DIMENSIONAL REPEATABILITY CASE STUDY OF FOUR MOLDING PROCESSES

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ABSTRACT

The objective of this study is to compare the repeatability of four distinct molding processes: gas assist molding, structural foam molding, conventional open loop injection molding, and cavity pressure controlled injection molding. The resulting data from this study points to cavity pressure control giving most repeatable dimensions on the test parts. This information will help engineers in determining which process to use on their specific applications.

INTRODUCTION

Some of the many benefits of gas assist molding or structural foam molding vs. injection molding could include reduced part weight, reduced molded-in stress, less warpage, reduced sink marks, and greater dimensional stability. In some people's minds, these attributes are what would make these processes ideal for tight tolerance applications. A tight tolerance process, however, requires that the process be repeatable, above all other attributes.

The purpose of this study is to look at the repeatability of the gas assist process, and to compare it to well known standards such as cavity pressure controlled closed loop injection molding, conventional open loop injection molding, and structural foam molding.

In order to make a comparison of these four processes as close as possible, the same mold (with very minor modifications), the same machine and technician, and the same materials would need to be used for all processes. The determination of a process' repeatability would be its ability to produce consecutive parts with the same dimensions for a given material and process setup. Differences in a given part dimension between parts of different materials or processes would be of no significance. Standard deviation calculations within a run of parts, on a critical dimension, would be the only meaningful measurement of repeatability.

It is with these thoughts and assumptions that this study was conducted.

EXPERIMENTAL METHOD

Process Description: The first stage molding trial was conducted to set the base-line on repeatability with cavity pressure closed loop control and conventional open loop molding. Each material was run in the mold using processing conditions that were at the midpoint of the resin manufacturers recommended range. Injection, holding, and cavity transfer pressures were left to the judgement of the molding technician to provide the best possible parts. Since specific dimensions were not a criterion for quality, part appearance and lack of sink and flash were used to determine processing parameters. Each material was allowed to "cycle in" and stabilize before forty consecutive parts were saved for measurement.

The mold was then modified, to accommodate the structural foam and gas assist processes. The same drying, mold, and melt temperatures were used as in

the cavity pressure closed loop stage of the experiment. The technician was again allowed to set up the pressures and speeds on both the molding machine and Krauss Maffei gas unit to provide the best parts. Good bubble penetration was deemed to be achieved when two particular gas channels were fully hollowed out, but no gas blowout occurred in the part.

Because the flow lengths in the part were not of equal size, and because the runners and gates of the mold were not "fine tuned" for balance, the length of bubble penetration varied within the part. This was not considered to be a hindrance to the experiment inasmuch as it was the repeatability of the process that was of interest, not any particular dimension.

Once again, as in stage one, the machines were allowed to stabilize before forty consecutive parts were saved for measurment.

MOLD: The mold was an injection molding P-20 steel tool which produced a business equipment internal part approximately 19" x 14" x 6" with a nominal wall section from .160" to .200". A center sprue fed a runner system with six gates symmetrically placed within a center opening in the part. A Dynisco pressure transducer was placed behind an ejector pin which was located approximately halfway between the gate and end of flow. The mold was used in this configuration to perform the cavity pressure closed loop stage and the conventional open loop molding stage of the experiment.

For the gas assist and structural foam stages of the experiment, the mold was modified to allow the gas assist process to work. 3/8" diameter channels were added to various locations within the part to facilitate melt flow and gas delivery.

EQUIPMENT: A Krauss Maffei 1100 ton molding press with a 93 oz. barrel was the machine used for all stages of the experiment. It was equipped with MC3 controller which had the ability to transfer from 1st stage pressure to holding pressure when triggered by a cavity pressure signal. For the control of the gas, a Krauss Maffei gas unit was used. A Krauss Maffei gas nozzle was used on the barrel of the machine. This nozzle acted as a polymer melt shut off nozzle and as the gas delivery mechanism into the melt stream.

MATERIALS: 2 different amorphous materials were used in this experiment: (1) Noryl® HM3020 resin, a PPO® resin based material with a 30% filler content of fiber-glass and mica. (2) LGK-3020® resin, a polycarbonate based material with 30% filler content of fiberglass and mica.

