

NIMONIC 90, NICKEL ALLOY 90, UNS N07090, AMS 5829

Nimonic 90 is a nickel-based superalloy known for its exceptional high temperature strength, corrosion resistance, and oxidation resistance. It belongs to the family of Nimonic alloys, which are widely used in applications requiring elevated temperature performance, such as gas turbine components, aerospace engines, and industrial furnaces.

Key properties of Nimonic 90 include:

- 1. **High Temperature Strength**: Nimonic 90 exhibits excellent mechanical strength at elevated temperatures, making it suitable for use in environments with temperatures up to about 1000°C (1832°F).
- 2. **Oxidation and Corrosion Resistance**: This alloy offers exceptional resistance to oxidation and corrosion, even in high temperature and harsh environments containing gases, such as hydrogen and sulfur.
- 3. **Creep Resistance**: Nimonic 90 demonstrates good resistance to creep deformation under constant stress at high temperatures, maintaining its dimensional stability over extended periods of time.
- 4. **High Fatigue Resistance**: The alloy has good fatigue resistance, allowing it to withstand cyclic loading and thermal cycling without failure, contributing to its durability and longevity in service.
- 5. **Weldability**: Nimonic 90 can be welded using conventional welding techniques, although preheating and post-weld heat treatment may be required to minimize the risk of cracking and ensure the integrity of the welded joints.
- 6. **Machinability**: While Nimonic 90 is generally more difficult to machine compared to conventional steels, it can be machined using appropriate tooling and machining techniques.
- 7. **Applications**: Nimonic 90 is commonly used in gas turbine components, such as turbine blades, turbine discs, combustion chambers, and exhaust systems, as well as in aerospace and industrial applications where high temperature performance is essential.

Chemical Composition

Grade	Chemical Composition Weight %													
	Ni	Cr	Co	Ti	Al	C	Si	Cu	Fe	Mn	B	S	Zr	Pb
Alloy 90	Bal	18-21	15-21	2-3	1-2	0.2 max	1.0 max	0.2 max	1.5 max	1.0 max	0.02 max	0.015 max	0.15 max	0.0020 max

Mechanical Properties

Material Extruded Bar	Temperature °C	Yield Strength 0.2 % (MPa)	Tensile Strength (MPa)	Elongation (%)	Hardness HV
Nimonic 90 bar Solution Treated (BS HR2)	RT	-	-	-	295 max
Nimonic 90 bar Precipitation Treated (BS HR2)	RT	695 min	1080 min	20 min	310 min
Nimonic 90 Bar Precipitation Treated (BS HR2)	500	672 (typical)	1038 (typical)	31	-

- Tensile Strength**: Nimonic 90 typically exhibits a high tensile strength ranging from approximately 850 MPa to 1100 MPa (123,000 psi to 160,000 psi), depending on the specific heat treatment and processing conditions.
- Yield Strength**: The yield strength of Nimonic 90 is typically in the range of 400 MPa to 800 MPa (58,000 psi to 116,000 psi), again depending on heat treatment and processing.
- Elongation**: Nimonic 90 typically has a moderate to high elongation at break, ranging from about 15% to 30%, providing good ductility for various applications.
- Hardness**: The hardness of Nimonic 90 can vary depending on the heat treatment and processing conditions. In the annealed condition, it typically has a hardness of around 150 to 250 HV (Vickers hardness).
- Impact Resistance**: Nimonic 90 generally exhibits good impact resistance, making it suitable for applications subjected to dynamic loading conditions.
- Fatigue Strength**: Nimonic 90 has good fatigue resistance, with the ability to withstand repeated cyclic loading at high temperatures without failure.

Physical Properties

The physical properties of Nimonic 90 include:

- Density**: The density of Nimonic 90 is typically around 8.18 g/cm³ (0.296 lb/in³).
- Melting Point**: Nimonic 90 has a relatively high melting point, which is approximately 1315°C (2400°F).
- Thermal Conductivity**: The thermal conductivity of Nimonic 90 is relatively low compared to some other metals, typically around 11.5 W/(m·K) at room temperature.
- Specific Heat Capacity**: The specific heat capacity of Nimonic 90 is approximately 410 J/(kg·K) at room temperature.
- Coefficient of Thermal Expansion**: Nimonic 90 has a coefficient of thermal expansion of around 12.8 µm/m·K at 20°C (68°F).
- Electrical Conductivity**: Nimonic 90 is not typically used for its electrical conductivity, but it generally exhibits low electrical conductivity.
- Magnetic Properties**: Nimonic 90 is generally non-magnetic in the annealed condition, but it can become slightly magnetic after cold working or heat treatment.

These physical properties are important considerations for engineering and design purposes, particularly in applications where thermal stability, dimensional stability, and other physical characteristics are critical.

Heat Treatment

Heat treatment is a process used to alter the physical and mechanical properties of materials, including metals and alloys, by heating and cooling them under controlled conditions. In the case of Nimonic 90, heat treatment can be employed to achieve desired characteristics such as improved strength, hardness, and ductility. The typical heat treatment process for Nimonic 90 may involve the following steps:

Solution Treatment: Nimonic 90 is usually solution treated by heating the material to a specific temperature range, typically between 1050°C to 1100°C (1922°F to 2012°F), and holding it at that temperature for a specified period. This step allows for the dissolution of alloying elements and the formation of a homogeneous microstructure.

