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# Purpose

The purpose of this procedure is to describe the process used to press ceramic tablets from ceramic powder.

# Responsibilities

Crystal Department engineering and management are responsible for maintaining this procedure.

Crystal Department technicians are responsible for carrying out this procedure.

# Associated Documents

ISO 9001, QAM, QSM, AS9100, CR025, CR034

# General Description and Practice

This procedure describes the tools and methods used to fabricate pressed ceramic parts from ceramic powder batches. It describes the general set-up and operation of the Stokes F4, Gasbarre 30T and OTC 55T mechanical die presses used to form the ceramic shapes, as well as the techniques used to insure the highest quality parts.

The three keys to producing quality pressed parts are cleanliness, proper material handling techniques, and proper equipment operation.

It is important that the tools used during the pressing operation be kept clean. This includes the press itself, the die table, the die set, and the feed shoe, as well as scoops that are used to transfer the powders from the batch container to the press. The micrometer, calipers and scale should also be kept clean. Always insure that the die set is clean before beginning any pressing operation, and promptly wipe it clean it after completion of a press run.

Great care is taken to prevent the batches from being contaminated during the batching operation. Care must also be taken to prevent foreign material from contaminating the batch during the pressing operation. Always keep the jars of batch material closed when not removing powder to fill the press. Do not return spilled batch material to its container, or try to recover the “tailings” left over from a press run, since these materials may have picked up contaminants.

Refer to the appropriate section for proper set-up and operation of each press. Make sure that the presses are properly maintained. Make sure that the micrometer or calipers used to measure the pressed parts are reading accurately, and are regularly calibrated. Make sure that the scale is tared and level before weighing any parts, and is regularly calibrated.

The pressing of ceramic powders can be somewhat sensitive to environmental conditions such as temperature and humidity. While there is no exact range required for these conditions, in periods of high humidity the powder may absorb moisture from the air, changing its pressing characteristics. It may be required to dry the powder in an oven prior to pressing under these conditions. However, check with the engineer before drying any batches.

# Safety Precautions

In the following operations, either a four, thirty or fifty five-ton mechanical press will be used. Currently, there are no fail-safe brakes or pinch point guards on some of the moving parts. Therefore, it is imperative that the operator understands the safe use of this equipment. The back of the Stokes press has an open, rotating flywheel. The front of the Stokes press has an open, reciprocating upper punch and crosshead assembly. By following some simple rules and guidelines, these presses can be operated safely.

* IN THE CASE OF ANY INJURY, INFORM YOUR SUPERVISOR IMMEDIATELY.
* While the press is in motion, do not attempt to make any adjustments, clear the die table, or allow your hands to come close to the upper punch and crosshead assembly. The Gasbarre press has a light curtain in front of the die area, but the Stokes and OTC presses do not. As the upper punch descends into the die cavity to compress the powder, it will compress anything else that gets in its way, such as tools and fingers, resulting in damage to the press and / or serious injury. Stop the press operation before making any adjustments.
* While the press is operating, keep the lower punch cover or cabinet doors closed except to make setup changes when the press is stopped. Keep your hands clear of the assembly.
* When using the F4, make sure the feed shoe is either removed from the die table or is attached to the shaker rod. Do not operate the press with the feed shoe on the table but not connected to the shaker rod, as this could damage the press.
* In case of any accidents or damage to the equipment, notify your supervisor immediately.
* It is generally recommended as safe practice to wear a dust mask whenever working with fine powders, since all fine powders can be irritating to the nasal passages, throat and lungs. When pressing parts out of PZT material, it is recommended that the operator wears a NIOSH-approved dust mask (3M 8233 or equivalent), since PZT contains lead, which is a hazardous material.
* When cleaning the area and the die tables and presses, do not use any type of compressed air to “blow off” the powders, as this will generate airborne particles. Use the lead vacuum to clean up any powder, and wipe the areas clean with a wet paper towel or the special lead dust cleaner wipes. Discard the used towels in the appropriate hazardous waste container.
* Any scrap parts, powder, or setup pieces of ceramic material must be discarded in the appropriate hazardous waste container. Do not throw away in the normal trash.

# Part Numbers (Fired Stock)

Each pressed part will have a distinct part number. The drawing provided with the job will show the “fired” dimensions of the part being pressed. These dimensions are slightly smaller than the dimensions of the pressed part to account for shrinkage after the subsequent ceramic firing process. The router or batch qualification traveler will specify which die set to use to press the desired piece.

For each new pressing job, create a record for the pressing data by creating a new copy of CR034 and save in the correct folder by item number. The folders can be found on the network: R:\Crystals\Batching Data\Density Measurements. Save a new copy of CR034 in the proper folder with the following naming convention: Mat’l Spec (Powder Lot)(Job No.) Press Date.xlsx. An example of this is as follows: PCB370 (140-4)(CR9421) 3-21-2017.xlsx.