MEASUREMENT: All parts molded for this experiment were allowed to stabilize at least four weeks before measuring. The measurement equipment used was a Sheffield® three axis coordinate measuring machine. All parts were fixtured to allow for three locator points (one in each axis) yet not induce any stress or movement of the part.

The parts were measured in the same order that they were molded. Various length and width dimensions were measured and recorded. X-bar and R charts were made from the resulting data so trends could be observed.

DATA AND OBSERVATIONS

Of all the dimensions available to be measured on this part, overall length, intermediate length and overall width were believed to give the most representative data on dimensional repeatability (Figure 1).

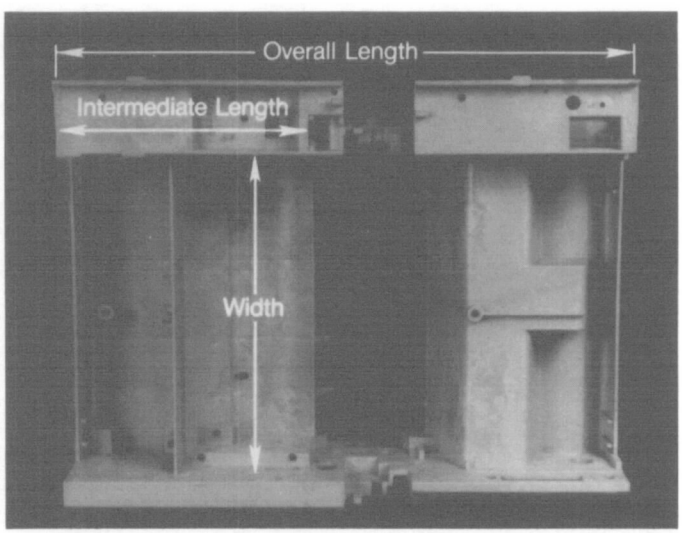

Figure 1

Standard deviation was used as the key indicator of repeatability, however, the total range of the measurements was also looked at.

The data below shows the standard deviation and range of the modified PPO® resin based material with 30% filler content of fiberglass and mica in each of the four processes (Table 1). This data is graphically represented in Figures II, III, and IV.

The data on the polycarbonate based resin with 30% fiberglass and mica filler is shown in Table 2. This data is graphically represented in Figure V.

RESIN "A"
(Glass/Mineral Filled, Modified PPO® Resin)

	CL	SF	GA	INJ	CL	SF	GA	INJ	CL	SF	GA	INJ
STANDARD DEVIATION	.0004	.0002	.0006	.0017	.0006	.0005	.0012	.0030	.0009	.0009	.0011	.0061
RANGE	.0013	.0007	.0037	.0076	.0021	.0021	.0069	.0135	.0037	.0039	.0043	.0273
	INTERMEDIATE LENGTH (IN.)				OVERALL LENGTH (IN.)				WIDTH (IN.)			

CL: Closed loop cavity pressure controlled injection molding
SF: Structural foam molding
GA: Gas assisted injection molding
INJ: Conventional injection molding

Table 1

RESIN "A"
Intermediate Length (in.)

