Plastics Institute of America, Inc.
A Non-Profit, Educational, and Research Organization

Proceedings
Technology Exchange Program

RECYCLINGPLAS VI—Conference

PLASTICS RECYCLING AS A FUTURE BUSINESS OPPORTUNITY

May 22–23, 1991
At the Mayflower Hotel
Washington, D.C.

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INTRODUCTION

The Plastics Institute of America has sponsored RecyclingPlas Conferences each year since 1986. These conferences have followed the rapidly expanding progress of plastics recycling as the base for new business ventures. The 6th RecyclingPlas held in May, 1991, demonstrated the importance of two newer directions for these ventures: waste plastics derived from automobiles, and secondly, the commercialization of technology for the chemical conversion of plastics to monomers or to hydrocarbon feed stocks for the production of new monomers. Both of these directions also show the increasing level of technology being brought to bear to solve complex recycling problems.

Five papers in the opening session of the conference are devoted to various aspects of automotive plastics, two of which cover the major thermoset plastics in automobiles (sheet molding composites (SMC) and polyurethanes) and the third describes a process to recover useful plastics from the "fluff" remaining from automobile shredding operations to reclaim steel. We can expect many years of development ahead for automotive plastics but the movement has certainly begun.

The presentations on the chemical conversion of waste plastics (so called "tertiary recycling") are especially significant in their broad scope. The conversion of PET bottle waste to new PET, or to unsaturated polyester resins are now commercial operations. For polyolefins back to hydrocarbon feed stocks, the operation of a prototype plant in Japan is described and the possibilities are explored for using existing petroleum refineries in the U.S.

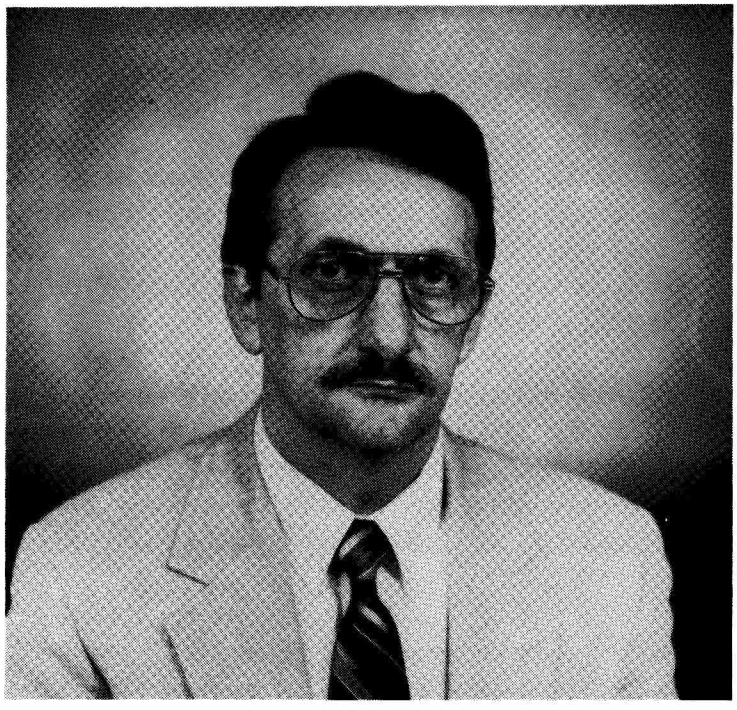
Businesses based reclaiming PET or HDPE bottles have reached a high level of maturity but many other packaging areas using multilayers, polystyrene, PVC and polyethylene film still face difficult collection and recovery problems. A number of the papers in the proceedings deal with these aspects.

Michael J. Curry

Michael Curry
Program Chairman

William Sacks
Executive Director

RECYCLING SMC (SHEET MOLDED COMPOSITES)



Arthur J. Stanley
Trans Plastics, Inc.

BIOGRAPHY: Art Stanley is Manager of Technical Services for Trans Plastics, a SMC molder supplying the automobile industry, and also serves as Chairman of the Technical Committee of the SMC Automotive Alliance --- a consortium of SMC molders and their suppliers.

