Die or Punch Breakage

Every die has a maximum pressure limit, beyond which it will crack. This is true regardless of the press, caliber or material being swaged. The larger the caliber, the less metal is left in the die walls, so larger caliber dies will break more easily than small calibers in the same outside diameter. But what saves us in many cases is the fact that the force applied to a large caliber bullet is spread over a wider area, so the actual pressure is less than the same force applied to a small caliber. Pressure (in psi) is the ram force in pounds divided by the area of the bullet cross section in square inches. Area is radius squared times pi (3.1415). Radius is half the diameter.

Alloy hardness increases the pressure nearly at the square of the increase in Brinnell (Bhn) hardness number. That is, if it takes 20,000 psi to form a certain bullet with pure soft lead (Bhn 5), it may take 80,000 psi to form the same bullet if you increase to a wheel-weight alloy of Bhn 10 hardness (double the hardness number, flow resistance goes up by four). Since the steel itself has an ultimate limit of under 200,000 psi in nearly any of the high strength alloys (far higher than tungsten carbide dies, by the way, which fracture at much lower pressure even though they tend to wear longer than alloy steels), you can quickly exceed the breaking point of nearly any practical size die by increasing the metal hardness sufficiently and then trying to form a bullet in the same die that was designed for normal metals.

Any lead alloy with more than 0.5% of anything else in it should be considered “hard” by swaging standards. Soft lead means exactly what it says, Bhn 5 pure lead. Type -R and -M dies are only warrantied for use with soft lead. Type -S dies for the Series II press can handle up to Bhn 8-10 depending on shape and other factors. Type -H dies for the Hydro-Press can handle nearly any alloy provided the die design and shape is suitable for the pressure, and proper technique is used.

Any die or punch can be broken by improper technique even with the softest metals. Hardness has nothing to do with pressure: you can apply excess pressure with pure lead just as you can with a piece of linotype alloy. It takes more pressure to make hard metal flow, and this is why people often apply too much pressure, attempting to get the corners to fill out, or the lead to extrude through bleed holes, with a material that resists flowing until the pressure is so high it can break the die. But this does not mean that any amount of force or any speed of application of that force can be used with softer metal! Applying too much force is not something the die-makers can control. A die broken from excess pressure cannot be covered by warranty, since any die can be broken if you apply too much force.

There are situations in which a low gauge pressure, or the effort you feel on the press handle, breaks a die or punch and yet you feel certain that you have applied more without any breakage in the past. Bear in mind that the maximum safe pressures listed in Corbin’s Power Swaging book apply to the smallest diameter in which the pressure is concentrated! A straight walled core seating die has only one diameter. If it will handle a gauge pressure of 1800 psi, then so long as the pressure is not exceeded at any point along the die wall, and no high pressure shock is applied that would momentarily exceed the limit, this die should not break regardless of the hardness of alloy used.

But a core swage die, or a point forming die, both have areas of much smaller diameter, into which the same amount of ram force will build extremely high pressures. For example, if you push a hard piece of lead into a point forming die, the area of first contact is somewhere in the ogive area. The diameter at this point is much smaller than the caliber. That is the diameter you have to use for your pressure limit calculation, until the lead expands and equalizes pressure on the entire die surface. Extruding metal up the ejection pin hole means you have to use the area of the ejection pin hole diameter as your pressure limit. Calculate it and you will see that there is an astronomical increase in internal die pressure with a given ram force applied! This is usually enough to destroy the die.

Core Swage dies and LSWC type dies both have bleed holes in the side to extrude extra lead. The diameter of the bleed hole plays a complex role in determining breaking pressure. The larger the hole, the faster the lead can escape and thus the lower is the pressure that can build, provided the lead has time to move out the holes fast enough. If you apply pressure quickly, the inertia of the lead will cause it to act like the holes are much smaller, and the pressure can spike and crack the die. As the holes become smaller, the effective length of the escape hole compared to diameter becomes much greater, and the friction and inertia of the lead becomes a major factor in restricting the flow.

With very small bleed holes, the pressure can build not only in the die, where the diameter is normal size for the pressure suggested, but also inside the bleed holes, where it can wedge the die apart at astronomical pressures. Some bleed holes are only .03 inches in diameter, so if you apply 20,000 psi in the full caliber die, for the initial moment before there is any significant flow of lead, the pressure can far exceed the metal tensile strength within the area of the bleed holes. The secret is to apply pressure gently, allowing the lead to start flowing before destructive pressure can build in the bleed hole areas.

Punches can be broken if they have a boattail cavity or a nose cavity machined into the tip, and any part of the cavity walls are unsupported when swaging pressure is applied. Making a bullet that is heavier than the design specification for the punch and die combination, or changing the internal punch to one with a longer head, can cause the bullet to start forming before the walls of the punch cavity are fully inserted into the die, past the tapered mouth area. Any force applied then expands the punch outward, cracking it. Make sure that the punch is well supported in a snug fitted die before any pressure is applied. Then apply it slowly.

