Welding Stainless Steel Studio System Parts (17-4 PH & 316L)

Introduction:

Welding is used to fuse metal parts together with the help of an external heat source and a filler material.

The Desktop Metal Application Engineering team welded several sample parts in 17-4 PH and 316L to understand the weldability of Studio System parts. This article describes the process used, recommendations, parts design, fabricate settings, and testing evaluation. If you are interested in replicating the process to weld Studio System parts, follow the procedure outlined below.

Recommendations:

- Add a “v groove” to the part design. A v groove is a "v-shaped" indentation along the entire length of the part's edge.
  - Before welding, post-process the parts by grinding an edge.
  - To eliminate post processing, add a v groove to the part design. For more information see the Additional Notes section below.
- Tack a corner of the parts before welding to evaluate the power required in amps (A). A tack weld is a small weld that spans a very small section to hold the two parts in place and to evaluate power usage.
- Clean the ceramic interface powder from the sintered parts thoroughly, otherwise popping may occur during welding due to contamination.

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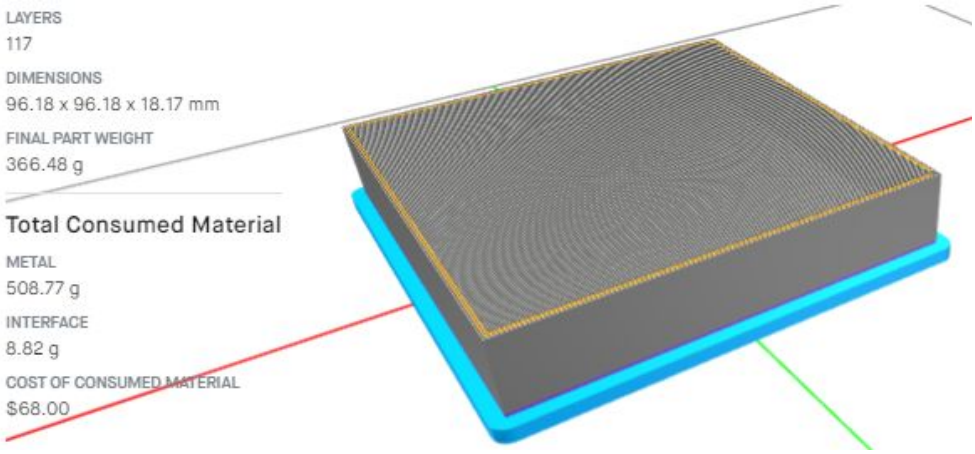
Recommendations for an Experienced Welder:

- 3D printed stainless steel parts weld like high quality off the shelf stainless steel.
- Welding Studio System parts refers to welding the shell (the contours around the part) not the infill (the porous structure inside of the part). The part's shell and infill may influence welding settings.
- Normal filler rod can be used to weld the parts.
- Normal welding techniques are used to weld Studio System parts.

Process:

1. Test specimen design

   The sample part used for this study was a square part as seen below:



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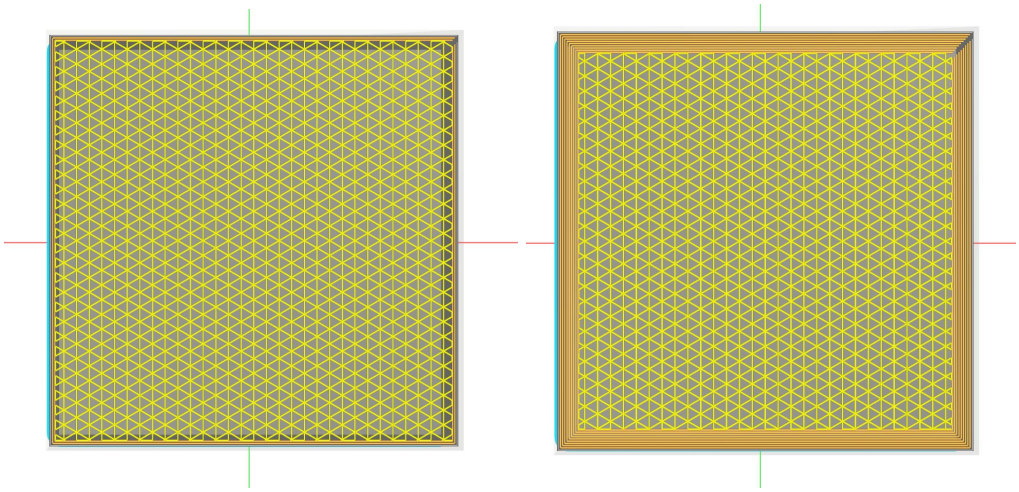
Two different samples were printed with varying shell thicknesses to better understand the effect of the weld on different shells. The first sample had a standard shell thickness of 1.5 mm as green and 1.2 mm as sintered. The second sample had a maximum shell thickness of 5 mm in green and 4 mm as sintered.



