REGIONAL TECHNICAL CONFERENCE

"Multiple Shot, Insert, and Co-injection Molding"

October 23 and 24, 1991

Holiday Inn Crowne Plaza

2855 N. Milwaukee Ave.

Northbrook, Illinois

Co-sponsored by

Society of Plastics Engineers

Chicago Section

Milwaukee Section

"Multiple Shot, Insert, and Co-Injection Molding"

Regional Technical Conference of the Society of Plastics Engineers
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KEYNOTE ADDRESS
BY
H. L. "JACK" CLAYPOOLE
CLAYPOOLE CONSULTANTS

CASE STUDIES IN PRODUCT AND PROCESS DEVELOPMENT AT THE ROGAN CORPORATION.

The Rogan Corporation is a proprietary injection and compression molder and decorator of primarily instrumentation knobs. We manufactured and sold direct over 14,000 different plastic knobs.

When I started in 1984, we were primarily an insert molder, but now do two shot molding and have developed and purchased bi-component molded parts.

Two case studies will be presented, one involving two shot molding and the other, bi-component or co-injection moldings. The paper will cover the following:

1. Origination of products
2. Development of product and process
3. End Result
4. Pitfalls and benefits of this development process

DEVELOPMENT PROCESS

I. Two-shot molding.

The concept of the product originated, when Hartley Peavey, owner of Peavey Electronics, Meridian MS, suggested to our owner Ed Rogan, that he would like a knob that had a soft rubber feel like a pen he had just received. Peavey Electronics purchased in excess of five million knobs per year from Rogan. They are probably the world's largest manufacturer of commercial "sound mixers" which contain several hundred knobs. In addition, they produce amplifiers, speakers, guitars, etc. for the entertainment industry. When Peavey spoke, we listened, as they were our largest single customer. We proceeded to attempt to satisfy their request, as no such knob was currently available.

The initial effort was to contact the pen company who advised that the pens were made in Japan. Contacting the Japanese and getting information from them proved to be an exercise in futility. However, I was informed that the rubbery material was a Thermoplastic Rubber. Additional research resulted in discovering "Santoprene", produced and sold by Monsanto. It had first been introduced by Monsanto in October, 1981.

Since the pen was obviously molded utilizing the two-shot process and since we lacked that capability, I decided to search for a custom molder who had two-shot capability and experience. The plan was to have a custom molder guide us in piece part and mold design, develop the process, and mold initial production quantities. Then, once we had a viable product acceptable to our customer, we would purchase the necessary machinery and equipment to produce parts ourselves.

The search started with two-shot molding machine manufacturers and ended by finding only two custom molders in the Chicago area that had two-shot machines. We picked the molder whom we felt had the most experience and expertise in two-shot molding, namely - Lewis Plastic, owned and operated by Bob Petrus.

From our piece part design, Lewis Plastic proceeded to have the mold and rotating device designed and built by one of their outside mold makers. This solved another problem by immediately finding a mold maker with two-shot experience. We only built cavities for one knob in order to prove the design and concept. However, remember that two-shot molding requires two cavities and cores, one for each material and one for color.

An interesting side light was our decision to use ABS as the base or first shot material, as virtually all of our other knobs were made from ABS. Because of the lead time for custom color concentrates and to satisfy our customer's requirements for both delivery in several special colors, we immediately ordered some $5,000 worth of color concentrates. It took only our first shot to realize that ABS would not be satisfactory. Santoprene is an olefin base which did not react with the ABS at all. Thus, we had no adhesion of the two materials. The knob design did not permit any type of mechanical interlock, so we were forced to change to polypropylene. Fortunately, the knob was small enough and not dimensionally critical, except for the core, that the shrink difference affected only the core pin. However, not so fortunately, $5,000 of color concentrates were eventually scrapped. This cost was eventually recovered by the significantly lower cost of polypropylene.

The project proceeded from there with no more than the usual mold development problems. Short shots and flashing of the TPR second shot were our major problems. The requirement for very accurate shut-offs of the second shot presents the largest single problem peculiar to two-shot molding. We added additional cavities and the molder ran production for us until we had ordered and received our own machine.

In the next three years, Rogan designed, tooled and developed more than fifty different "pure touch" knobs plus some two-shot knobs of the same material but different colors. In addition, we purchased two additional two-shot machines. We were the only knob manufacturer to offer, as a catalog item, a knob with a soft exterior. Peavey Electronics converted almost 100% and have purchased several million such knobs. This new product and capability enabled Rogan to retain the Peavey business and was and continues to be an outstanding success story.

II. Bi-Component or Co-Injection Molding of a Ball Knob.

The origination of this product resulted from an analysis of the knob market, resulting in the fact that our sector of the market was shrinking. Since knobs were Rogan's only product, we decided to expand our product line. One of the products selected was a series of industrial "Ball" knobs which had sales of over one million dollars per year.

