PMC3™ vs. Art Clay 650

Comparative Testing: by Tim McCreight and Darnall Burks

PMC GUILD

It will come as no surprise to the readers of this magazine that the PMC Guild has a bias when it comes to which brand of metal clay we prefer. To get the full disclosure out of the way right up front, the Guild receives financial and material support from Mitsubishi Materials Corporation, the company that makes PMC®.

Still, we take seriously our obligation to hold a high standard for sound research and fair practice. This commitment led the Guild to commission a blind test between PMC and Art Clay™. Frankly, the process developed a life of its own, and grew into a larger enterprise than we expected. This article is a first look at the results, fulfilling our promise to give Guild members inside information before it is released to the general community.

What We Did

The Guild approached Dr. Andrew Nyce, PhD, a metallurgist with extensive experience in powdered metallurgy, to conduct tests. In consultation with Darnall Burks, a technical consultant to the Guild, he designed several methods to prepare samples that could be tested using standard scientific test methods and techniques that are common in the powder metallurgy field that would give us repeatable results.

The Guild purchased Art Clay™ from a commercial dealer like any private artist. The material was removed from the packaging and assigned random numbers. Not only did the researcher not know which material was which, but when he reported his findings to a second reviewer, that person also didn't know which sample was which. These two layers of obscurity classify the test as "double blind."

In the first phase of the test, all types of PMC® and Art Clay were evaluated. In a second phase, more detailed tests were run on Art Clay 650 and PMC3™. In all cases, the tests focused on three points:

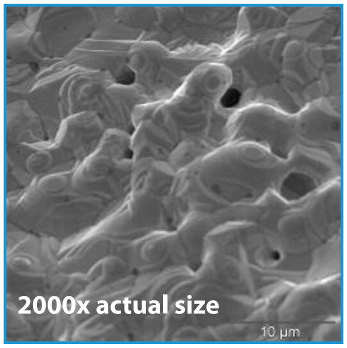
- Green Strength (the strength of the material when air dried but not fired)
- Fired Density (a good measure of how well the metal has compacted)
- Fired Strength (how well the sample stands up to force)

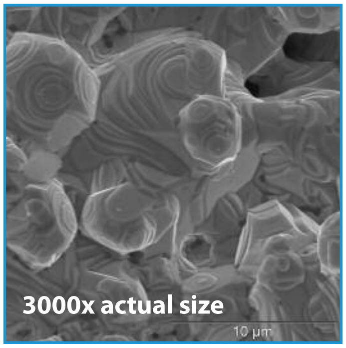
How It Works

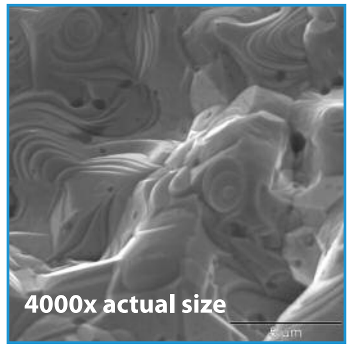
There are three steps in this process. First the samples are prepared, then mechanical tests are performed, then the results are compiled. In this case, Dr. Nyce prepared the samples to ensure that each piece was identical. Most of the tests required a thick rectangular bar. These were prepared in molds and uniformly oven dried to remove the water. Some tests were made on unfired (green) samples, and others required that the metal clay be fired. This was done in laboratory furnaces, at several times and temperatures; consistent with manufacturers' instructions.

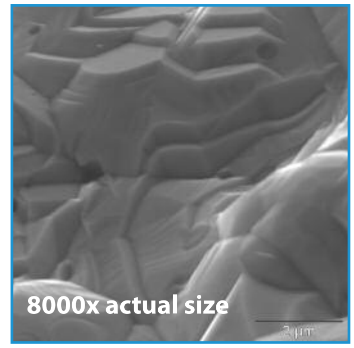
The samples were then sent to an independent testing lab that specializes in sintered metals. They used standardized tests, again with exacting precision, to ensure that the data collected was reliable. A sample of one of the tests (simplified in the illustration, figure 1) shows how measured force is applied to a sample to determine the point at which it fails.

The results are written down and described in great detail then assembled into formats like a chart or graph that reveals relevant patterns. This information is then verified and interpreted by another person who doesn't know which samples are which. Only then do we match up numbers to the metal clay types. That information will then be made available, for instance through articles like this one.