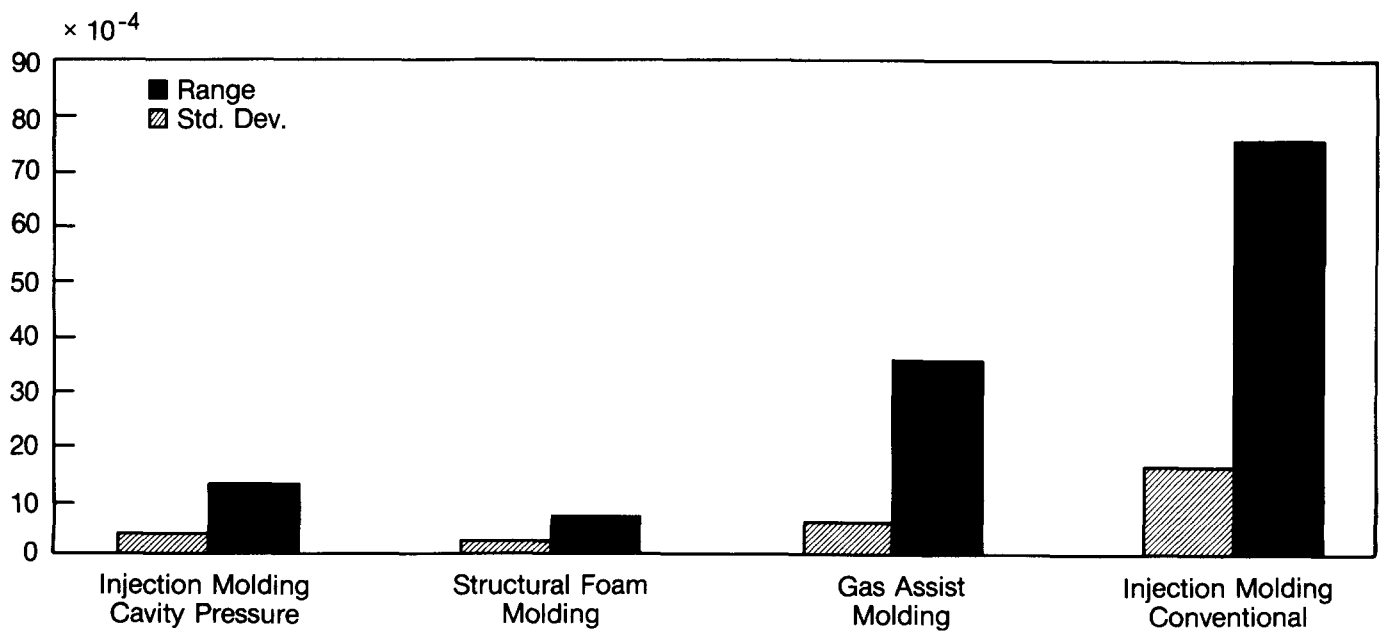

Figure II

RESIN "A"
Overall Length (in.)

