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Reinforced Nylon Rocker Arm Cover

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ABSTRACT

The 1981 AMC OHV 6 cylinder engine for passenger cars is the first to use glass and mineral reinforced nylon 66 for an engine rocker cover. The rocker cover design uses a novel attachment system and RTV silicone sealant. Vydyne® R-400G nylon resin was developed by Monsanto for this engine application.

The paper will discuss the development program from both a material and a part performance viewpoint. Material performance will be reviewed including physical property data and specific "under-the-hood" test data. Part performance results ranging from dynamometer testing, test track and fleet testing to initial production start-up will be reviewed.

THE USE OF PLASTIC MATERIALS in automotive components has more than doubled in the past decade, reaching the 200 pound per car level in the 1980 model year. Previous usage of plastics has concentrated on decorative trim applications. The new opportunities for plastics are in functional applications. Several engine parts, like distributors, fans, radiator end caps, and oil pans are being tested now. The materials being tested are much more than simple resins. They are actually engineered polymer systems, often incorporating more than one type of reinforcement in an engineering thermoplastic matrix.

The use of Vydyne®R-400G glass/mineral resin by Monsanto Company in the American Motors Corporation OHV 6 cylinder engine rocker arm cover is one of the success stories of the functional applications in the 1981 models. This rocker arm cover is the largest plastic rocker cover ever molded, and the first to be molded in glass/mineral nylon. It is currently in production on the 1981 model AMC Concord®, Spirit®, Eagle® and Jeep CJ® series vehicles equipped with 6 cylinder engines.

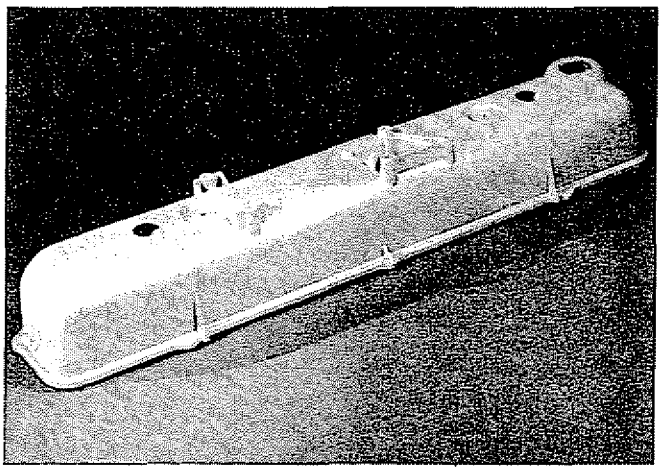

Fig. 1

The use of the glass/mineral reinforced nylon rocker arm cover was one of several recommendations in a program AMC developed to take 100 pounds out of the engine. The cast iron block was lightened by reducing wall thicknesses, and several components like the intake manifold, oil pump, and water pump were converted to cast aluminum from cast iron. Several materials were considered for the rocker arm cover, including cast aluminum. The use of Vydyne® R-400G resin allowed many of the bosses and brackets for engine wiring to be molded on the part. With a metal part, these fastening devices all had to be manufactured separately and welded on. In addition, the nylon cover doesn't radiate as much heat or transmit as much noise as a metal cover, and from a design and engineering standpoint, the tooling costs were less.

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The final design cut the part weight from 3.91 pounds down to 1.96 pounds, a 50% weight savings. A formed-in-place silicone gasket replaced cork for metal covers several years ago, and is used with this cover also.

The rocker arm cover development program spanned a two and one half year period, evaluated several materials in a total of three prototype injection molds, and required thousands of hours of testing on engine test stands, test track trials, and fleet cars.

MATERIAL SCREENING

The initial material screening in the laboratory was aimed at finding materials that had sufficient heat resistance and chemical resistance to gasoline, oil, and miscellaneous engine fluids at typical engine compartment conditions. That means temperatures of 250°F with peaks up to 400°F. Physical property retention under these test conditions was checked. Reinforced grades of nylon and polyester were selected for the part testing program.

The first mold was made early in 1978 as a simple duplication of the existing steel cover. The mold was a single cavity, cast Kirksite tool, and included water cooling and ejector pins to simulate production mold conditions. This tool was used for the initial material screening runs, but was quickly outdated as the new engine block required significant design changes in the rocker arm cover.

A variety of engineering thermoplastics were evaluated in the first state of testing.

Glass/mineral reinforced nylon 66
Mineral reinforced nylon 66
Glass reinforced nylon 66
Glass reinforced polyester (PBT)

The mineral reinforced nylon was eliminated following the molding run. The high mold shrinkage of this material resulted in a part too small to fit on the engine. The relatively low modulus of mineral nylon compared to glass reinforced products was also judged to be marginal at best. Of the three remaining products, the glass/mineral nylon was the flattest, while glass reinforced nylon and glass reinforced polyester had some molding warpage. Nonetheless, covers molded from these resins were bolted to the test stand engines, and the dynamometer tests were underway.