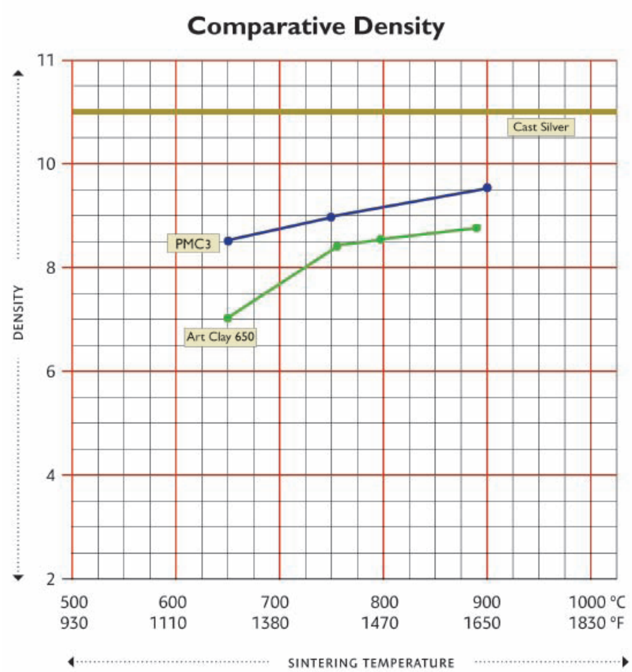


Photomicrographs

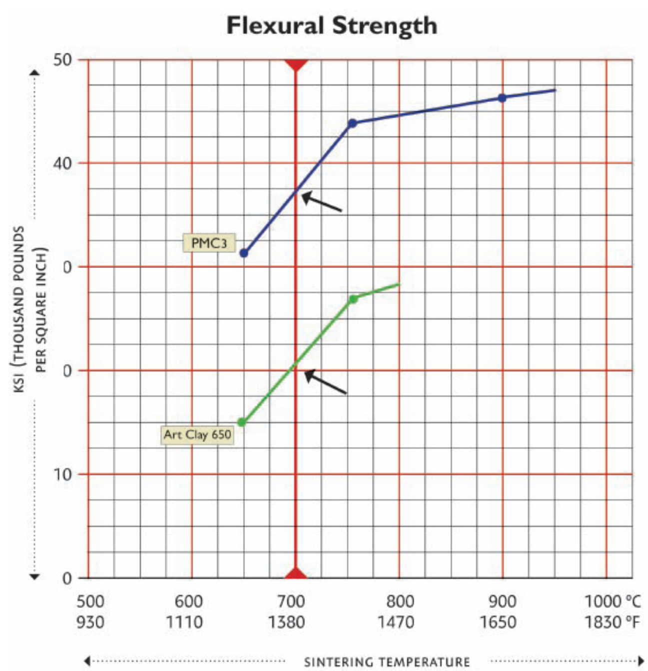
These photographs, taken with a scanning electron microscope, show PMC+™ that has been fired for 30 minutes The first image (2000 times actual size) shows the spherical clusters of silver powder. The spheres, each made up of thousands of silver atoms, have flowed together and bonded (like chocolate chips sticking together in a warm pan).

The next photo zooms in to 3000 times actual size and reveals the strength of the bonds. There are only a couple of voids; a photo taken earlier in the firing process would show more of those because the silver particles had not so fully joined together.

At 4000 and 8000 times actual size, the geometric structure of the silver crystals becomes clear. Because it is a crystal, silver rows according to fixed geometric pattern, similar to the way snowflakes form. This appears as terraced layers at this tiny scale. Photomicrographs by Tina Carvalho, MicroAngelo.

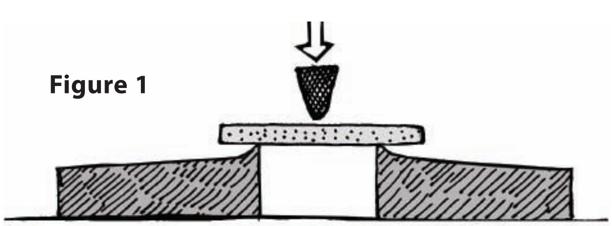


The fact that both lines slope upward shows that both metal clays sinter, densify and get harder as the temperature goes up and the soak time increases. Art Clay™ starts off less dense than PMC® and never catches up. Neither type of metal clay gets as dense as cast fine silver (the green line near the top) but PMC comes closer.



The chart above maps the breaking point of both clays at many firing scenarios. To understand it, look at any vertical line—let's take the firing at 1380°F/700°C for an example. The arrows show the points where the green and blue lines cross that vertical line, the point where that firing schedule was used. As schematically illustrated in the sketch showing two weights, the PMC® can withstand a lot more force before it breaks. (figure 2)

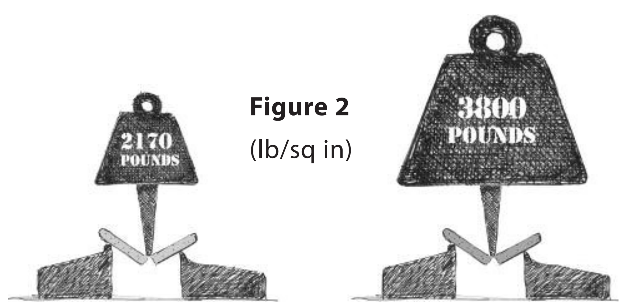
Figure 1



This schematic shows how measured pressure is applied to a sample of PMC® (the gray bar). Force, indicated by the arrow, is measured in pounds per square inch, and recorded when the material first starts to fail and again when it breaks entirely. This test was performed on green (unfired) samples, and again on samples fired to manufacturers' instructions.