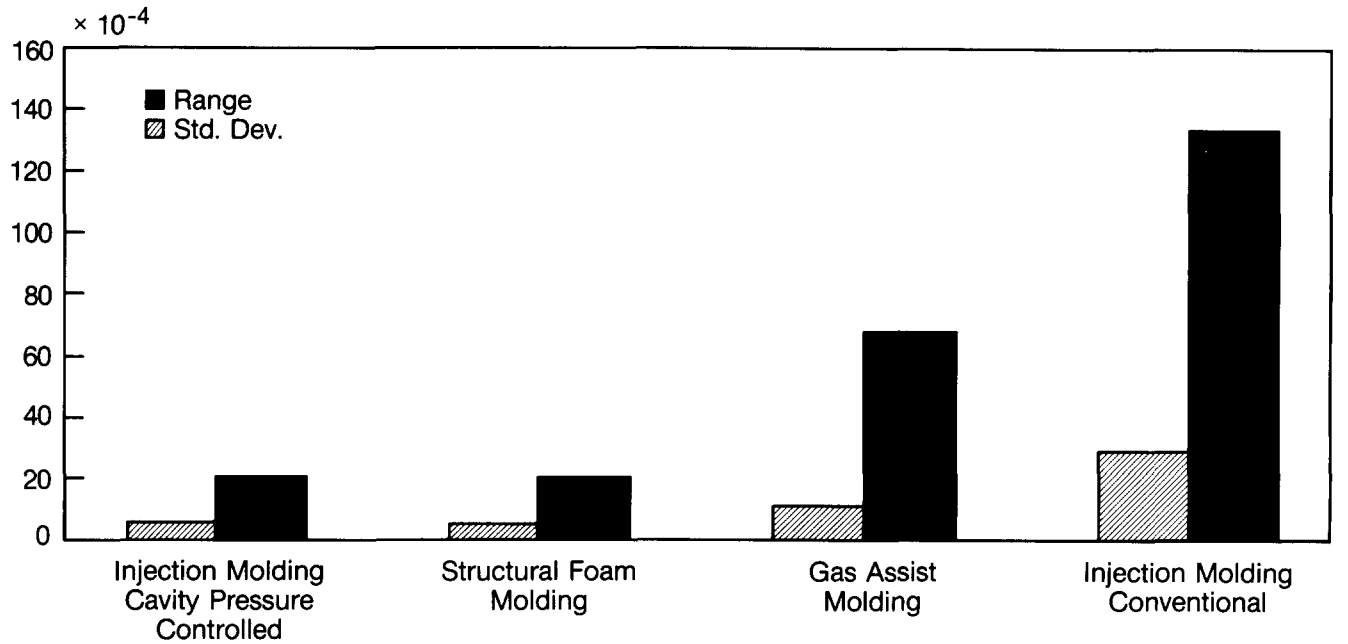

Figure III

RESIN "A"
Width (in.)

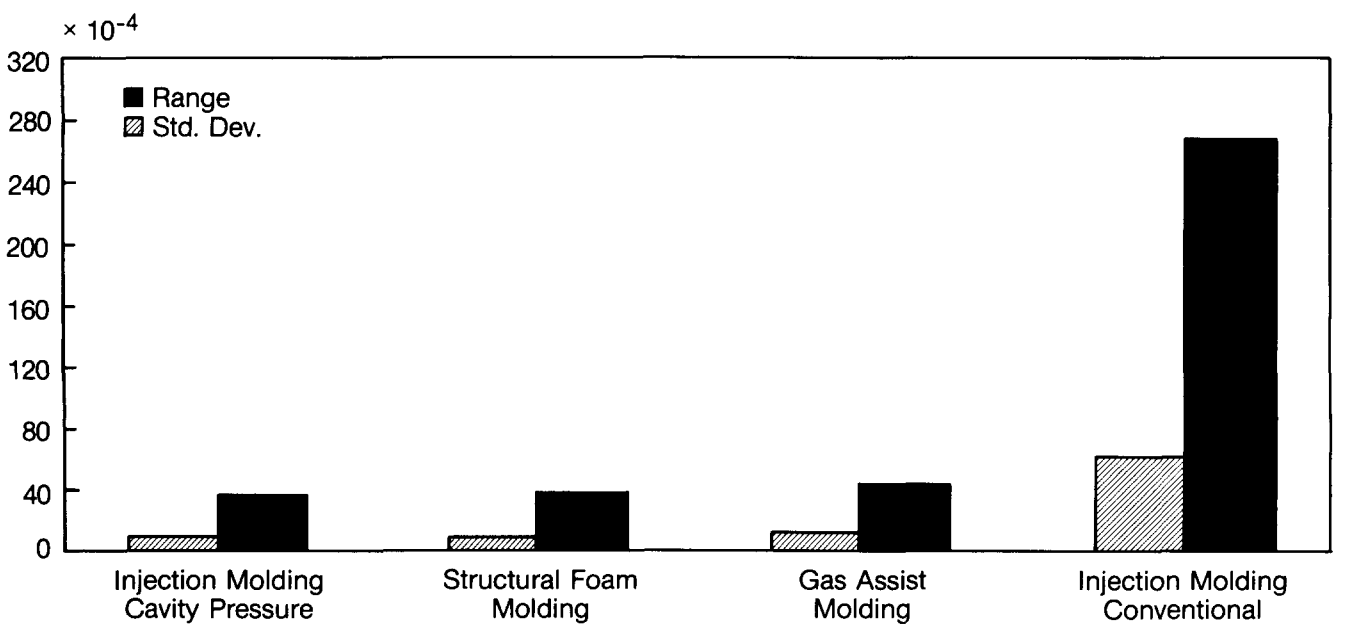

Figure IV

RESIN "B"
(Glass/Mineral Filled, Polycarbonate Resin)

	SF	GA	SF	GA	SF	GA
STANDARD DEVIATION	.0005	.0003	.0012	.0011	.0026	.0009
RANGE	.0017	.0008	.0047	.0036	.0138	.0028
	INTERMEDIATE LENGTH (IN.)		OVERALL LENGTH (IN.)		WIDTH (IN.)	