The pressing log should also be filled out for each fired stock job. The log can be found on the network: R:\Crystals\Ceramics\Powder Pressing Log. For each job, fill in the Date, Job Order number, Part number, the Powder Batch being used, the Item number for the Press Tooling being used, the quantity of parts pressed on that job, and the Room Temperature and Humidity measured using the handheld meter.

# Stokes F4 Mechanical Press

The Stokes F4 is capable of generating 4 tons (8,000 lbs) of force. It is used most often to produce large lots of smaller parts (<1”).

The Stokes F4 is a single station eccentric cam press. It applies pressure from both the top and bottom simultaneously to produce parts of uniform density. A stationary core rod can be used so that parts with holes can be produced. The sequence of operations that take place as the press is operating is as follows:

* The shaker arm pulls the feed shoe across the die table, pushing the last piece pressed from the die area.
* The lower punch drops to its die fill position.
* The shaker arm agitates the feed cup back and forth across the die opening, filling the cavity with powder.
* The feed cup is pulled away from the die area as the upper punch begins to descend towards the die.
* At the instant the top punch enters the die cavity, the lower punch is pushed upward toward the top punch. Therefore, the powder is compressed equally from the bottom as well as from the top.
* The top punch is pulled from the die cavity. For a short distance of about 0.010”, the bottom punch travels upwards with the top punch so that there is not a sudden release of pressure.
* The bottom punch raises from the pressing position to the eject position flush with the die table, ejecting the pressed piece from the die.
* The shaker arm pulls the feed shoe across the die table, pushing aside the pressed part, and starts the sequence again.

## Removing the Die Set from the Press

1. Remove the feed shoe from the press. Be careful not to hit the upper punch when lifting the feed shoe off of the die table.
2. If there was a core rod used with the old die set, loosen the lock nut on the bottom of the core rod assembly and remove the split clamp. Drop the core rod assembly down, and separate the core rod shafts as required. Remove the core rod from the upper core rod shaft by unscrewing the core rod.
3. Remove the upper punch by loosening the upper punch locking screw, and pulling the top punch from the punch holder. Do not allow the punch to drop freely. This will damage the punch tip and / or die.
4. The lower punch and die are released by removing the lower punch locking screw and removing the 4 hold-down cap screws from the die clamp ring. If necessary, vacuum out any powder that fell into the hold-down screws before removing the hold-down screws.
5. Remove the die from the table by first removing the die clamp ring, then lifting out the die. Be careful not to lose the shims which are used to adjust the height of the die in the table. Remove the lower punch by lifting it up through the die table.
6. Thoroughly clean the punches, die and core rod of all powder before storing. If the powder will not wipe off, wash in a beaker of methanol in the ultrasonic cleaner for a few minutes, then wipe clean. When the die set is clean and dry, store it in its proper drawer.
7. Clean the press of all loose powder using a brush and the lead vacuum cleaner. Make sure all areas where the punches and dies must seat are clean. If necessary, wipe clean with a paper towel soaked in methanol. Clean the screw threads and holes so that the locking screws will thread freely.

