ACCURATE BRAZING
And Thermal Processing

CASE STUDY 1.07

2020 INDEPENDENT HIP STUDY

Improve Creep Rupture Properties of Engine Run, Fr7FA.03, 1st Stage Buckets.

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The first stage bucket in Figure 1 operates for 2 or 3 service intervals depending on whether the engine operates in base load or cyclic mode. Table 1 shows how after 2 service intervals the airfoil material, GTD111TM has degraded such that it is significantly below the as-cast virgin like stress rupture properties.

TABLE 1

Location on bucket	Condition of material	Temp F°	Stress in ksi	Hours to Failure	Elongation % at failure	Reduction of Area (RoA)%
Pressure side Sample 1	As received-engine run- 2 hotgas path (HGP) service intervals	1800	27	10.2	15.2	29.3
Pressure side Sample 2	As received-engine run- 2 hot gas path (HGP) service intervals	1800	27	14.7	15.6	28.7
Suction side Sample 1	As received-engine run- 2 hot gas path (HGP) service intervals	1800	27	28.8	21.2	33.1
Suction side Sample 2	As received-engine run- 2 hot gas path (HGP) service intervals	1800	27	31.2	22.4	31.9
Shank side Sample 1	As received-engine run- 2 hot gas path (HGP) service intervals	1800	27	51.4	26.8	48.4
Shank side Sample 2	As received-engine run- 2 hot gas path (HGP) service intervals	1800	27	54.3	28.8	46.6
Root side Sample 1	As received-engine run- 2 hot gas path (HGP) service intervals	1800	27	33.7	27.7	55.6
Roots side Sample 2	As received-engine run- 2 hot gas path (HGP) service intervals	1800	27	39.9	24.3	51.1
Pressure side	HIP Rejuvenated material. HIP cycle is 2215F/4hrs/15ksi	1800	27	94.7	30.2	57.2
Suction side	HIP Rejuvenated material. HIP cycle is 2215F/4hrs/15ksi	1800	27	97.4	33.1	54.4
Shank side	HIP Rejuvenated material. HIP cycle is 2215F/4hrs/15ksi	1800	27	88.9	30.1	51.1
Root side	HIP Rejuvenated material. HIP cycle is 2215F/4hrs/15ksi	1800	27	89.9	34.3	49.3
N/A	Virgin Material	1800	27	50	10 minimum	10 minimum
Pressure side Sample 1	As received-engine run- 2 hot gas path (HGP) service intervals	1400	95	8.2	16.9	29.8
Pressure side Sample 2	As received-engine run- 2 hot gas path (HGP) service intervals	1400	95	14.7	17.6	27.9
Suction side Sample 1	As received-engine run- 2 hot gas path (HGP) service intervals	1400	95	15.8	16.2	23.1
Suction side Sample 2	As received-engine run- 2 hot gas path (HGP) service intervals	1400	95	18.7	18.6	22.3
Shank side Sample 1	As received-engine run- 2 hot gas path (HGP) service intervals	1400	95	104.5	15.1	31.9
Shank side Sample 2	As received-engine run- 2 hot gas path (HGP) service intervals	1400	95	109.3	16.2	36.4