DYNAMOMETER ENGINE TESTING

The dynamometer testing is designed to stimulate in the lab the engine performance under several driving conditions.

The Durability test is a 300 hour test in which the engine speed varies from about 1500 rpm's to 4000 rpm's with a standard load while numerous engine indicators like oil pressure, water temperature, and exhaust temperature are checked. Normal maintenance is also done periodically.

The Wide Open Throttle test runs the engine at a wide open throttle and cycles from a high to low engine rpm every 4 minutes by changing the load on the engine. The load stimulates conditions of a fully loaded automobile traveling alternately on level ground and up a steep incline. This test is considered severe for both vibration and heat build up. During this test, the exhaust manifold glows red hot less than one inch from the cover.

Three of the five glass reinforced covers leaked oil after only a few hours into the Durability test. They were removed, cleaned, and resealed with new silicone. They were dropped from the test after leaking a second time.

The covers made of Vydyne® R-400G glass/mineral nylon resin passed both tests with no leakers. Covers used on the Wide Open Throttle test were returned to Monsanto's laboratory for a check on the material properties after the chemical and heat exposure of actual engine conditions. No unexpected change in properties was observed, even in areas adjacent to the hot manifold.

PROTOTYPE MOLD WORK

A second prototype mold was built in late 1978 to incorporate some of the design changes in the engine. While used for several molding studies, little engine testing was conducted. Continuing design changes in the engine rocker arms resulted in some clearance problems. A new cover design was undertaken replacing the seven flange bolts with a two point attachment.

The third prototype mold was ready in early 1979. The five side bolt holes were replaced by locating studs, with the cover being bolted down through the top. A bracket to support a control valve, and several reinforcing ribs were added at this time.

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One additional design feature came from a need to develop a better removal procedure. Three reinforced pry-off locations were incorporated into the flange. This allows a simple wedge effect to break the silicone bond and pry the cover loose from the block.

VEHICLE TESTS

Covers made of Vydyne® R-400G resin were tested on a variety of vehicles as part of the normal engine testing program. Local Detroit area cars were used as the initial test fleet. High speed testing was conducted at Michigan International Speedway. As confidence grew, testing was expanded to fleet and track tests for California emissions, Arizona heat soak, Canadian cold temperature, and special endurance runs and Yuma. The cover utilizing Vydyne® R-400G nylon resin passed all these tests with excellent results.

Laboratory tests were also performed on covers returned from the fleet tests. Some covers discolored, particularly in areas close to the exhaust manifold. The discolored surface layers were carefully scrapped off and tested. No evidence of thermal degradation of the polymer was noted.

PRODUCTION START-UP

Quality assurance is an important part of the rocker arm cover production. At the molding machine, all parts get checked for flatness around the periphery. After the baffles are sonically welded, both baffles are checked for impact. They must pass a 15 inch pound falling weight impact test. One cover from each run is put through a stringent thermal cycle test. The cover is secured to an engine head simulator with 25 inch pounds of torgue. It is then subjected to five thermal cycles consisting of three hours at 250°F, three hours at -20°F, and a final half hour at room temperature. At the end of the fifth cycle, the cover must be functional and not leak. Another routine test measures the flatness before and after a 2 hour heat soak at 250°F. The difference in flatness must be less than 0.007 inches.

Covers are then sent to Kenosha, Wisconsin where the engine is assembled. Each assembled engine undergoes a brief check by running the engine on a test stand for about 10 minutes. The hot engine is then checked for leaks by pressurizing the engine and noting any unusual decay in the pressure. The rocker arm covers made of Vydyne® R-400G resin are performing at a leaker rate of less than 1% which is fully comparable to the metal covers.

PRODUCTION FINE TUNING

In spite of thousands of hours of testing, full scale production proved to be a demanding test of the plastic cover. Several additional changes in both assembly line practices and part design were made in the first few months to insure performance at the desired levels.

On the assembly line, improved head cleaning was needed to insure a clean surface for the silicone. The "open cure time" of the silicone on the covers was also adjusted to improve the sealing characteristics.

A few part changes included the addition of ribs to the ends of the cover an improvement in the mechanical fit of the mounting studs, and a change in the silicone groove to allow for a larger sealing surface.

The procedure for calibrating the engine pressure testing was improved when variations in the test pressure were found to cause sporadic leakers.

SUMMARY

The glass/mineral nylon rocker cover has been in production for close to one full year. Several start up problems were corrected, and the cover is now performing well. The single most important characteristic of the cover's performance is the "leaker" rate. The covers made of Vydyne® R-400G resin are performing at leaker rates less than 1%, and as good if not better than the metal cover used on the prior model.

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