Mold cavity size vesus temperature - a test!
-TheProfessor

The question of whether holes, half holes, etc. get bigger or smaller when a mold is heated up is periodically brought up in various postings. I have always believed that one fact is worth a thousand opinions, and so I decided to run a simple measurement test.

Test procedure
Four molds of different brands with approximately the same size cavity were selected. Two molds are made from a ferrous material and two are made from an aluminum alloy. A inside diameter micrometer caliper graduated to 0.001 in was used to take all measurements. Only one cavity in each mold was measured. The only feature of the cavity measured was the base band diameter.

The mike was checked before each set of measurements was taken and after the test was completed. There was no change in zero throughout. The molds were held together lightly with a small (1-1/2") aluminum C-clamp. The measurements were taken first at room temperature (approximately 76F), then after the molds were put in a 28F freezer for 40 minutes, and then finally after heating in a 450F oven for 30 minutes.

Each set of measurements was taken in two directions - across (perpendicular to) the split line and with (parallel to) the split line. Several practice runs to minimize the time necessary to take each measurement was performed. By using the ratchet on the mike consistently repeatable readings could be obtained very quickly. The molds were taken out of the freezer and oven one at a time and in no case did it take more than one minute to remove and measure each mold, thus minimizing heat gain/loss.

At the end of the test the molds were allowed to return to room temperature and then remeasured. There were no measurable differences in size before and after. All measurements are reported to the nearest 0.0005".

The molds
RCBS 2 cavity 45 -250 RF (made from a ferrous alloy)
Lyman 2 cavity 452460 SWC (made from a ferrous alloy)
Lee 6 cavity 430-265 RFTLGC Ranch Dog (made for aluminum alloy)
Homemade 4 cavity .45 217 gr WC ((made from 6061-T651 aluminum alloy)

The results

28F******RCBS*****LYMAN******LEE*****Homemade
Across**0.4560***0.4550****0.4030*****0.4520
With****0.4565***0.4535****0.4000*****0.4515
76F
Across**0.4570***0.4565****0.4035*****0.4525
With****0.4565***0.4545****0.4015*****0.4520
450F
Across**0.4580***0.4560****0.4060*****0.4545
With****0.4570***0.4560****0.4030*****0.4525

Analysis
1. In all cases but one the base band diameter got larger or stayed the same size between room temperature and 450F. The Lyman mold got 0.0005" smaller across the split line but 0.0015" larger with the split line.

2. In all cases at least one of the two measurements was larger at 450F than at room temperature.

3. The RCBS mold and my homemade mold started out the roundest; the RCBS mold stayed the roundest at all temperatures. The Lyman mold was the roundest at 450F. The Lee wasn't very round at any temperature. (I really like RCBS molds, they just don't put enough cavities in them! And I have no problem with a good Lyman mold.)

4. The expansion of the aluminum molds was greater than the ferrous molds.

5. In all cases the size change resulted in a larger mold cavity volume at 450F compared to the size at room temperature.

<u>Conclusion</u>

Mold cavities in metal mounds on the average get larger as they are heated from room temperature to casting temperature. Individual cases of warpage from uneven heating or internal stresses can keep one axis of a a cavity from increasing in size or even cause a slight decrease, but expansion in a different axis more than makes up for this and increases the average diameter and volume of the cavity with increasing temperature.

Note that this does not address the size of the bullet that drops from the mold but only the size of the cavity.

Why doesn't a hole get smaller when the material it is in gets heated up? Because under "textbook" conditions the material around the hole is expanding. Think of it this way. I'll refer to an analog clock face as a frame of reference for a 2-dimensional example. Draw an area of any shape, a square or circle is fine but it doesn't really matter. Put a hole in the middle of it. Measure the diameter of the hole in two mutually perpendicular directions - let's say from 12 to 6 (vertical) and 3 to 9 (horizontal).

If the material has a positive expansion coefficient (size increase with temperature increase) then the material on either edge of the hole will expand parallel to one of your lines. For example, the material at the 12 and 6 position will expand in a direction parallel to the line drawn horizontally from 3 to 9. (Actually, if the piece isn't mechanically restrained it will expand in all directions, increasing its volume, but <u>one</u> of directions it will expand in is horizontally.) When it expands, the distance (diameter) between 3 and 9 gets bigger. The material at 3 and 9 is free to expand vertically, thus increasing the distance between 12 and 6.

If you extend this thought to any two perpendicular lines drawn at any angle (or an infinite number of angles) you can see that the material around a hole will always expand and increase the diameter of the hole.

Now, if the piece is mechanically restrained so that it cannot expand in one or more axes, the material will expand at a greater rate in the other directions, and it will exert a force against the restraint equal to the amount of force necessary to squeeze the piece down from the size it *should* be to the size it is restrained at. There are equations commonly used the engineering area of Strength of Materials (a common name for this class) that allow you to calculate the magnitude of this force.

I said that this is all "textbook" stuff, and good stuff it is indeed. It is based on sound, scientific principles and has been verified by scientists and used by engineers and technicians for well over a hundred years. But the real world sometimes includes effects that aren't readily visible that mess things up and lead to confusion. Expansion coefficients are measured based on materials that have a certain grain structure of a certain size using materials that have a uniform "thermal history", i.e. have been cycled enough times to stabilize the grain structure. The samples are held at uniform temperature and measured with the best instruments available.

Non uniform heating and grain structure will cause warpage, in some cases enough to cause dimensional changes greater than the amount of expansion. Note the Lyman mold that got smaller across the split line by 0.0005" even though it got 0.0015" bigger parallel to split line. One possible reason might be the uncertain "thermal history" of this mold, as it is an unused mold. I might check it a few years from now after I've cycled it through a few casting sessions.

One more note. I measured these cavities in two directions using a direct reading inside micrometer that only touched the cavity at two points. I know "pin gauges" are very popular here, I read about people using them to measure revolver throats and such. But sometimes they can lead you to an erroneous conclusion, since they really only tell you the size of the largest inscribed circle that will fit in a hole of any shape. (You can put a pin gauge in a triangular hole, but what useful information will you get from it?) Had somebody conducted this test by seeing what size pin gauge (or cherrying reamer) would fit in the Lyman cavity they could easily come the logical ***but wrong*** conclusion that holes get smaller in hot materials.

Note that this does not address the size of the bullet you get from the mold, since that includes a lot of the same effects mentioned earlier - material composition, thermal history, etc.

Quiz: Will a mold cavity get deeper when it is hot?