The competition was all in compression molded phenolic. Although we had this capability and actually produced a line of compression molded knobs, we could see no economic advantage in copying our competition who had been in the business for many years. Therefore, we felt we had to offer something new and different to the market place. In addition, it was a highly competitive market from a pricing standpoint.

Since the largest ball with decent sales potential was initially felt to be 2-3/8" in diameter, I could not see conventional injection molding as being the answer for the following reasons:

1. Excessive machine cycles due to wall thickness of up to 1" and inherent cooling problems.

2. Excessive shrink due to both the mass and the economic need to use high shrink polypropylene. It was mandatory that we produce a truly round ball.

Considerable research led me to the co-injection process which was capable of producing a high finish skin with a foamed core. Investigation of machinery manufacturers led me to the Presma Corporation, an Italian molding machine manufacturer, who will be presenting a paper tomorrow. Presma offered what appeared to be the perfect solution in the form of molding machines with co-injection capability plus a rotary clamp table.

After visiting several molders who operated Presma Rotary machines, I selected the only custom molder in the U.S. who was molding on a co-injection Rotary machine. They were new to the industry, were molding paint brush handles, and were located in the hills of northeastern Tennessee. In addition, they were more than willing to help us develop a line of ball knobs using the co-injection process.

Again, we followed virtually the same procedure as we used for the two-shot knobs. With their guidance on mold design, we had the initial mold built in Elgin, Illinois. I should add that our initial step, even before contacting molders, was to have Presma build and try out an aluminum prototype mold in Italy. This proved the concept to be viable, but not much more. The eventual development of both the mold and the process was quite extensive as both the molder and ourselves were treading on unknown ground.

The project was initiated in the fall of 1988, but it wasn't until April of 1990 that we actually completed the initial production tooling. This tooling consisted of seven four cavity molds and the original two cavity mold. By this time we had dropped the 2-3/8" diameter ball due to its being too difficult to mold plus having minimal sales potential. We ended up with five different sizes of balls from 1" to 1-7/8". The total of eight molds was a compromise of potential volume versus the economics of filling all ten stations of the molding machine.

Unfortunately, we received our first sales order shortly after receiving the production tooling. The order was for the 1-7/8" ball which was, by far, the most difficult to produce. In addition, we had yet to complete the tooling and process development of all eight molds. The end result, was that the simultaneous development and production of five different sizes of balls in eight different molds on a ten station machine proved to be insurmountable from a cost and quality standpoint. The quality problem was surface finish and integrity. Flow lines were an ever present problem. Remember, we were trying to duplicate a compression molded phenolic finish. The selection, after many trials of the proper polypropylene, resulted in an acceptable gloss.

Our only customer's requirements kept increasing to the point they taxed the vendor production capacity. As a result, we found ourselves in a "Catch 22" situation where we had to produce and had to run eight undeveloped molds to keep the production cost down. This results in creating an inventory of over 200,000 knobs which were 20% to 40% defective, with an expensive sorting cost.

Finally, the inability to solve the quality, cost and delivery problems resulted in a search for another vendor. We found one who also had a new Presma Co. injection rotary molding machine. However, they ended up producing our 1-7/8" ball from our four cavity mold using a conventional molding machine plus small amounts of chemical blowing agent. Quality, as well as yield, was significantly improved and it permitted us to only mold the 1-7/8" ball for which we had orders.

I should point out that this vendor in Maryland had years of experience in molding paint brush and similar handles, using blowing agents and conventional as well as rotary clamp molding machines.

In conclusion, I would like to summarize our approach to new Product and Process Development and briefly review its pitfalls and benefits.

1. Select a custom molder who has the required molding capability and technical expertise.

2. If you eventually desire to own your own process, be up front with your vendor as to your intent. Give them the opportunity to make a profit from the initial production runs as well as their development costs.

3. Have your technical personnel work closely with vendors to learn process and arrange for future training.

4. Have specific understanding as to quality, cost and delivery of timing requirements.

Potential Pitfalls

1. Vendor unwilling, or unable due to their own requirements, to put forth the required engineering and development effort. Very seldom, if ever, will you find vendors willing to expend their resources as you would your own.

2. Vendor lacks technical and/or production capability.

3. Can take much longer due to No. 1 above.

4. Vendor gives up before achieving completion due to little future potential profit or demands of their own business.

5. You lack full control of scheduling and quality.

6. Selling product before you have a viable product and process.

All of these pitfalls applied to the ball knob.

Benefits

1. Capital expenditures are not required until you have both a proven process as well as a viable product.

2. You acquire technical knowledge at a relative low cost.

3. Can shorten development cycle.

4. Does not interfere with your own production capacity.

In Rogan's case we did not buy two-shot molding machines until we had firm orders and a viable process we felt comfortable with. They now have three two-shot machines.