## Installing a Die Set into the Stokes F4 Press

1. Check the new die set for cleanliness. Clean if necessary. Identify the top punch from the bottom punch.
2. If there is a core rod in the die set, screw the core rod into the upper core rod shaft. Install the core rod assembly through the core rod bracket, and feed it upward. Attach the lower core rod shaft, and continue to feed the core rod assembly upward. Attach the core rod split clamp onto the core rod assembly above the core rod bracket, and slightly tighten the set screws in the clamp. Screw the core rod lock nut onto the core rod. Loosely adjust the height of the core rod by means of the lock nut and split clamp on either side of the base bracket.
3. Insert the bottom punch into the lower punch holder (over the core rod if there is one). Push the punch down into the holder as far as possible. Insert the lower punch lock screw and tighten.
4. Slip the die over the lower punch and push down until level with the die table. Set the die clamp ring over the die. Install the four (4) cap screws in the clamp ring and tighten.
5. The lower punch must be adjusted so that its face is exactly flush with the die table or a few thousandths of an inch above the die table. This position is called the eject position. The use of a straightedge or steel rule will help in determining the position of the lower punch with respect to the die table. To adjust, turn the machine over slowly by hand until the lower punch is at its highest position. Loosen the two locking cap screws on the upper collar on the lower plunger assembly. Turn this collar either to the left or to the right until the punch is at its proper level. Tighten the cap screws making sure that the split of the collar is equal on both sides of the plunger shaft. The adjustment of the ejection level may shift as the locking screws are tightened and may need to be readjusted several times before it is correctly set. Turn the machine over a revolution or two to make sure that the adjustment is correct.
6. Adjust the core rod so that the tip is flush with the top of the bottom punch or a few thousandths of an inch below the bottom punch. This is done by means of the nut and split collar at the bottom of the core rod assembly. Use the collar above the support bracket to adjust the level of the tip and use the bottom nut as a locknut. You will find though, that as the assembly is tightened, the level of the tip will change. It may take several tries to get the tip in the proper position. The clamping screws of the upper clamp must be tightened before tightening the lower nut. The split of the clamp should be approximately equal on both sides of the core rod base. Again, the use of a straightedge or ruler will make this positioning easier.
7. Refer to the router or batch qualification traveler for the density range required. Once this information is determined, the die fill and other press settings can be adjusted appropriately.
8. Adjust the lower punch to the proper die fill position. As a starting point, assume a fill depth of twice the desired press thickness. To adjust this position, loosen the lock screw on the fill position collar, and turn the collar as necessary to lower the bottom punch to the desired depth of fill. Tighten the lock screw on the collar, and check to see if the position of the punch moved. If the punch moves on locking, loosen the set screw and repeat the process until the depth of fill is adjusted to the desired reading once the locking screw is tightened. Rotate the press by hand through one complete cycle to make sure the indicator indicates the correct eject and die fill positions.
9. Rotate the press in a forward direction past its die fill position. You will notice that at the lowest level, the rocking lever will push the bottom punch up to a stationary position. Then it will move up approximately 0.010” shortly thereafter, remain stationary for a short time, and then move up to its ejection position, which is level with the die table. Now rotate the press to the first stationary position after the die fill position. This is the point where the upper punch will be at its lowest position and the most amount of pressure is being applied to the piece to be pressed. This is the bottom punch press position, the point in the pressing cycle to which the bottom punch must be adjusted to for pressing. Loosen the locking screws of the lowest collar of the lower plunger. Rotate the collar either to the left or to the right until the lower punch is in the proper position for pressing. Tighten the locking screws on the collar. If the position of the lower plunger shifts on tightening, readjust so that it is in the proper position with the locking screws tightened. Rotate the press by hand through its cycle, checking the position of the lower punch throughout its cycle. Make any changes as necessary.
10. Insert the upper punch into the upper punch holder. Push the punch up into the holder as far as possible. Insert the upper punch locking screw into the threaded hole and tighten.
11. Adjust the upper punch to its uppermost position by loosening the locking handwheel on the left side of the upper plunger assembly and turning the adjusting handwheel on the right side of the upper plunger assembly. The punch is at its uppermost position when the screw in the eccentric bushing appears to be at the bottom.
12. Rotate the press by hand until the upper punch is just above the die. Make sure that the upper punch is aligned with the ID of the die. If necessary, slightly loosen the set screws on the upper punch holder and align the upper punch with the die ID. Slowly turn the flywheel to lower the punch slightly into the die. Tighten the set screws in the upper punch holder. Rotate the press by hand again through a cycle to confirm the upper punch to die alignment.

## Final Adjustments for Density

1. Insert the feed shoe back into the die table and reattach the shaker rod.
2. Fill the feed shoe with the material to be pressed.
3. Turn the press over by hand in the forward direction until the upper punch is in its lowest position of the cycle. Use the hand cranks on the upper crosshead assembly to lower the upper punch until some (not much) pressure is being applied by the upper punch. Now turn on the press and press 1 to 2 pieces.
4. Weigh the pieces and compare with the desired weight. If necessary, adjust the middle collar of the plunger assembly to adjust the die fill to be closer to the desired mass. Then make the calculation of what the bottom punch position should be at the pressing position and adjust the lowest collar to that position. Again, turn the press over to the pressing position and adjust the top punch so that it is applying only a small amount of pressure. Turn on the press and press 1 to 2 pieces. Continue to weigh, compare, adjust and press samples of pieces until the pieces have approximately the right amount of mass.
5. Use a micrometer or calipers to measure the dimensions of the last pieces pressed that have the correct mass. Calculate the density of the piece using CR034. Compare this density to the desired pressed density for the piece.
6. Loosen the left hand crank of the upper plunger assembly and turn the right hand crank to make the upper punch go down if the density was low and up if the density was high. The density of the piece should be adjusted to within the range shown on the router or batch qualification traveler. The upper punch should only be changed in small increments, either up or down. When pressing small diameter pieces, the punches can be easily damaged by excessive pressure if the upper punch is lowered too much at one time. Start with the density low and build up to the proper density range.
7. After several pieces have been pressed within the desired density range, snap a couple of pieces in half or cut in half using a razor blade to check for laminations. Examine the broken edges under a microscope with adequate lighting. The broken surface should look rough and granular. Signs of laminations are small cracks parallel to the pressed faces, and visible lines or layers within the broken surface. Even minor laminar cracks at the very outer edges of the piece are cause for rejection, since these can propagate during the subsequent firing process and lead to reject pieces later in the process. Refer to the Appendix for examples.
8. If laminations are present, make the appropriate setup adjustments to reduce the density. Press several pieces, then check again for laminations. If the laminations cannot be eliminated after several attempts to lower the density, stop pressing and notify the engineer.