Default Shell Maximum Shell

Visit this Knowledge base article to understand shell thickness limitations.

2. Fabricate print processing

We modified the following Custom Settings in Fabricate for the sample with the maximum shell thickness.

Custom Setting	Setting Value	Rationale
Shell > Wall Thickness	4	To test the sample with the largest recommended shell thickness. The largest recommended shell thickness is 4 mm if infill is present and 5 mm with no infill present.
Shell > Top & Bottom Thickness	4	

3. Fabricating the parts

Using the Studio System and 17-4 PH build media, we printed, debound, and sintered two samples with default settings and two samples with maximum shell thicknesses. The test

specimens were printed individually and then batched for processing in the Studio Debinder and Studio Furnace.

4. Preparing the samples

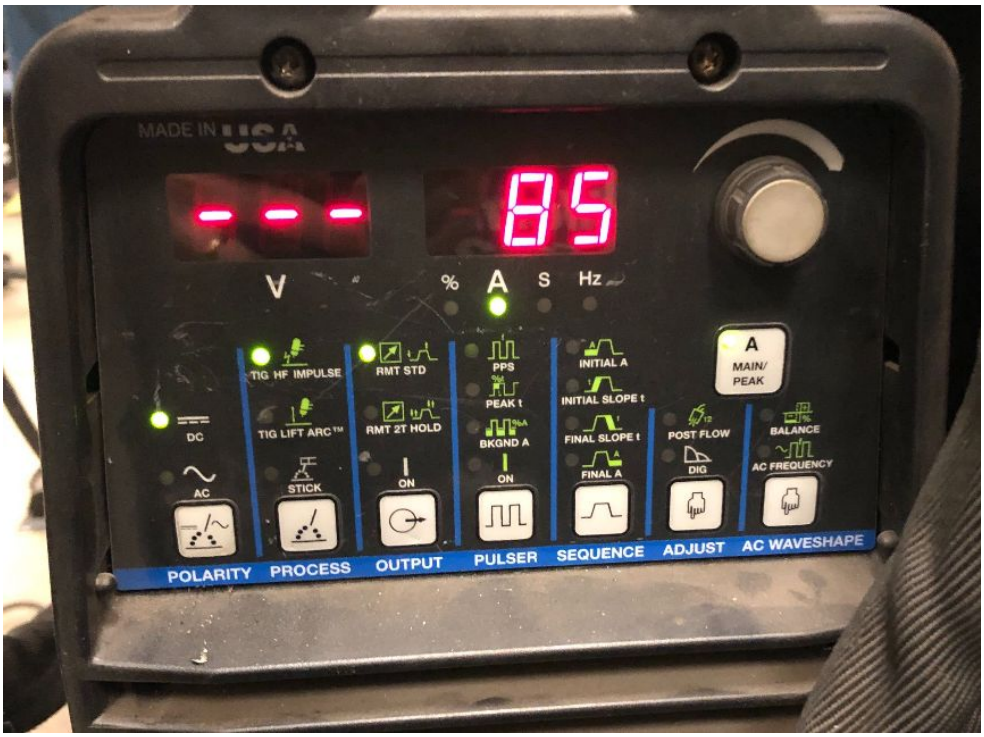
    a. Cut samples in half using a band saw. The final result should be two identical rectangular samples. This was done to ensure welded samples had the exact same shell thickness.

    b. Clean debris and or ceramic powder from samples using pressurized air.
        i. Skipping this step can cause popping during the welding process
    c. One of the samples with the default shell had a v groove post machined to the edge.
        i. This is common practice to get a better weld between the two parts. Please see the recommendations section below for more information regarding v grooves.

5. Welder Setup

The Welder used was a Miller Dynasty 200 with a 3/32 Tungsten 2% thoriated electrode and a 17-4 Stainless Steel filler rod.

a. Set polarity to DC
b. Set process to TIG HF IMPULSE
c. Set output to RMT STD
d. The rest of the settings should be turned off



6. Welding Procedure

The following steps describe the welding procedure the Application team used to weld the sample parts.

