ACCURATE BRAZING
And Thermal Processing

CASE STUDY 1.01

2020 INDEPENDENT HIP STUDY

# HIP'ing Yields Greatest Tensile Strength for Inconel 718 Components Produced Using Additive Manufacturing.

BY WARREN MIGLIETTI, PH.D., FALL 2020

Inconel 718 is the most popular Ni-based gamma double prime strengthened alloy and is used for manufacturing of high strength functional components. Table 1 shows the chemistry/composition of Inconel 718.

Four heat treatments were conducted on the AM coupons as shown below:

1. AS BUILT (No heat treatment)
2. STRESS RELIEF: 1950°F, 1.5 hours
3. SOLUTION HEAT TREATED (SHT): Per AMS 5596K, Heat to 1725°F to 1850°F, hold for time commensurate with product thickness air cool (or faster)
4. SOLUTION AND AGE HEAT TREATED: Per AMS 5599, Heat to 1325°F to 1400°F, hold for approx 8 hours, cool at 100°F/hr to 1150°F, hold for approx. 8 hours then air cool
5. HIP'ed: proprietary parameters

| ELEMENT | RANGE (WT%) |
|---|---|
| Fe | Balance |
| Ni | 50.00 - 55.00 |
| C | 0.08 max |
| Si | 0.5 max |
| Mn | 0.35 max |
| P | 0.015 max |
| S | 0.015 max |
| Cr | 17.00 - 21.00 |
| Mo | 3.3 max |
| Cu | 0.3 max |
| Nb | 5.5 max |
| Al | 0.3 max |
| Ti | 1.15 max |

**TABLE 1:** Compositional range of Inconel 718 alloy

Table 2 shows the Tensile Properties produced in the AM coupons as a result of the 4 heat treatments compared with wrought sheet/plate material.

The HIP'ed heat treatment yielded the best tensile properties of the AM Alloy Inconel 718 samples.

**TABLE 2:** Comparison of Tensile Strengths of As-build vs 4 post-built heat treatments

| HEAT TREATMENT | ULTIMATE TENSILE STRENGTH | YIELD STRENGTH | ELONGATION |
|---|---|---|---|
| Wrought Sheet/plate | 140 ksi | 80 ksi | 30 % |
| Wrought Sheet/plate SHT and AGE HT | 180 ksi | 150 ksi | 12 % |
| AM-As-built | 127 ksi | 112 ksi | 30% |
| AM + Stress Relieved | 133 ksi | 75 ksi | 42 % |
| AM + Solution heat treated per AMS 5599 | 119 ksi | 46 ksi | 29% |
| AM + Solution and Age heat treated per AMS 5599 | 198 ksi | 153 ksi | 20% |
| AM + HIP'ed | 209 ksi | 162 ksi | 19 % |

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## About the Author

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*Dr. Miglietti is currently the President and Principal Metallurgical Consultant of Miglietti and Associates, LLC, a consultancy company based in Kansas City, Missouri. Prior to this he was Director of Repair Technology at ProEnergy and worked for 7 years at PSM-An Alstom Company. In addition he worked for 5 years at GE's Repair Development Center and 5 years for Sermatech International as a process repair engineer and as a component repair engineer respectively. His principal responsibility was the development of novel repair techniques and processes for components, operating in advanced land-based gas turbine engines, such as the Frame 7FA.03, GT24/26 and W501F/M501F engines. He has over 30 years of experience and expertise in the Welding (GTAW and Laser), Brazing (Narrow and Wide Gap Diffusion), FIC, Acid Stripping and Heat Treatment of Ni and Co-base superalloys. Dr. Miglietti is the outgoing chairman of the Commission XVII – "Brazing and Diffusion Bonding" of the International Institute of Welding (IIW) and was past chairman of the Manufacturing, Materials and Metallurgy Committee of IGTI, an affiliate of ASME. He has authored or co-authored 47 technical papers and has 13 repair technology patents. Today, he has a strong focus on assisting clients with materials characterization and mechanical property evaluation of Additive Manufactured/3D printed components, as well as providing heat treatment information for these components.*

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