## Pressing Pieces

1. Once the press is operating at the proper density with the motor running, begin pressing the desired quantity of pieces. Make sure that the press has been oiled at the beginning of the run or at least at some point earlier in the day.
2. Add powder to the feed shoe as necessary. Try to keep the level of powder in the feed shoe at a consistent level, between full and half-full, at all times. This will help maintain consistent pressed density. Never let the feed shoe run out of powder, as the density of the last parts pressed will be considerably lower than desired.
3. After each pressing job, turn off the press and check for powder buildup on the punch faces. If necessary, wipe off the punch faces with an alcohol-dampened kimwipe.
4. As the pieces build up on the die table and chute, they must be removed. A storage container or disposable beaker can be positioned to catch the pieces as they come down the chute. Turn off the press and sweep pieces down the chute with a brush. Do not allow too many pressed pieces to lay on the die table, as they could interfere with the press operation.
5. When finished pressing, turn off the press. Clean the material from the shoe, die table, and work table, and dispose of material in the hazardous waste container. Use the lead vacuum to remove remaining powder from the die table. Wipe the punch faces clean.

# OTC 1851 Hydraulic Press

The OTC 1851 Press is capable of generating 55 tons (110,000 lbs) of force. It is used to press small lots of large square blocks (>1”) due to its high tonnage capacity and manual operation.

The OTC has a single hydraulic cylinder that applies pressure from the top. The punches and die are loaded into place underneath this cylinder and it is manually actuated using a hydraulic/pneumatic system.

## Using the OTC 1851 Press

1. Press on the back of the foot pedal to retract the press piston.
2. Place bottom punch facing upwards under the press piston.
3. Arrange 2 4x4 wood blocks on either side of the bottom punch.
4. Slide the die body over the bottom punch and rest it on the wood blocks.
5. Add the premeasured powder to the die cavity.
6. Level the powder with a plastic spatula to help insure a consistent density in the pressed part.
7. Carefully insert the top punch into the die, making sure that the die set is centered under the press piston.
8. Depress the foot pedal to bring the press piston down and begin applying pressure to the die.

NOTE: Keep your hands away from all moving parts of the die.

1. Continue to let the press come down until the desired pressure is reached, for achieving the needed density.
2. Release pressure from the press by pressing the back of the foot pedal until there is sufficient space to remove the top punch.
3. Carefully remove the top punch and the 4x4 blocks holding up the die.
4. Place the 2 parallel metal blocks on either side of the die cavity.
5. Place one of the 4x4 wood blocks across the 2 parallels, centered underneath the press piston.
6. Depress the foot pedal to bring the press piston down to the wood block.
7. Apply force to the wood block until the pressed part is removed from the die set.
8. Repeat this process to achieve the desired number of parts.

# Gasbarre 30T Die Set Mechanical Press

The Gasbarre 30T press is capable of generating 30 Tons (60,000 lbs) of force. Of the presses PCB owns, it is used for large lots of large disks.

The Gasbarre 30T Press is a single station, eccentric cam press that uses a floating-die configuration. In this configuration, the bottom punch is stationary, compaction pressure is applied by the top ram, and ejection is accomplished by die plate motion. Additional systems such as under-fill, density control and top punch hold-down are used to improve the quality of the pressed parts.

The sequence of operations can be broken down into three cycles: die fill, compaction, and ejection.

During the die fill cycle, the feed shoe will move forward over the die plate. The die plate then rises up to the fill position while the shoe is over top, creating a suction fill. The shaker cams agitate the feed shoe over the die opening, to fill the cavity with powder evenly. The feed shoe is then pulled back from the die plate. If the underfill option is being used, an air cylinder will fire and the die plate will rise slightly to lower the powder level inside the die cavity. This prevents the powder from splashing out as the top punch enters the die cavity.

During the compaction cycle, the top ram moves downwards and the top punch enters the die cavity, compacting the powder. If the density control option is being used, the top ram will push on the density control rods in the crosshead, moving the die plate downward (ideally, half the pressed thickness) during the compaction stroke, simulating the action of two punches moving toward each other. This way, the powder is compressed equally from the bottom as well as from the top. The top ram will move upwards and the top punch will exit the die cavity. If the top punch hold down option is being used, an air cylinder will keep the top punch in contact with the part as the top ram retracts.

During the ejection cycle the die plate will move downwards to the ejection position, stripping the pressed part from the die cavity. If the top punch hold down option is being used, the top punch will remain in contact with the part throughout this cycle, reducing shear stress. The top punch will then retract back to the top ram. The feed shoe then moves forward over the die plate, pushing the pressed part down the chute and beginning the die fill cycle again.