Default Shell Thickness Weld Sample (No v groove):

a. Place the weld samples on a workbench. The gap between the two samples should be half the distance as the as-sintered shell or approximately 0.6 mm.
    i. This was done since the samples did not have a v groove to test the worst case scenario. A gap is required to allow space for the 17-4 stainless steel filler.
b. Increase power on the welder to 65 A.

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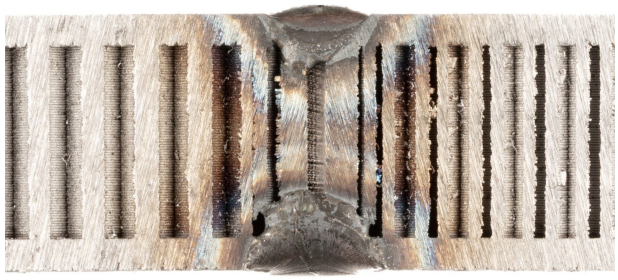
c. Tack weld a corner of the two samples to hold the parts for the full weld and to evaluate the power outage.
    i. The filler melted too quickly so the power was lowered to 60 A.
d. Weld the part from the non tack corner to the tack corner.
e. The power was increased to 120 A since 60 was too low for required penetration.
f. The opposite side was also welded to determine if there's a difference.



Side View (top weld with 60 A; bottom weld with 120 A)

60 A Top View

120 A Top View

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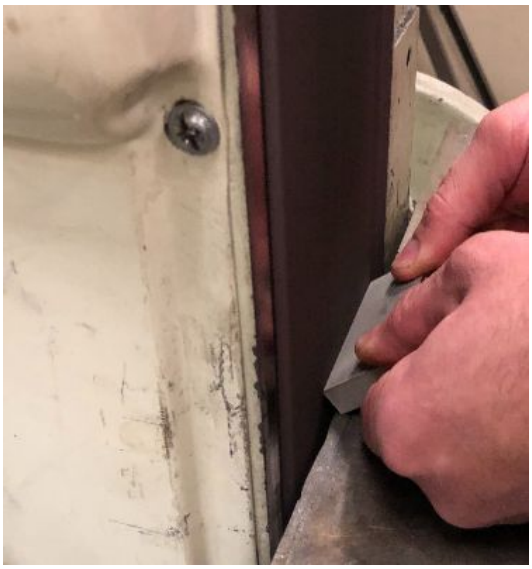
Default Shell Thickness Weld Sample (With machined in v groove):

a. Take the weld samples and use a belt sander to machine the v groove.

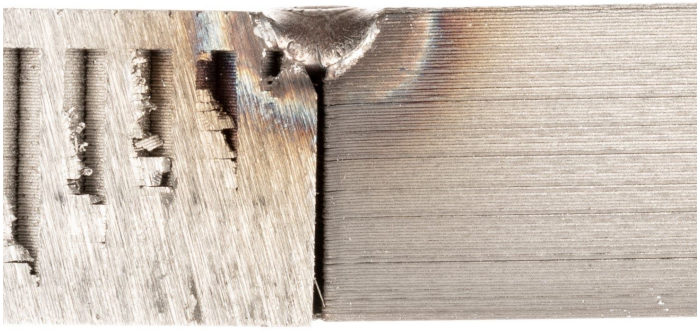


Belt sanding a v groove

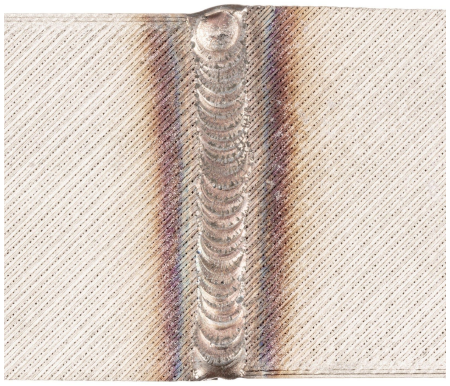
b. Place the samples so the grooves are touching and are facing upwards in a v formation.

c. Increase power on the welder to 65 A.
d. Tack weld a corner of the two samples to hold the parts for the full weld and to evaluate the power outage.

e. Weld the part from the non tack corner to the tack corner.



