



Flowformed Nickel-Based Superalloy Inconel 718 AMS 5662

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Dynamic Flowform Corporation of Billerica, Massachusetts, USA, has been successfully flowforming Inconel 718 for many years. Flowforming is a cold forming process for the production of seamless, dimensionally precise tubular components. Besides offering lower cost alternatives to machining from solid bar, due to the cold working of the material, the microstructure of flowformed products are superior to that of bar or sheet.

After flowforming, shafts with a wall-thickness of 0.098" were given a standard solution heat treatment (at a temperature of 1750° F) and a two-step precipitation or aging heat treatment. Flat-type tensile specimens having the curvature of the tube were prepared from a representative piece. The results from these tests are as follows.

Properties of flowformed Inco 718 after solution & aging heat treatment

| Spec. # | Y.S., ksi | U.T.S., ksi | Elong., % | Hardness, Rockwell C |
|----------------|--------------|--------------|-------------|----------------------|
| 9-1 | 192.0 | 222.0 | 20.6 | 48 |
| 9-2 | 192.0 | 221.0 | 21.0 | 48 |
| 9-3 | 185.0 | 219.0 | 20.8 | 48 |
| 9-4 | 188.0 | 221.0 | 20.2 | 48 |
| Average | 189.2 | 220.8 | 20.8 | 48 |

Microstructures before and after flowforming

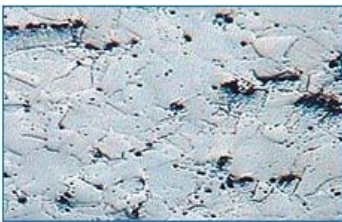


Figure 1:
Preform 100X etched

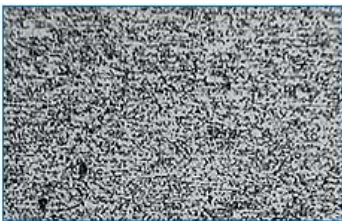


Figure 2:
Flowformed 100X etched

A typical microstructure of Inconel 718 AMS 5662 is shown in Figure 1. The specimen was etched in Kallings' (non-water containing) etching solution by immersion for 5 minutes. The grain sizes range from ASTM 5.5 – 6.

The microstructure of flowformed Inconel 718 after a full heat treatment is shown in Figures 2 and 3. The specimen was electrolytically etched in a solution of 50% hydrochloric acid, 50% water plus a few drops of hydrogen peroxide for 30 seconds at 6 volts. The grain sizes range from ASTM 11 - 12.



Flowformed Inconel 718 60" tube on the left and 15" preform on the right

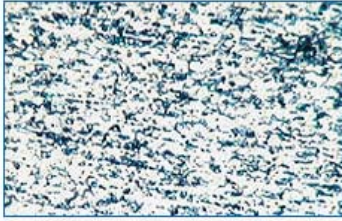
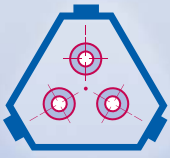


Figure 3:
Flowformed 700X etched

The directionality imparted by the flowforming process is shown in Figure 3 at a magnification of 700X.

The etching procedure delineates the secondary phases but the grain boundaries of the matrix are not visible. However, based on prior experience, the very high density of the secondary phases indicates an extremely fine grain structure as would be expected from solution heat treating a heavily cold-worked structure at 1750 F during the full heat treatment.

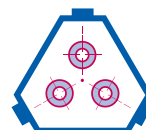
It is noteworthy that microstructural examination of specimens from this and other parts reveals no evidence of internal cracking, galling or tearing of the metal from the flowforming process. Typical surface finishes are 8 micro inch on the ID and 16 on the OD.

Concluding Remarks

The flowforming process offers the designer an opportunity to explore the very high tensile properties including grain refinement of Inconel 718 after a full solution heat treatment of the flowformed tubular parts.



Flowformed Inconel 718 with 8 micro inch finish on the ID



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