ABSTRACT: SMC usage is expected to nearly double over the period of 1990 - 1995 to over 400 million pounds per year. This growth is predominately due to SMC's overwhelming acceptance as durable, corrosion resistant products which offer weight savings that result in improved fuel efficiency. But growth also brings the question of responsible disposal and recycling potential.

The SMC Automotive Alliance recognizes a responsibility for product stewardship and has sponsored extensive programs to develop viable recycling methods. These programs and initial economic projections will be discussed.

RECYCLING SHEET MOLDED COMPOSITES (SMC)
RecyclingPlas Conference, May 22,23, 1991

Art Stanley
SMC Automotive Alliance
Trans-Plastics, Inc.

Editor's Note: Following is a list of slides shown by Mr. Stanley during his lecture. For more information please contact him at Trans-Plastics, Inc., 333 Gore Road, Box 687, Conneaut, Ohio 44030.

Slide 1 Title

Over the past two years, the SMC Automotive Alliance has been sponsoring work on the recycling of Sheet Molding Composite or SMC. The member companies (major domestic SMC molders and their raw material suppliers) accept their responsibility to help the industry develop environmentally sound recycling technology.

Slide 2 SMC is--

SMC IS RECYCLABLE

Slide 3 Outline

Why recycling SMC is important.
Some details of what, we feel, are the 2 most promising recycling technologies: Regrinding and Pyrolysis
Properties of composites containing recycled SMC and some of the economics of recycling

Slide 4 Lift Gate

Thermoset composites are coming of age. This is clear when we look at some current applications such as:
Jeep Cherokee/Bronco lift gates

Slide 5 Lift Gate

The lift gates on Aerostar vans

Slide 6 Fender

4 x 4 Fenders

Slide 7 APV

and several body panels on the GM APV van

Slide 8 Bumper

There are also structural components such as: the Ford/Mazda bumpers

Slide 9 Leaf Springs

Slide 10 Wheel and the Motor Wheel

Slide 11 Why RCY Growth

Why recycle SMC. First, SMC is presently enjoying a high growth rate.

Slide 12 Graph

As this slide demonstrates, the volume of SMC used is expected to nearly double over the period of 1990 to 1995 to over 400 million pounds per year. This is probably overstated since the survey was prior to current economic slump, but growth also brings with it the question of responsible disposal and recycling.

Slide 13 Why Recy. Tipping

As the volume of SMC increases and the SMC, already in service in the transportation market, reaches the end of its life cycle, the volume of SMC being disposed of will also increase. It is projected that in the year 1995 some 100 million pounds of SMC will be discarded. This increase occurs at the same time as we experience a reduction in the number of landfill sites and significant increases in tipping fees.

Currently auto dismantlers and scrap dealers see plastics as a burden rather than a valuable part of the automotive recycling business... and we need to maximize the recyclability of all the automotive components.

Slide 14 SMC FORMULA

The SMC composite consists of a blend of calcium carbonate filler, fiberglass reinforcement, unsaturated polyester resins, low profile additives to give surface quality, and other processing additives. The polyester is crosslinked in a polymerization reaction with styrene. This gives the high strength, environmentally stable composite.

Slide 15 Flow Diagram

We have developed this flow model for the disposition of scrap SMC. The key point concerns how "clean" the SMC is. If the SMC is not mixed with other materials then regrinding is the preferred recycling technology.

On the other hand if the SMC is present in a mixed stream with other materials such as thermoplastics, other thermosets, large amounts of adhesives, or even as part of automotive shredder residue or fluff, then pyrolylsis may be the best approach.

Slide 16 Regrind Processes - 1. Regrinding

The regrinding technology involves size reduction of the SMC part to give a new raw material that consists of a combination of fiber and filler or milling all the way to a filler. Once reduced in size, the SMC can be formulated into Bulk Molding Compound (BMC) or SMC and reused in thermoset composites. There is also the potential to use it in other applications.

Slide 17 Shred

The first step in regrinding and reuse of SMC is shredding.