Side View



Top View

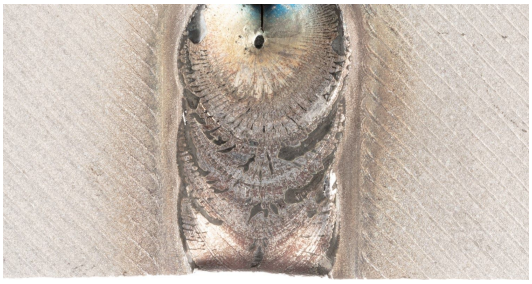
Maximum Shell Thickness Weld Sample (No v groove):

a. Place the weld samples on a workbench. The gap between the two samples should be half the distance as the as-sintered shell or approximately 2.5 mm. This was done since the samples did not have a v groove.
b. Increase power on the welder to 120 A.
c. Tack weld a corner of the two samples to hold the parts for the full weld and to evaluate the power outage.
d. Weld the part from the non tack corner to the tack corner.
e. The power was increased to 150 A. This was done to show penetration with different power output.

f. The opposite side was also welded to determine if there's a difference.

Side View (top weld with 120 A; bottom weld with 150 A)

120 A Top View



150 A Top View

7. Testing Evaluation

The table below summarizes the power range recommended for 17-4 PH sample parts:

	Default Shell 1.5 mm green 1.2 mm sintered	Maximum Shell 5 mm green 4 mm sintered
Min Recommended Amp	60	120
Max Recommended Amp	80	150

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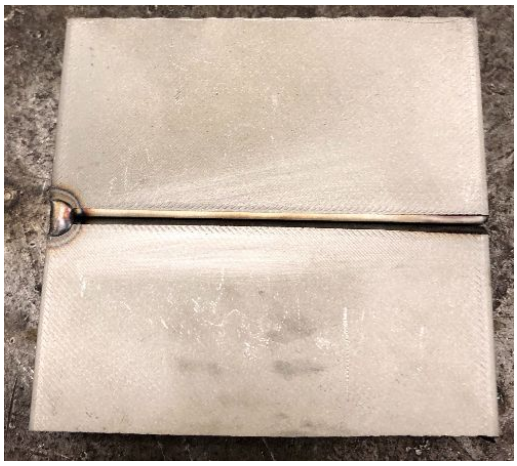
The table below summarizes the penetration of the weld with respect to the power. Penetration may vary depending on the speed of the weld.

Power (A)	Penetration Distance (mm)
60	2.39
120	3.18
150	4.12

Additional Notes

Initial welding evaluation:

Tack a corner of the parts before welding the entire edge to evaluate the power required. Once the tack weld is evaluated and power is adjusted, weld the part from the non tacked corner to the tacked corner.



Tack Weld

Welding From Non Tack Corner to Tack Corner

V groove recommendation:

It is recommended to design the v groove between the two parts that will be welded.

1. The v groove should have a 45 degree angle.
2. The length should be the thickness of half the as sintered shell. If the shell thickness is 3 mm the length of the v groove should be 1.5 mm.

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Welding without a v groove will only weld the contours and not the full part to part. The filler material will only adhere to the outside surface (contours) and will not penetrate all the way through the part. A v groove will allow the filler material to penetrate further and adhere to more surface area.

Welding over infill:

When welding over infill, filler material might fall through the infill gaps if there is not enough shell material. This is only relevant if the part will be machined after sintering as some material (shell) will be removed. When this occurs:

- Slow down the welding process to allow filler material to fill in the gap
- Reduce the current (A)

Filler material:

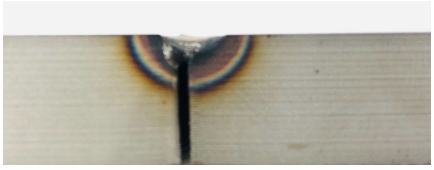
Filler material is typically a metal rod that is heated, liquified, and welded between close fitting parts. For this test we used 17-4 PH as filler. We recommend using filler material that is the same material as the parts. Using different filler material may affect the strength of the weld.

Welding 316L:

Similar welding testing has been done using printed 316L printed blocks. Standard shell parameters were used when printing the parts. 316L filler was used when welding the parts. The power was set to 65 A.

There were two samples: one of them had no v groove; one had a machined v groove. There were no noticeable issues welding 316L.

Without v groove



With v groove

Feel free to contact applications@desktopmetal.com with any feedback about this article.