. It will not be necessary to allow the long intermediate cure stage for surfacing. Consideration must be given to the stage of production in which the product would be applied according to practicality and performance. If the product is to be applied prior to the metal cleaning and preparation process, some method of cleaning metal in those areas to be filled will be necessary. The effect of the water solutions in the cleaning process on the product must be known. On the other hand, relative bond strengths to the metal and paint bond to the product must be taken into account. These factors can be resolved and it appears that the major question remaining is one of adapting plastic fillers to production lines.

Good reasons exist for making the change. You may have noticed the article in "Life", the January 11, 1963 issue, entitled, "Glow in Detroit" by Kieth Wheeler. One of the photos in this article carried the caption, "Flourishing Ford. Looking like spacemen, Ford workers in Detroit protected from lead poisoning - sand down solder." These workers were protected by a heavy covering to the waist, and connected to an external air supply. The greatly reduced toxicity hazard is an important factor. It has already been noted that less skilled workers are required for application. Capital equipment expenditures would be reduced. Another important asset is the lower cost of product per unit production. A total of 5½ lbs. of automotive solder will occupy approximately equal volume to 1 lb. plastics body filler. Solder cost per pound is about 1.2 that of plastics body filler. Using a figure of 5½ lbs. of solder per production unit, only 1 lb. of plastics body filler would be required at a savings of over 80% in raw material cost.

Published figures for 1962 automotive production are approximately 6 million passenger car units and 8 million units including trucks and buses. Using an average figure of 1 lb. per unit, the automotive industry represents a potential market of 8 million lbs. By contrast, the automotive repair market is 25-30 million lbs. This figure is based on a three-year average, 1958 thru 1960, service job analysis of about 17 million body and fender repairs at an average consumption of 1½-2 lbs. per repair. Other markets will probably account for an additional 5 million lbs.

In addition to the huge amount of material used by the automotive repair market and the estimated volume of material which will be used in production, a considerable volume of these materials are

also being sold to the public as a do-it-yourself repair product. Sales are through the automotive retail outlets, hardware and in some areas, even through the super grocery and discount type stores. Most of the manufacturers stress that although this is basically an auto body filler material, there are many other uses such as repairing scratches, dents and gouges on boats, repairing furniture and toys around the home and in-plant use where filling and/or adhesive qualities possessed by these products are required. Not only is it suggested they use this as a filler but also as an adhesive to hold two pieces of wood or metal together. Many of the manufacturers are offering the material in kit form which includes the filler and hardener as well as sandpaper, fibreglass screening and applicator.

It is known that one well-known manufacturer of custom cars has been using the body fillers in their production for several years now with considerable success. In addition, Fibre Glass-Evercoat Company has had one car on which plastics was used instead of solder put through a production line of a major manufacturer. This car has been driven for over two years and the plastics has held up exceedingly well.

The industry has progressed markedly in the past five years. additional progress can be expected. This progress has now brought us to the stage where it is believed that the next logical step is adoption by the automotive industry of plastics body filler for manufacturing use.



SOCIETY OF PLASTICS ENGINEERS, INC.

National Executive and Business Offices
65 Prospect Street
Stamford, Connecticut

APPLICATION FOR MEMBERSHIP

Gentlemen:

I hereby make application for membership in the Society of Plastics Engineers, Inc. on the basis of my training and experience given herewith. I wish to affiliate with the _____ Section. (Geographical Location)

I certify that the statements made in the record of my training and experience are correct. I agree, if elected, to be governed by the Constitution, By-Laws and Rules as long as my connection with the Society shall continue. I agree to promote the object of the Society as far as shall be within my power.

Date of application. _____

Signature in ink. _____

REFERENCES

The By-Laws require the names of three men who are familiar with your work. One of them should be a member of the Society. Assistance in providing member references when needed will be provided on request to National Office or Section.

1. _____ Address _____
2. _____ Address _____
3. _____ Address _____

ADDRESSES—Please print or type

Applicants Full Name _____

Please fill in both addresses and check one to which mail should be sent. (Advise immediately of any change)

☐ Business: Company Name: _____

Street No.: _____ Street: _____ City: _____ Zone No. _____ State: _____

☐ Home. Street No.: _____ Street: _____ City: _____ Zone No. _____ State: _____

APPLICANTS: Do not write below this line on this side.

COMPLETE BOTH SIDES OF THIS APPLICATION

This Space For Credentials Committees Use Only	For National Office Use Only
(This Record must be completed by the local section)	
Report of Application to Nat'l. Office (Blue Copy) Date _____	Initiation Fee Rec'd. _____
Submitted to Section Credentials Committee Date _____	Application Ackn. _____
Years of credit given for: _____	Elected as _____
Education _____	Section _____
Experience _____	Number _____
Total _____	Date processed _____
This man is classed as a: _____	Remarks _____
_____ Senior Member	
_____ Associate Member	
_____ Junior Member	
_____ Student Member	
_____ Date _____	
Signature of Chairman Section Credentials Committee _____	
Approved by Section Board of Directors, Date _____	
_____ Signature of Section Secretary _____	

_____ Signatures of National Credentials Committee _____	

OVER

Record of Training and Qualifying Experience

(Please type or print information)

Full Name _____ Birthplace _____ Citizen of _____ Birthdate _____

RECORD OF EDUCATION

Technical education and the holding of a degree are NOT necessary to qualify for membership, however credit will be given on the following basis in lieu of, and in addition to qualifying experience: Doctorate in technical subject - 5 years; Masters in technical subject - 4 years; Other in technical subject - 3 years; Other in non-technical subject - 2 years.

SCHOOL	PLACE	ATTENDANCE		MAJOR SUBJECTS
		FROM	TO	

Degree of _____ from _____ date _____

PRESENT OCCUPATION

Title or Position _____ Name of Company _____

Company address _____

Nature of work done by company _____

Explain in detail, the nature of your work and responsibilities _____

RECORD OF QUALIFYING EXPERIENCE

In the space below, supply complete record of past connections in detail. Describe duties fully and state briefly any important engineering work you have done. If space is not sufficient continue record on separate sheet of same size. Your proper classification depends greatly upon the clarity of your record of experience and the degree of technical knowledge or skill required.

DATES	NAME AND ADDRESS OF COMPANY	TITLE or POSITION	*RESPONSIBILITIES

PROFESSIONAL ACTIVITY GROUPS — CHECK ONE OR MORE OF PRIMARY INTEREST

- | | | | | |
|--|--|---|--|---|
| ☐ Casting and Plastic Tooling | ☐ Finishing | ☐ Metals for Plastic Molds | ☐ Plastics In Electrical Insulation | ☐ Standards for Reporting Properties |
| ☐ Extrusion | ☐ Forming | ☐ Plastics in Buildings | ☐ Polymer Structure and Properties | ☐ Thermosetting Molding |
| ☐ Fabricating | ☐ Injection Molding | ☐ Plastics in the Auto-motive Industry | ☐ Reinforced Plastics | ☐ Vinyl Plastics |

COMPLETE BOTH SIDES OF THIS APPLICATION AND MAIL WITH INITIATION FEE TO S.P.E. OFFICE