Slide 18 Feed Machine

Using shredders like the one pictured here, full sized SMC-parts are processed.

Slide 19 Blades

The shredder uses low speed, high torque cutting discs to conver the SMC parts ---

Slide 20 Product

--- to narrow strips, about 2 inches wide by 4 to 10 inches long.

Slide 21 Granulate

Following shredding, granulation is carried out.

Slide 22 Nelmor

In granulation, the shredded SMC is fed into a granulator such as this 25 HP model. Using an angled knife bed and ---

Slide 23 Nelmor Blades

---rotary knives, the shredded material is cut in a scissors like fashion to give ---

Slide 24 Product

a blend of free fiberglass fibers, milled polyester resin, and calcium carbonate filler that can be reused as a fiber reinforcement and filler in composites.

Slide 25 Micrograph

Under magnification the fibrous and filler-like nature can be more readily seen.

Slide 26 Milling

Milling can then be used to further reduce the granulated SMC particle size - if desired ---

Slide 27 Milled Product

This material has been processed through an air swept mill to give a free flowing, small particle size filler that can be used to replace calcium carbonate.

Slide 28 Compound

In the compounding step, the granulated SMC was formulated into BMC as a partial replacement for both glass and filler. In SMC, the milled recycled material replaced part of the filler. Standard mixing and molding equipment was used for both the BMC and SMC compounds.

Slide 29 Properties

To determine properties of the composites, test plaques were molded out of the various BMC and SMC formulations and a number of important properties determined.

Slide 30 Table 10% BMC

This table shows properties obtained from a BMC formulation in which 10 percent granulated SMC was used. As you can see, there is a fall off in properties vs. the control on the right (EXAMPLE) but substantial strength is maintained.

Slide 31 Table 70% BMC

Replacing all the virgin glass and filler in the BMC formulation, as shown by the data in this slide, has the biggest effect on properties.

But I think the real "take home" message here is that the granulated SMC is a different raw material. With optimization of a BMC formulation it should give predictable engineering properties that may be adequate for many applications at a potentially lower cost.

Slide 32 Table 10% SMC

The use of 10 percent recycled SMC milled down to filler particle size in an SMC formulation was also studied. When compared to the control data listed on the right, mechanical properties are equivalent. Milled SMC may be a direct replacement for calcium carbonate filler.

Slide 33 Application

Some practical application for these formulations were also investigated.

Slide 34 Tire Stop

This parking lot tire stop is made from a BMC compound containing 30 percent resin and 70 percent granulated SMC. It weighs some 70 pounds if molded solid and about 40 pounds with a 1 inch wall. The weight of a standard concrete version is well over 150 pounds.

Slide 35 Van Cover

In this prototype van engine cover, recycled SMC was used to replace about 20 percent of the calcium carbonte filler. The recycled SMC was milled down to filler size then formulated as a direct replacement for the calcium carbonate ---

Slide 36 Door Inner

This sports car door inner panel was also made using milled recycled SMC

Slide 37 Pyrolysis

Pyrolysis of scrap SMC is the second technology that the Auto Alliance has explored. As this diagram indicates, pyrolysis is the thermal decomposition of

material in the absence of oxygen. Organic materials evolved from the process such as pyro-oil and pyro-gas can be collected and used as fuel.

Slide 36 Incineration Diagram

Incineration (in contrast to pyrolysis) is where the organics are burned off in the presence of oxygen.

Slide 39 Pyrolysis of SMC

The key concepts for pyrolysis include:

size reduction as required to feed the pyrolysis unit

recovery of gas and oil from the degradation of the organics in the SMC

Reuse of the inorganic solid residue in thermoset composites such as BMC or SMC

and potential for the use of the solid residue in other applications.

Slide 40 Shredding

The first step is identical to the regrinding operation - shredding

Slide 41 Process

This is followed by the actual high temperature oxygen free, pyrolysis operation.

