HAYNES 25, UNS R30605, 2.4964

Haynes 25, also known as L605 alloy, is a high-temperature alloy. It is a cobalt-based alloy known for its excellent high-temperature strength, oxidation resistance, and corrosion resistance. It is commonly used in aerospace, aviation engines, petrochemicals, medical devices, and other industries. Haynes 25 alloy performs well in high-temperature environments, enduring the harsh conditions of elevated temperatures and corrosion.

Chemical Composition

The chemical composition of Haynes 25 alloy typically includes:

- Cobalt (Co): Approximately 50%
- Chromium (Cr): Around 20%
- Tungsten (W): Typically 15%
- Nickel (Ni): Approximately 10%
- Iron (Fe): Usually less than 3%
- Molybdenum (Mo): Generally less than 2%
- Carbon (C): Typically less than 0.1%
- Other trace elements: Including small amounts of manganese, silicon, sulfur, and boron.

Please note that the exact composition may vary slightly depending on the specific manufacturing process and the desired properties of the alloy.

Mechanical Properties

1. **Tensile Strength**: Haynes 25 has a high tensile strength, typically ranging from 800 MPa to 1100 MPa (116,000 psi to 160,000 psi), depending on the heat treatment and processing conditions.

2. **Yield Strength**: The yield strength of Haynes 25 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.

3. **Elongation**: Haynes 25 exhibits moderate to high elongation at break, typically ranging from 10% to 25%, providing good ductility for various applications.

4. **Hardness**: The hardness of Haynes 25 can vary depending on the heat treatment and processing conditions. In the annealed condition, it typically has a hardness of around 200 to 300 HV (Vickers hardness).

5. **Impact Resistance**: Haynes 25 generally demonstrates good impact resistance, allowing it to withstand dynamic loading conditions.

6. **Fatigue Strength**: Haynes 25 has excellent fatigue resistance, with the ability to withstand repeated cyclic loading at high temperatures without failure.

These mechanical properties make Haynes 25 suitable for use in demanding environments where high strength, excellent oxidation resistance, and thermal stability are required, such as aerospace, gas turbine engines, industrial furnaces, and medical implants.

Physical Properties

1. **Density**: The density of Haynes 25 is typically around 9.24 g/cm³ (0.334 lb/in³), making it a relatively dense material.

2. **Melting Point**: Haynes 25 has a high melting point, which is approximately 1325°C (2417°F). This high melting

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point contributes to its ability to withstand elevated temperatures.

3. **Thermal Conductivity**: The thermal conductivity of Haynes 25 is relatively low compared to some other metals, typically around 11.5 W/(m·K) at room temperature.

4. **Specific Heat Capacity**: The specific heat capacity of Haynes 25 is approximately 415 J/(kg·K) at room temperature.

5. **Coefficient of Thermal Expansion**: Haynes 25 has a coefficient of thermal expansion of around 12.8 µm/m·K at 20°C (68°F). This value indicates how much the material expands or contracts with changes in temperature.

6. **Electrical Conductivity**: Haynes 25 is not typically used for its electrical conductivity, but it generally exhibits low electrical conductivity.

7. **Magnetic Properties**: Haynes 25 is typically non-magnetic in the annealed condition, but it can become slightly magnetic after cold working or heat treatment.

These physical properties contribute to the overall performance and suitability of Haynes 25 alloy for high-temperature applications, where factors such as thermal stability, dimensional stability, and resistance to environmental factors are important considerations.

Heat Treatment

The heat treatment process for Haynes 25 alloy, also known as L605 alloy, typically involves the following steps:

1. **Solution Treatment**: Haynes 25 is first solution treated by heating the material to a specific temperature range, usually around 1180°C to 1220°C (2156°F to 2228°F), depending on the specific composition and desired properties. The alloy is held at this temperature for a certain duration to dissolve any precipitates and achieve a homogeneous microstructure.

2. **Quenching**: After solution treatment, the alloy is rapidly quenched, usually in water or oil, to "freeze" the microstructure in its high-temperature state. Quenching helps to lock in the desired properties, such as high strength and hardness, achieved during solution treatment.

3. **Aging or Precipitation Hardening**: Following quenching, Haynes 25 may undergo an aging or precipitation hardening process. The alloy is reheated to a lower temperature, typically around 760°C to 870°C (1400°F to 1600°F), and held at this temperature for a specific time period. During aging, fine precipitates form within the microstructure, further strengthening the material.

4. **Cooling**: After aging, Haynes 25 is cooled naturally or air-cooled to room temperature. This completes the heat treatment process and stabilizes the microstructure of the alloy.

The exact parameters of the heat treatment process, including temperatures, durations, and cooling rates, may vary depending on the specific requirements of the application and the desired properties of the final product. It's essential to carefully control the heat treatment process to ensure that Haynes 25 alloy achieves the desired

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combination of mechanical properties, such as strength, hardness, and toughness, for its intended use.

Welding Properties

Welding Haynes 25 alloy, also known as L605 alloy, requires careful consideration of its unique properties to ensure successful and durable welds. Here are some key points to consider when welding Haynes 25: 1. **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. 2. **Welding Method**: Gas tungsten arc welding (GTAW or TIG) is commonly used for welding Haynes 25 due to its precision and control. Gas metal arc welding (GMAW or MIG) can also be used, but it may require additional precautions. 3. **Filler Material**: Select a filler material that matches the composition of Haynes 25 and provides suitable mechanical properties for the intended application. Haynes 25 filler wire or rod is often used for welding Haynes 25. 4. **Preheat**: Preheating the base metal can help reduce the risk of cracking and improve the weldability of Haynes 25. 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. 5. **Welding Parameters**: Adjust welding parameters such as current, voltage, and travel speed to achieve optimal penetration and fusion while minimizing the heat input. Haynes 25 is sensitive to overheating, so it's important to avoid excessive temperatures during welding. 6. **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. 7. **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. 8. **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. 9. **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 Haynes 25, ensuring the integrity and performance of the welded components in demanding applications.

Machining Properties

Machining Haynes 25 alloy, also known as L605 alloy, requires special attention due to its unique properties. Here are some key points to consider when machining Haynes 25: 1. **Tool Selection**: Use cutting tools made of high-speed steel (HSS) or carbide with sharp cutting edges and coatings designed for high-temperature alloys. These tools provide good wear resistance and cutting performance. 2. **Cutting Speed**: 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**: 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

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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 Haynes 25. 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, you can achieve efficient and accurate machining of Haynes 25, meeting the requirements of various industrial applications while extending tool life and minimizing production costs.

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