## General Press Operation

1. Pull out the Red Emergency Stop (E-stop) button.
2. Press the Master Control Reset (MCR) button. This will start up the Danfoss variable frequency drive (VFD). This process will take 15-20 seconds. When the Danfoss VFD is ready, all the lights on the electrical panel will be lit up green. Press the RESET software button to clear the Danfoss Fault.
3. Check the air pressure gauges for correct settings. A list of acceptable ranges is provided in the Appendix.
4. Fill the hopper with powder, if this is not already done. If you are adding powder to an empty feed shoe, first plug up the screw holes on the front of the shoe so powder does not spray out. Be sure to remove them before operation so the powder flows correctly.
5. Press the yellow Motor Start button. The press can now be operated in any of a number of modes.
6. To operate the press in INCH mode, turn the key to INCH. The press may now be incrementally moved through the cycle by pressing the hand pads. This mode is typically used during initial setup.
7. To operate the press in SINGLE mode, turn the key to SINGLE. The press may now be cycled by pressing the hand pads and holding through at least the first 180 degrees of the cycle. This mode is typically used any time adjustments are being made to the mass or thickness of the pellet. It is typical practice to make an adjustment, press 2 pieces, discard the first, and test the second for your adjustment.
8. To operate the press in CONTINUOUS mode, turn the key to CONT and press the blue Continuous Acknowledge button. The press may now be started by pressing the hand pads. The Continuous Acknowledge button will only remain activated for a few seconds before it needs to be pressed again. This mode is typically used in normal production runs.
9. To set a counter to run the press for a desired batch size, enter that number in the Batch Size setting on the control panel. It may be necessary to first set the count to 0 to clear out an old setting, then enter the desired number. After the counter is complete, the press will stop. You will need to clear the message on the control panel before beginning another press run.
10. To stop the continuous cycling of the press, it is easiest to press the yellow Top Stop button. This will park the press near 300 degrees, close to its highest point, but not quite TDC. In order to restart the press, you will have to press the RESET software button to clear the Top Stop Fault.
11. To immediately stop the press, regardless of where it is in the cycle, and turn off the Danfoss VFD, press the red E-stop button. The press will have to be restarted beginning with the E-Stop and MCR. Attention should be given to where in the cycle the press was halted.
12. To shut the press down after the press run in complete, the press should be parked near TDC.

## Installing and Removing the Die Set

NOTE: Presently, PCB does not use a core rod with this press. If this changes in the future, these work instructions will need to be updated.

It is possible to remove the entire die set from the Gasbarre press, but this is not necessary under regular operation conditions. The process for doing so is outlined in the equipment manual, but is an intricate process – more nuanced than the manual suggests – that should be undertaken by trained experts only. In the event the die set has sustained damage, or the press needs to be moved, it may be necessary to remove the die set. It this situation arises, Engineering and Operations should work with Gasbarre for technical support.

## Installing and Removing the Tooling

NOTE: Presently, PCB does not use a core rod with this press. If this changes in the future, these work instructions will need to be updated.

1. Assemble all the tools, hardware, rags, lubricant, etc. needed for the process. Have everything ready before beginning the process. Wipe down all the tooling components to remove oils and dust. Even the smallest amount of powder between two components will alter the fit unacceptably. Be thorough and be careful.
2. Install the bottom punch. Make sure all the surfaces inside the die pot, the clamp ring and punch are wiped clean. Again, be thorough and be careful. Turn the press to tool setup mode and jog the press to TDC, stopping it in the Ejection Position. This way the top ram is as far up and out of the way as possible, and the stationary ram is as far up in the die pot as possible. Clean the die pot again. Check for cleanliness and stray powder again. This is important and should not be rushed. Set the clamp ring onto the bottom punch. The bottom punch is designed so it is always longer than the upper punch. Compare the two if you are unsure which is which. The bottom punch is designed to float slightly under the clamp ring, so if you are unsure if they are the correct set, test this on the tabletop. Set the bottom punch into the recess. If the bottom punch has a molded rubber cover on it, leave it on to protect the brittle carbide edge. If it is not present, be sure to cover the punch edge with your hand as you work to protect it. If you hit the edge, it will break. Install the screws by hand and hand-tighten until they are seated. Tighten them in a star pattern. Verify that the bottom punch is able to move slightly under the tightened collar.
3. Install the die. Make sure all the surfaces of the die are wiped clean of oil and powder. Be thorough, be careful. Thread two long 10-32 screws into the threaded holes in the top of the die body. These will act as handles. Carefully set the die onto the bottom punch. The bottom edge of the die bore is radiused to aid this process, but the sharp edge of the bottom punch can still be chipped. The threaded holes should be oriented at the sides of the die, so the feed shoe and parts do not pass over them during operation. Remove the two long screws used as handles, being careful to cover the bottom punch with your hand. If you drop a screw on the bottom punch, it will chip. Once the die body is in place, turn over the press a few times slowly to let everything align. After doing this, park the press near 50 degrees and hit the E-stop to turn the VFD off.
4. Set the lower (stationary) ram position.

NOTE: The lower ram position should not need to be adjusted unless a much thicker part is being pressed. At startup, the press was adjusted to roughly the middle of its travel to retain as much flexibility for future work as possible.

1. Set the underfill position, if this feature is being used.

NOTE: The underfill feature was set to about 0.030” at press installation and should not need to be adjusted.