Figure 2

(lb/sq in)



Green strength of Art Clay™ 650

Green strength of PMC3™

What Does This Mean for PMC® Artists?

The charts and compelling images from the scanning electron microscope are interesting, but what does this really mean in practical terms?

Green Strength

See figure 2. This refers to the strength of the metal clay before firing. If it is strong, you will be able to sand edges, carve, drill, file and in other ways handle the form. You can smooth the inside of a ring shank with sandpaper, or file a sharp tip on a wire. You can use a foam sanding pad to round over a sharp edge, or assemble components with thick slip.

High green strength makes a piece less likely to break with carving or sanding.

If the green strength is low, the pieces are more likely to break if you do these things. Because of this, you will be hesitant (with good reason) to refine the form before firing. This adds up to more finishing time because it takes longer to sand silver than dried metal clay. Also, metal clay dust can be recycled into slip, but silver filings can only be reclaimed as silver, which is a financial loss.

Density

The dots at the left side of this drawing (figure 3) are separated by a lot of space. The dots in the center start to bump into each other, making many points of contact. The dots at the right are clumped together, creating many more points of contact and what we'd call a dense structure.

The denser the metal, the more rigid it is. This means it will resist bending out of shape. The denser the piece, the less likely it is to break. We can think of all these points of contact as struts that brace each other. The more points of contact, the better the structure will hold up to force. If you are wearing a dense ring, when you slam your hand on the desk to make a point, the ring won't snap.

The blind test used sophisticated equipment, but here is a way you can test strength yourself. Prepare identical strips of metal clay, mark each one, and dry completely. Fire at whatever schedules you want to test and write down details for each sample. Grip one end in a vise and the other in pliers and twist slowly, counting the turns.

Hardness

Hardness is a shorthand measurement for a combination of factors that metallurgists would identify separately as malleability, tensile strength, ductility and wear resistance.

This is very similar to density, but refers to the ability of the fired metal to stand up to external force. Imagine two rings with delicate patterns. If one is stronger than the other, it will look about the same after years of wear. The piece with a lower hardness number will look smudged because the metal has been pressed down and sideways in normal wear.

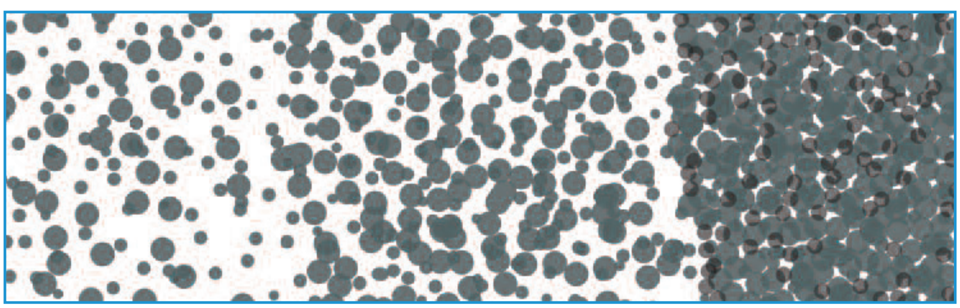


Figure 3. Density is probably the single best measure for strength, wearability and toughness. The term here means just what you think—individual parts packed tightly together. Just like people in an elevator or houses in a neighborhood, if they are dense there is less space between the parts. Of course the spaces in PMC® are submicroscopic, but the idea is the same.

Firing

The tests described here used manufacturers' instructions, followed to the letter. In practice, most artists find a schedule for firing that they use in most cases. It is important to understand that all metal clays rely on a balance of time and temperature. The higher the firing temperature, the quicker the result. If you choose to fire at a lower temperature, it is necessary to extend the time.

The reasons to choose a lower temperature are usually to accommodate a gemstone, to include a glass ornament or because of a metal implant like a sterling finding. If you don't need to work around those, fire any type of metal clay up to 1650°F.

The reasons to choose a shorter firing time are usually because of time restrictions in a workshop or to economize on fuel (Hot Pot and SpeedFire™ Cone). In other situations, fire for at least an hour, except for Original PMC®, which should be fired for two hours. A standing rule is this: Always fire as hot as possible, up to 1650°F (900°C) for as long as practical (say two hours at temperature) to ensure the best and most consistent results.

PMC® Firing Chart

All versions of PMC® should be dry before firing. Air dry or use a hairdryer, stove or lightbulb. PMC3™ takes a bit longer to dry because of its high density.

PMC®	1650°F	900°C	at least 2 hours
PMC+™	1650°F	900°C	at least 10 minutes
	1560°F	850°C	at least 20 minutes
	1470°F	800°C	at least 30 minutes
PMC3™	1290°F	700°C	at least 10 minutes
	1200°F	650°C	at least 20 minutes
	1110°F	600°C	at least 45 minutes

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