Slide 42 Pyrolysis Unit, WA

Pictured here is a continuous pyrolysis unit located in the state of Washington. It was used to process considerable quantities of SMC

Slide 43 Product Recovery

The next step is recovery of the products

Slide 44 Flask of Oil - These include the pyro oil

Slide 45 Gas Burner

Pyro gas shown here being burned to sustain the pyrolysis

Slide 46 PSBP and the solid residue

Slide 47 Mix of Product

The pyrolysis yields about 30 percent gas and oil and 70 percent solid byproduct.

Slide 48 Milling

The solid residue has been milled to filler for further use.

Slide 49 Milled Product

It gives a black, free flowing small particle size material.

Slide 50 Compound

The milled pyrolyzed SMC was compounded using standard SMC equipment and formulation.

Slide 51 Properties

Properties of SMC made from the pyrolyzed product are summarized on the following slides.

Slide 52 Tensile 10, 30% SMC

Mechanical properties for SMC using both 10 and 30 percent milled pyrolyzed SMC are comparable to the control data on the right.

Slide 53 Adhesion 10, 30 % SMC

Adhesion testing also gave results within the range of standard material.

Slide 54 Loria

These Loria numbers also indicate that the surface of the recycled SMC is comparable to a Class A SMC formulation.

Slide 55 Applications

Applications include prototype parts made using the milled pyrolyzed product in many of the same parts shown in the earlier slides.

The data and prototype applications demonstrate that both regrinding and pyrolysis followed by milling are technically viable recycling technologies. They give raw materials that can be reused in composites.

Slide 56 Economics

A final, but very important question is the economics of recycling. As we all know "Nothing happens until someone buys something". In other words the products of recycling must have a cost/benefit ratio of value to the customer.

We have put together an elaborate Lotus cost model that is capable of predicting the economics of recycling SMC.

Slide 57 Regrind Cost Model

The model is based on a stand alone operation processing some 12 million pounds per year of input SMC scrap. The major product produced is milled material suitable for use as filler. Byproducts may include scrap ferrous metal. For the regrinding process the major equipment required includes shredding, metals separation, granulation, and milling at an estimated cost of $320,000. Total investment including building, and other items is about 1/2 million dollars.

An additional variable used is the tipping fee. This is the price charged to the SMC scrap source to drop off his material at the recycling operation. It is a source of income to the recycling operation. A second variable is the selling price of the scrap metal recovered from the SMC. And finally, the last variable is the selling price, the price a customer is willing to pay for the milled SMC.

Four cases were studied:

Case 1 represents a typical set of costs that might be found today. These include a $60 per ton tipping fee, 25 cents per pound selling price for the ferrous scrap, and 6 cents per pound for the milled product. Using these values a net profit in Case 1 of about $32,000 is calculated for a total investment of $500,000. When tipping fees increase, let's say to $90 per ton as in Case 2 --- or the milled SMC can command a price higher than calcium carbonate (as in case 3 or 4) the profit increases.

Slide 58 Pyrolysis cost model

A similar analysis for pyrolysis is shown here. The investment for the pyrolysis unit makes the total capital required significantly higher than the regrind approach.

This analysis includes the value of the pyro oil generated in the process at 26 cents per gallon. Due to the capital investment this analysis shows a profit when tipping fees increase to $90 per ton and the milled solid product is priced at 11 cents per pound as shown in Case 1.

Slide 59 Conclusions

SMC IS RECYCLABLE - Two processes have been demonstrated that can lead to reuse of the SMC in new composites.

Regrinding is the favored process for "clean" scrap -- that is SMC not seriously contaminated with other materials.

Pyrolysis is the favored process for "mixed" scrap.

Today, the value of the recycled product as a filler and/or reinforcement vs. current landfill cost, drives the decision to begin recycling SMC. Legislation or public pressure could drive that decision tomorrow.

Slide 60 Summary

The SMC Automotive Alliance and others in our industry have demonstrated that SMC is recyclable and are developing economically and environmentally sound recycling methods and potential markets.

Slide 61 SMCAA LOGO

Co-authors George Hartt, Chuck Cucuras and Art Flax

SMC AUTOMOTIVE ALLIANCE

Proposed Recycling Facility