We avoided the expenditure of several hundred thousand dollars for a co-injection rotary molding machine to produce the ball knob.

Session I

Insert Molding

INSERT MOLDING

IMPROVEMENT OF PROPERTIES & COST REDUCTION

INTRODUCTION:

Insert molding combines favorable properties of plastics with different materials. In the insert molding process, typically a non-plastic component or "insert" is located in an open mold before the molding cycle.

After closing the mold the plastic "melt" is injected into the mold and around the insert. The mold controls the amount of encapsulation creating an integral assembly approaching one piece construction. Properly designed and manufactured insert molded products can give superior properties over alternate products and at the same time give cost reduction.

Insert molding can be looked upon like a marriage. Combine two different entities or materials for the purpose of creating a good union, however, if some incompatible factors are joined, LOOK OUT. They each react to each other and they react differently to stress during their life cycle.

Let's look at some advantages, disadvantages, and design factors in our search to realize improvement of properties and cost reduction.

ADVANTAGES:

A) FASTENING METHODS. Insert molding threaded fasteners can significantly improve mechanical properties of a molded plastic product. Consider the following factors with insert molded metal fasteners:

1) higher torque loads,
2) higher pullout loads,
3) metal inserts have closer tolerances of threads than plastic,
4) ability to repeatable reassemble a product without as rapid a loss of above properties compared to an all plastic part.

The advantages of insert molding fasteners have been known and used since the early days of plastics molding. Included in my display of insert molded items is a housing molded over forty years ago. It shows screw machine fasteners still molded solidly in place.

B) ELECTRICAL & ELECTRICALLY INSULATING PROPERTIES. Terminals are molded for electrical applications. The terminals are anchored in plastic for subsequent assembly, soldering and end use. An added advantage is that the terminals are sealed from allowing the passage of liquids, vapors, and gases areound the molded border of the insert. Popularly used inserts are often made from metal stampings, screw machine parts, wires, pins, or other electrically conductive components. Some applications include circuit boards, plugs, connectors, and wire harnesses.

C) COMBINE TWO HIGH LOAD-BEARING PARTS. Examples are, a tool to a handle, or a gear to a shaft. An early success story of this was years ago when screwdrivers were insert molded with a cellulosic plastic that served as the handle. The plastic tolerated repeated misuse of being pounded by a hammer without fracturing. The plastic was superior to the wood formerly used. The toughness of plastic was combined with the strength of steel. Another example used for years has been the automotive steering wheel.

D) FRAMEWORK FOR WOVEN MATERIALS. Examples are strainers and filters. The pre-woven fabric used can be made from synthetic or metal materials. The plastic is designed to give a framework of a rigid or flexible frame.

E) HERMETIC SEALING. A more recent success story here is the example of semiconductors. Semiconductors that are insert molded are inherently hermetically sealed. Before insert molding, can diodes were hermetically sealed by a costlier process.

F) OTHER ADVANTAGES. In addition to advantages listed above consider the following when proper materials are chosen for insert molding:

1) improved mechanical strength,
2) improved toughness,
3) thermal factors,
4) chemical resistance,
5) colors with transparency ranging from clear to opaque,
6) the insert is encapsulated with a plastic which has a desirable "feel" for industrial and consumer use,
7) plastics can give weight reduction,
8) plastics can save on the cost of the insert by downsizing it to an optimum size for a standard of performance.

DISADVANTAGES

A) INITIAL COST. Often the up front investment in tooling and equipment is more expensive than alternate processes. Because of this high volume production may be required to meet a break-even point and realize a cost advantage over alternate processes.

B) STRESS CRACKING. Remember that the Coefficient of Thermal Expansion, CTE, is usually much more for plastic than for the insert. This brings us to a major problem for some insert molding, and that is stress cracking. When a plastic is molded around an insert the insert will act as some kind of shrink fixture. As the plastic shrinks stresses are created. This can be described as molded-in hoop stress. When this stress exceeds the yield point of the plastic the plastic will stress crack.

There are guidelines that can be used in evaluating this factor. Consult data books on a given plastic. Find the estimated mold shrinkage and flexural modulus for the material.

Shrinkage times flexural modulus equals stress.

Evaluate materials that give a lower stress factor. For example, by comparing published data of nylon and acetal, it can be determined that nylon is more stress crack resistant than acetal. Preheating inserts prior to molding may be required to compensate for the effects of CTE.
C) PERSONNEL. If insert molding is to be done semi-automatically, that is, with the use of press operators and assistants, personnel can make or break a job. Operators need special aptitudes, physical dexterity for handling inserts, and training to make this process work.

Fully automated insert molding requires technically trained and skilled personnel for set-up and maintenance of this sophisticated molding pro-