SF: Structural Foam Molding

GA: Gas Assist Molding

Table 2

RESIN "B"
(Glass/Mineral Filled Polycarbonate)

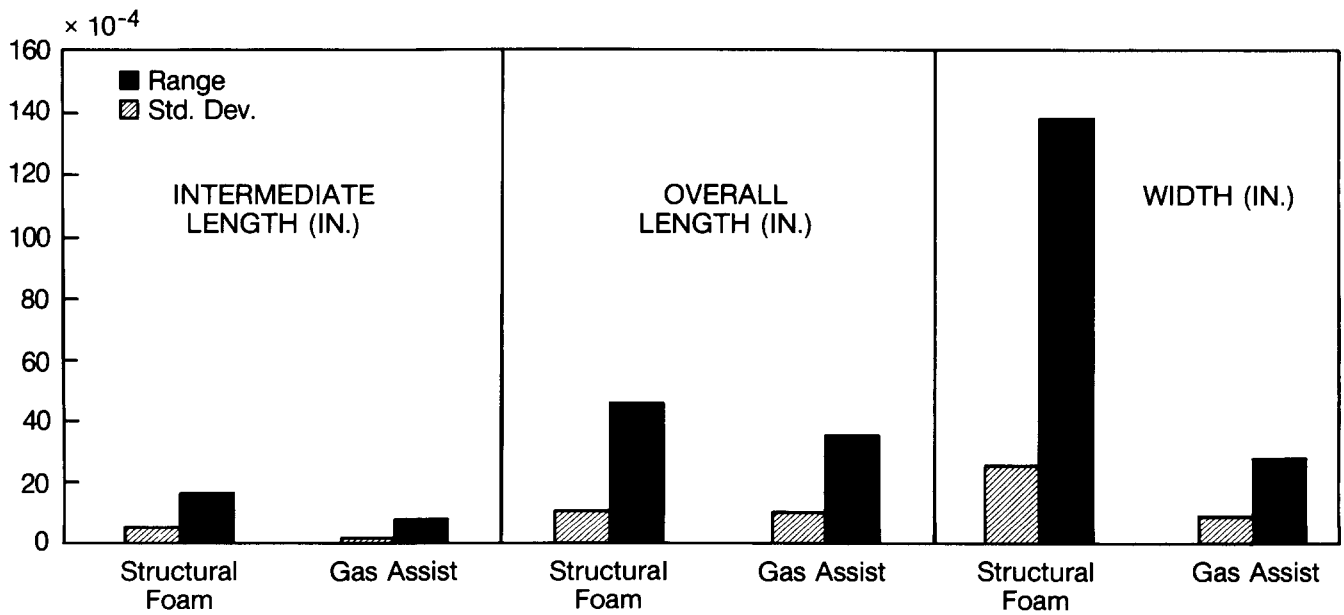

Figure V

CONCLUSIONS

The data from this study would lead one to conclude that cavity pressure controlled closed loop injection molding and structural foam molding are the more repeatable processes when compared with the gas assist process. The data further showed that conventional open loop molding had the worst dimensional repeatability of the four processes studied. Arguements may be made that a different mold or material, or a different version of gas assist methodology may give different results. The authors, however, feel that greater variability would be inherent in the gas assist process simply because it has all the variables as injection molding, plus the added variables of gas pressure, gas speed, gas timing, and a greater sensitivity to melt viscosity.

If the question were posed "Is this a process to be used for tight tolerance molding?" The answer would be a resounding "MAYBE". Although gas assist may not appear as good as cavity pressure control, the results are still pretty impressive. To definitively answer the above question, these questions must be answered first: "How tight is 'tight' on your dimensional requirements?" "which tolerance is critical in your application?" and "does the geometry of the part make the gas assist process a good candidate?"

SUMMARY

Standard deviation and range data was compared among the four processes (Table 1, Figures II-IV). Cavity pressure controlled and structural foam molding demonstrated better repeatability in the dimensions studied.

Resin B showed good repeatability performance for gas assist and structural foam molding (Table 2, Figure V).

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