Quenching: After solution treatment, Nimonic 90 is rapidly cooled, or quenched, usually in water, oil, or air, to achieve the desired mechanical properties. Quenching helps to "freeze" the microstructure in its high-temperature state, resulting in increased strength and hardness.

Aging or Precipitation Hardening: Following quenching, Nimonic 90 may undergo an aging or precipitation hardening process. This involves reheating the material to a lower temperature, typically between 720°C to 760°C (1328°F to 1400°F), and holding it at that temperature for a certain period. During aging, fine precipitates form

within the microstructure, further strengthening the material.

Cooling: After aging, Nimonic 90 is allowed to cool naturally or is air-cooled to room temperature. This step completes the heat treatment process and stabilizes the material's microstructure.

Welding Properties

Welding Nimonic 90 requires careful consideration of its specific properties and characteristics to ensure a successful and durable weld. Here are some key points to consider when welding Nimonic 90:

- Preparation**: Thoroughly clean the surfaces to be welded to remove any contaminants, such as oil, grease, or oxides, which can negatively affect the quality of the weld.
- Welding Method**: Gas tungsten arc welding (GTAW or TIG) is commonly used for welding Nimonic 90 due to its precision and control. Gas metal arc welding (GMAW or MIG) can also be used, but it may require additional precautions.
- Filler Material**: Select a filler material that matches the composition of Nimonic 90 and provides suitable mechanical properties for the intended application. Nimonic 90 filler wire or rod is often used for welding Nimonic 90.
- Preheat**: Preheating the base metal can help reduce the risk of cracking and improve the weldability of Nimonic 90. Preheat temperatures typically range from 150°C to 300°C (300°F to 570°F), depending on the thickness of the material and the welding process.
- Welding Parameters**: Adjust welding parameters such as current, voltage, and travel speed to achieve optimal penetration and fusion while minimizing the heat input. Nimonic 90 is sensitive to overheating, so it's important to avoid excessive temperatures during welding.
- Shielding Gas**: Use a high-purity inert gas, such as argon or helium, as a shielding gas to protect the weld pool from atmospheric contamination and oxidation.
- Post-Weld Heat Treatment (PWHT)**: Depending on the specific requirements of the application, a post-weld heat treatment may be necessary to relieve residual stresses and improve the mechanical properties of the weld.
- Welding Position and Joint Design**: Consider the welding position and joint design when planning the welding process. Ensure proper fit-up and accessibility to facilitate welding and achieve high-quality welds.
- Cooling Rate**: Control the cooling rate of the weldment to minimize the risk of cracking and distortion. Slow cooling or post-weld annealing may be necessary for thicker sections or complex geometries.

By following these guidelines and best practices, it is possible to achieve high-quality welds when welding Nimonic 90, ensuring the integrity and performance of the welded components in demanding applications.

Machining Properties

Machining Nimonic 90 requires careful attention to its unique properties to achieve accurate and efficient results. Here are some key points to consider when machining Nimonic 90:

- Tool Selection**: Use cutting tools made of high-speed steel (HSS) or carbide with suitable coatings such as titanium nitride (TiN) or titanium carbonitride (TiCN). These tools offer good wear resistance and cutting performance when machining Nimonic 90.

2. **Cutting Speed**: Nimonic 90 is a hard and heat-resistant material, so use moderate to low cutting speeds to minimize tool wear and heat generation. Start with conservative cutting speeds and adjust as needed based on tool performance and workpiece conditions.
3. **Feed Rate**: Adjust the feed rate to achieve optimal chip formation and evacuation. Use higher feed rates for roughing operations and lower feed rates for finishing operations to achieve desired surface quality and dimensional accuracy.
4. **Depth of Cut**: Nimonic 90 is prone to work hardening, so use shallow depths of cut to minimize tool wear and ensure consistent cutting performance. Avoid aggressive cuts that may lead to excessive tool pressure and heat generation.
5. **Coolant Use**: Use ample coolant or cutting fluid during machining to dissipate heat and lubricate the cutting tool-workpiece interface. Flood coolant or through-tool coolant delivery systems are effective in cooling and lubricating the cutting zone.
6. **Tool Geometry**: Select cutting tools with appropriate geometry, including rake angle, clearance angle, and cutting edge geometry, to optimize chip formation and evacuation. Sharp cutting edges and positive rake angles are generally preferred for machining Nimonic 90.
7. **Workpiece Fixturing**: Secure the workpiece firmly to minimize vibrations and ensure stability during machining operations. Use proper clamping devices or fixtures to hold the workpiece securely in place.
8. **Tool Wear Monitoring**: Regularly inspect cutting tools for signs of wear and damage, such as flank wear, chipping, or built-up edge. Replace worn or damaged tools promptly to maintain machining accuracy and productivity.
9. **Chip Control**: Manage chip formation and evacuation to prevent chip recutting and tool damage. Use appropriate chip breakers, tool coatings, or chip evacuation systems to control chip flow and improve machining efficiency.
- By following these guidelines and best practices, it is possible to achieve efficient and accurate machining of Nimonic 90, meeting the requirements of various industrial applications while extending tool life and minimizing production costs.