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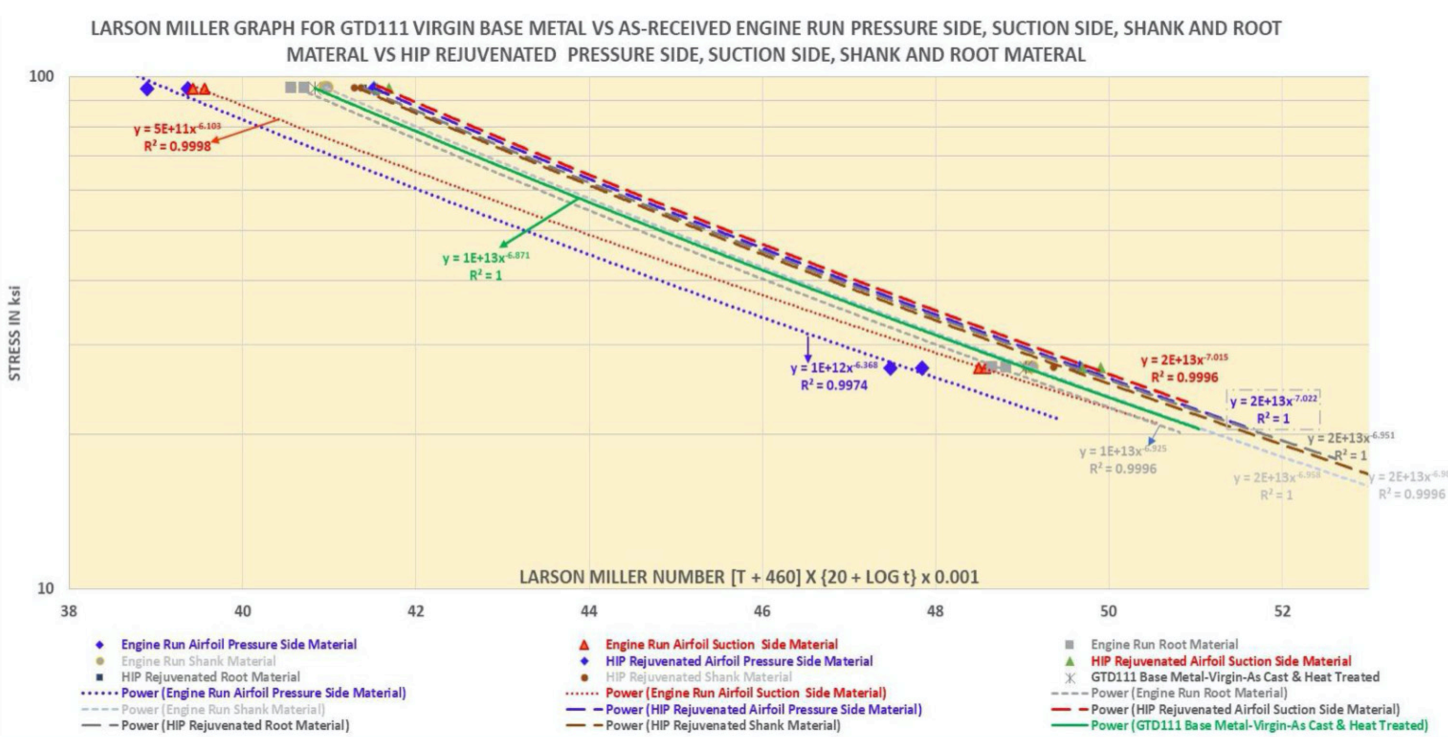
Root side Sample 1	As received-engine run- 2 hot gas path (HGP) service intervals	1400	95	64.6	19.3	32.5
Roots side Sample 2	As received-engine run- 2 hot gas path (HGP) service intervals	1400	95	77.9	18.8	24.7
Pressure side	HIP Rejuvenated material. HIP cycle is 2215F/4hrs/15ksi	1400	95	210.1	18.5	31.9
Suction side	HIP Rejuvenated material. HIP cycle is 2215F/4hrs/15ksi	1400	95	220.2	18.8	36.6
Shank side	HIP Rejuvenated material. HIP cycle is 2215F/4hrs/15ksi	1400	95	175.5	17.7	39.5
Root side	HIP Rejuvenated material. HIP cycle is 2215F/4hrs/15ksi	1400	95	180.4	17.9	40.7
N/A	Virgin Material	1400	95	100	15 minimum	20 minimum

As can be seen in Table 1, the engine run material removed from the airfoil and root all failed below 50 hours when stress rupture tested at 1800°F/27ksi; whereas the 2 specimens removed from the shank barely passed achieving 51.4 and 54.3 hours respectively. However, all the HIP Rejuvenated material removed from the airfoil, shank and root successfully met the 50 hours minimum life. In fact, the HIP Rejuvenated material was 1.78X – 1.95X superior/better than virgin as cast and heat treated material at the stress rupture conditions of 1800°F/27ksi. A similar conclusion was reached at the 1400°F/95ksi condition, where the engine run material removed from the airfoil and root all failed below 100 hours; whereas the 2 specimens removed from the shank barely passed achieving 104.5 and 109.3 hours respectively. However, all the HIP Rejuvenated material removed from the airfoil, shank and root successfully met the 100 hours minimum life. In fact, the HIP Rejuvenated material was 1.76X – 2.20X superior/better than virgin as cast and heat treated material at the stress rupture conditions of 1400°F/95ksi. This first case study shows how the proper use of HIP Technology can be used to extend the life of these stage 1 buckets.

FIGURE 1: (below) Shows the same tabular data in Table 1 in graphical form. What is clear is that all HIP Rejuvenated material represented by the 4 dashed lines (not dotted lines) essentially lie on top of each other, showing that the HIP Rejuvenation process reduced scatter in the data. R squared values of 1 were recorded 4 times. The other crystal clear information shown in Figure 1 is that the HIP Rejuvenated material even had better stress rupture properties compared to that of the virgin like base metal, proving that HIP Rejuvenated material has superior stress rupture properties when compared to original cast and heat treated material. The 2 dotted lines show the engine run pressure and suction side of the airfoil material, indicating that engine run material declines in strength and creep properties as a result of engine exposure.

FIGURE 1



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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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