1. Set the lower punch fill position. This will be roughly twice the finished part thickness, plus the depth of the underfill. The press should already be in the ejection position at this point, but if it is not, jog the press to near 50 degrees. All adjustments to the fill position must be done with the press in the ejection range (and vice versa). The position may be checked by floating the die table and measuring. Initial measurements may be done using a 6” rule. To adjust the position, dump the air pressure off the die table float and adjust. Unlock the guard over the adjustment screw and turn it to adjust. Adjustments may be made using the speed-wrench or a cordless drill. Float the die table again, by turning the air pressure back up to level, and check the change to the fill position. Just get it close for now. Fine-tuning will be done later.
2. Set the lower punch eject position. The density control rods must be out of the way for this operation. Wind them up so they do not impede this setting. Jog the press to BDC/180 degrees. All adjustments to the ejection position must be done with the press in the fill range (and vice versa). The alignment of the lower punch to the top of the die may be confirmed using a dial indicator.
3. Install the Die Clamp Ring. Cover the bottom punch in the die bore with a rag to protect it as you install the next set of screws. If you drop one in, it may chip the punch. Install the die clamp ring. Use two long screws as handles to lift it. Orient the holes as the sides, similar to the die body, then remove the long screws. Install the 6 die clamp ring screws by hand and hand-tighten until they are seated. Tighten them in a star pattern. They should be tight, but not overly so. Remove the rag from the die bore, start the press up again and turn it over a few times slowly to let everything align. Check the press for smooth operation. After doing this, park the press near 50 degrees and turn the VFD off. Plug the die up again with a rag again to protect it.
4. Install the wear plate. Make sure all surfaces of the wear plate and bumpers are clean of oil and powder. Be thorough, be careful. Install the four rubber bumpers into their holes. Install the wear plate over the die clamp ring. The wear plate has a long side and a short side. The long side goes to the back. Install the 4 screws by hand and hand-tighten them until they are snug. Then, incrementally tighten them down in a star-pattern to evenly distribute the load. The sides of the wear plate should be as close to perfectly flush with the die as possible. This may be confirmed with a dial indicator. The front and back of the wear should also be as close to perfectly flush with the die as well, but the front of the wear plate may be just under the level of the die, and the back may be just proud of it. By erring in this manner, the parts would not hit the edge of the wear plate on ejection. However, the gasket of the filler shoe will rub across both edges during its movement.
5. Install the upper punch. Make sure all the surfaces of the punch and clamp ring are wiped clean. Again, be thorough and be careful. Move the density stops out of the way, if they are not already. Next, set the top punch on the table, facing upwards and adjust the TOP RAM height so it is close. This may be a large adjustment, so use the speedwrench or cordless drill. Lock the underfill on by temporarily setting the angles to 295-95 and 95-295 on the touchscreen. Make note of the previous settings so they can be restored afterwards. Load the die with powder, similar to the amount needed to press the intended part, to protect the faces of the punches. Install the top punch directly into the die bore, with the clamp ring in place around it. The punch should set directly onto the powder loaded into the die. Now, rotate the press to 170 degrees or nearly to BDC. Now, adjust the TOP RAM height to snug right up to the punch, so it begins to compress the powder. Install the screws by hand and hand-tighten them until they are snug, but do not tighten them. The top punch screws are slightly shorter than the bottom punch screws and have a ground tip. There is a special 3/16” hex key with a shorter end that is helpful for installing these screws. Tighten the front and back screws first. Adjust the TOP RAM height up and out of the die using the speedwrench or drill and vacuum out the powder. Inch the press so the punch is almost entering the die but not. Then, adjust the TOP RAM height to enter the die, testing the fit and alignment. Raise and lower the TOP RAM height a few times to test the fit. The punch must be alignment perfectly in the die. If the punch contacts the wall of the die in any way during entry, it will be ruined. A dial indicator placed against the top punch should have zero indication as its enters and exits the die. If the dial indicator has any movement whatsoever, it is insufficient. If the fit is good, tighten the other two screws and repeat this testing process. If it is not good, put more powder into the die, loosen the screws and start over. Be thorough, be careful. Have a spare set of tooling. Once all four screws are tightened, jog the machine a few times to verify everything. After doing this, return the underfill settings to their previous angles, cycle the press a few times again, then park the press near 50 degrees and turn the VFD off.
6. Install the guide rails on the table. Make sure all surfaces of the guide rails are wiped clean. The guide rails are installed on either side of the wear plate to prevent powder that splashes out of the die from spreading. If the ceramic powder were to get into the grease on the die set guide rods, it would wear them prematurely.
7. Install the feed shoe, hose and hopper. Make sure all surfaces of the feed shoe and hopper are wiped clean and free of powder, as much as possible. A spare assembly is maintained, and in the future it may be desireable to have separate assemblies for each material being pressed. If the gasket material on the underside of the shoe is being replaced, cut the gasket slightly oversized and trim to exact fit. The ends of the gasket should be super-glued together. The gasket should then be lapped smooth using WD-40 and fine SiC Wet/Dry abrasive paper to even the surface. Connect the hopper to the shoe using a length of gum rubber hose and hose clamps. Hang the hopper on one of the four hooks on the back of the press. Turn off the two switches for the Filler Shoe In and Down air pressure regulators and bleed off the air. Set the shoe onto the wear plate behind the die and connect it to the filler shoe linkage. Turn the Filler Shoe Down regulator switch back on and turn the air pressure back up to approximately 30 psi. When re-energizing the Filler Show In you must consider where in the cycle the cams are, and if the shoe is going to move forward. Turn the Filler Shoe In regulator switch back on and turn the air pressure back up to approximately 40 psi. After doing this, turn the press over a few times and confirm everything is moving correctly. These two air pressure settings may need to be adjusted.