Punches which have deep cavities (such as a 1.5-E or longer round nose, or a spitzer shape over 4-S ogive) can be difficult to fill out under normal pressure. Air and lubricant can become trapped in the tip, friction along the long walls can restrict the lead flow, and the inertia of the lead mass can hold back the flow at higher swaging speeds.

When possible, minimize the length of noses that are formed in a punch cavity rather than a point forming die. If you can use a 1-E, do so instead of a longer round nose, or use a 2 to 4-S spitzer rather than attempting to make a 6-S in this way (point forming dies are much preferred for long ogives).

If you must make a very long nose in a punch cavity, use gentle force applied slowly and increase it only gradually to get the end filled. If the end does not want to fill, try pre-swaging the bullet so the nose end is flat and even, rather than rough cut. This often solves the problem completely. Sometimes, just reversing the bullet so the base becomes the nose will solve the problem by evenly concentrating force along the walls instead of allowing it to build on one side at the expense of a small depression on the other side.

With LSWC type dies, the bleed hole location can be such that your particular length and shape of punches puts the edge of a punch right over a bleed hole, at a certain bullet weight. Even a few grains difference would solve the problem. But for that particular weight, the punch edge is unsupported over the bleed hole, and it can be cracked or nipped away by the extreme pressure flow over its edge.

Be aware that if your bullet seems to have the bleed holes very close to the either end, you may be close to damaging a punch. Also, if the punch comes down over the hole and blocks it, it can cause you to break the die by applying excess pressure, in an attempt to get lead to extrude when it is blocked by the punch.

In nearly every case, the cause of a broken die is excess pressure and not a defect in the die itself. The exception would be a die which was extremely hard, where the carbide content is excessive. Such a die will wear very well, but becomes more brittle as it becomes harder. Any shock generated by rapid application of pressure can over-stress and crack the die.

Corbin can Rockwell test the broken die for you to determine the hardness. Normal hardness range for best wear and low expansion will be in the Rc58 to Rc64 range. As the hardness increases, the wear resistance increases but the chances of a sudden application of pressure cracking the die go up. Send broken punch or die parts back along with the bullet that you used when the die broke, and we can test the components as well as the die. The information can help you avoid future breakage.

An interesting phenomenom can occur when a die has been used at the edge of its breaking point and then put away for some time. Just as a gun can be stressed beyond its normal breaking point and fail at some later time under normal pressures because of metal fatigue, These kinds of breakage are often puzzling to the operator, because no abnormal force was being applied when the die broke. Nearly all the damage was done to the metal structure of the die in a previous abuse which did not quite break the die, but weakened it severely.

Such failures are apparent from the crystal structure of the metal along the failure line, in most cases. A die can be nearly broken, but put away and stored in this condition for years, then long after the original use has been forgotten, an operator breaks the die under what would be normal circumstances with a new die. There is nothing that the operator could do differently at that time, and yet the abuse of the die originally would not be a problem that could be covered by warranty.

Warranty replacement in the case of broken dies and punches is of necessity limited to those conditions over which the manufacturer has control, such as the hardness of the metal. If the metal hardness is within the normal range, and the die or punch is broken anyway, the only possible thing that can do it is more pressure than the part was designed to handle, or pressure applied to an area that is unsupported, regardless of the way it was accomplished.

Excess pressure means excess for the diameter and wall thickness where it is applied, not simply a total pressure on the gauge. The same pressure that is perfectly safe with a solid core seating die can blow up a core swage die (with bleed holes) because the lead is applying pressure to the inside of the bleed holes, and this is the new diameter that limits the pressure, relieved only by the rate of lead flow, which in turn is controlled by its effective inertia and friction within the bleed holes.

The same pressure that formed hundreds of good bullets can crack a point forming die if the pressure is applied too quickly. The force can be concentrated in the ogive in a small ring instead of spread over the full surface area of the die, as it would if the pressure were allowed to expand the seated core during the time that the inertia of the bullet mass tries to keep it in original diameter. Slow down the press a bit, so that impact shock and pressure spikes are reduced, giving the lead time to flow before the full pressure is delivered to the die.

The desire to “go faster” can sometimes cause situations where components are broken even with what would be “normal” pressure to a different operator. Likewise, very slight differences in diameter of punches compared to the die bores, caused by normal wear, expansion and metal stress, mean it is critical that the die-makers have the die and punch when cavity-end punches are to be modified or replaced, so they can be hand fitted for the best support. Doing it “by the numbers” or from a sample is not as good as having the complete tool for testing and hand fitting.