NOTE: The current machine setup has the timing of the shoe tuned for a suction feed. This means the shoe will be over the die before the table raises to the fill position, so the action draws the powder in the die bore, in constrast to strictly gravity feed. The timing of this die fill strategy requires a bumper on the front of the shoe to move the last part pressed out of the way slightly earlier than the lead edge of the shoe would by itself. It was recommended to PCB to do this using a small piece of RTV Silicone, weather strip, or similar.

NOTE: The die shoe has been vented to aid in the flow of powder. This means a number of holes have been drilled into the front of the shoe for air to escape. If the powder is dumped into the hopper very quickly, it will create a dust cloud puffing out of these holes. The holes are threaded and should be plugged using screws before loading the powder. After filling the hopper, they should be removed or returned to their previous state before beginning the press run.

1. Fill the hopper. Load the powder you want to press into the hopper using any appropriate means, being careful not to create a dust cloud.
2. Manually press a piece. Turn the press over manually (INCH mode) through one complete pressing cycle. It is likely the first cycle will not compact at all. If this happens, vacuum the powder away, adjust the TOP RAM position and try again. Continue this process until a piece with enough green strength to handle is produced.
3. Adjust the mass. Once a part with sufficient green strength for handling is produced, weigh the piece. If it is not within specification adjust the DIE PLATE FILL accordingly. Manually press another piece and test the mass. Continue this process until the parts are within specification.
4. Adjust the thickness. Once the part is within mass specification, measure the thickness. If it is not within specification adjust the TOP RAM accordingly. Manually press another piece and test the thickness. Continue this process until the parts are within specification.
5. Make fine tuning adjustments. Manually press another part and observe the dimensions, mass and calculated density on CR034. If necessary, make small adjustments to the mass or thickness to get the parts within specification and check again. Snap a few pieces in half and observe them under the microscope, looking for physical defects (coining, lamination, end caps, etc.).
6. Engage Top Punch Hold Down (Optional). If the Top Punch Hold Down (TPHD) feature is going to be used, it should be set up now, only after the part is in spec. Cycle the press manually so the top punch just enters the die. Remove the two lock-up bolts from the cylinder near the top punch. Check the air pressure regulator setting for TPHD UP. It should be 40-60 psi. During operation, this setting may be adjusted so the cylinder retracts promptly, but doesn’t slam too hard. Check the air pressure regulator setting for TPHD DOWN. It should be 20-40 psi. During operation, this setting may be adjusted so it is just enough to keep the cylinder down against the part during the ejection phase. Excessive pressure will wear out the die prematurely. Finally, turn the TPHD function on using the red switch on the control panel. Cycle the press slowly and few times, confirming the operation is correct and adjusting the DIE PLATE FILL or TOP RAM positions if the part requires fine tuning.
7. Engage Density Control (Optional). If the Density Control feature is going to used, it should be set up now, only after the part is in spec. The control rods can be moved into place by loosening the jam nut on the front the of the top ram and winding them by hand for coarse adjustment, or using the bar holes for fine adjustment. Turning them to the left will lower them, to the right will raise them. The density control rods should be adjusted to push the die table downwards roughly to half the final part thickness. This may be confirmed with a dial indicator, or by observing a burnish line on the edge of the part.

## Pressing Pieces

See section 7.4 for general instructions for starting and ending a press run.

# Testing the Pieces

1. Check the dimensions and density of the pressed pieces periodically to make sure that it is not deviating outside of the acceptable range. The sampling rate will be noted on the router. Record the measurements of the sample set on CR034.
2. Test the dimensions of the pressed pellets directly from the parts. When pressing glass frit preforms – which have very low strength – only measure the thickness directly, and measure the diameters from the die body and core rod.
3. After testing the dimensions and mass of each sample, destructively tested for defects, as before. The samples should be snapped in half or cut in half using a razor blade. Refer to the appendix for photographs of examples of defects.
4. Large blocks pressed on the OTC press do not need to be destructively tested. In this case, only the setup pieces for each press run need to be broken.

# Appendix A: Troubleshooting

Table I. Troubleshooting Pressing Defects

| **Problem** | **Probable Cause/Explanation** | **Suggested Action** |
| --- | --- | --- |
| Laminations | Excessive pressing force or trying to press at too high of a density. As the pressing force is released, the pressed part tries to expand too much while still in the die, leading to lamination cracks. | Lowering the density usually will correct this condition. |
|  | Entrapped air in the pressed part. This can happen if the press is running at too high of a speed. | Slowing down the pressing speed should allow the air to escape from the powder during the pressing cycle. |
|  | Excessive die wear. As a die becomes worn, a “belly” forms in the die, resulting in the diameter of the die where the pressing takes place being slightly larger than the diameter that the part is ejected through. As the part is ejected, laminations and other cracks will be generated in the part. | A new die is required. |
|  | Excessive buildup of powder on the punch faces. This can be a result of either the powder being too wet, or worn punch faces. The pressed piece may not release from the punch face as it should, resulting in laminations as the pressure is released or when the feed shoe tries to clear the pressed piece away from the pressing area. | If the powder is too wet, drying in an oven should eliminate the problem. If the punch faces are worn, send the punch out to be refinished per the drawing. |
| Variations in Density | The bottom punch is sticking in the die. This can lead to changes in the die fill. | Make sure the bottom punch is dropping to the proper fill position during the pressing cycle. If it is not, tear down the die set up and clean the die. |
|  | Loose punches. | Check that the lock screws are tightened on both the upper and lower punches. |
|  | Condition of the powder. Excessive fines and / or poor granulation can cause inconsistent die fill. |  |
|  | Die fill collar is loose. | Check that that the collar is tight. |
| Press Labors Hard During Pressing or Ejection | Unusual creaking or knocking sounds during the pressing cycle can be due to material between bottom punch and die. | Remove the bottom punch and clean. |
|  | These same sounds can be caused by trying to press at too high of a density. | Reducing the density should eliminate the problem. |
|  | Due to the compressibility of the material (moisture content, granulation, etc.) and / or the size of the punch, the size piece at the density desired is beyond the capabilities of the press. | Contact the supervisor or engineer if this condition exists. |



Figure 1. Example of a ½” disk, illustrating both a featureless (left) and end-capped (right) fracture surface. The image on the right shows the defect extending diagonally inward from the edge, and is a typical example of the defect when we find it. In extreme cases, this defect can extend all the way to the center of the part in a conical shape. The defect is typically associated with high fines content or overpressing the parts, and can be remedied by decreasing the pressed density target.



**Figure 2. Example of a ¼” disk, cut in half using a razor blade, illustrating a delamination defect in the bulk. The bottom surface shows the penetration of the razor edge in the pressed part. The internal crack is circled.**

# Appendix B: Air Pressure Regulator Settings for the Gasbarre 30T DSP

|  |  |  |  |
| --- | --- | --- | --- |
| Regulator | Description | Typical Level, psi | Adjustment |
| Air Clutch |  | 80 |  |
| Ejection | Maintains cam/follower contact for the ejection rods and plate. | 60 | Only need enough to maintain cam/follower contact. |
| Filler Shoe In | Maintains cam/follower contact so the feed shoe is moved out over the die. | 60 | Needs to be set to maintain cam/follower contact and ensure smooth operation of the filler shoe during die fill. |
| Filler Shoe Down | Holds the filler shoe in contact with the die plate, minimizing powder leakage. | 50 | Needs to be set so the filler shoe does not tip up when moved into fill position, or leave a thin film of powder behind. Should not be set too high or it can overcome the Filler Shoe In pressure and stall. |
| Core Rod Up | This feature is not currently being used, so this is set to 0 and turned off. | | | |
| Core Rod Down | This feature is not currently being used, so this is set to 0 and turned off. | | | |
| Core Rod Index | This feature is not currently being used, so this is set to a minimal level (20psi) to keep it engaged and not error out. | | | |
| TPHD Up | Retracts the top punch back up to the ram. | 50-60 | Adjust to less if it is slamming too hard. Adjust to more if it is too slow. |
| TPHD Down | Holds the top punch in contact with the pressed part during ejection. | 20-40 | Only use as much as you need to maintain contact with the part. This can be as low as 0 psi. Too much and you will wear the die out. |
| Inner Punch | This feature is not currently being used, so this is set to 0 and turned off. | | | |
| Outer Punch | This feature is not currently being used, so this is set to 0 and turned off. | | | |
| Underfill | Cylinder that is de-energized just before the the top punch enters the die, to pop up the die plate so the powder level sits inside the die bore. | 60 | Too little pressure and you will get variation, too much and you will wear out the seals. |
| Die Plate Float | Holds the die table up in the fill position. | 80 | Needs to be set high enough to overcome the weight of the die plate and related components. |
| Die Plate Exhaust | Balances the die plate in the molding position. | 35 | Only needs enough to maintain cam/follower contact. If it is set too high, the die plate will bounce up as the top ram retracts. This will separate the part from the lower punch and possibly crack it during ejection. This setting is critical to the quality of the pressed part. |