HAYNES® 214® alloy

Welding

HAYNES® 214® alloy is a precipitation-strengthened alloy. When the gamma prime phase (Ni_3Al) precipitates, the alloy undergoes a slight volumetric contraction. It is possible that stress and strain caused by welding and mechanical deformation caused by the precipitation may cause cracking.

Good welding practice to join gamma prime alloys applies to 214® alloy:

- Base metal should be normally in the solution-annealed condition
- Minimize heat input
- Minimize restraint
- Cleanliness is critical
- Use stringer beads
- Maintain interpass temperature of 200°F maximum
- Use better layers or forgiving fillers (HASTELLOY® X alloy or HASTELLOY® S alloy) as required
- A convex profile (crowned) weld bead is mandatory
- No partial penetration welds

HAYNES® 214® alloy has been joined successfully using gas tungsten arc (GTAW), gas metal arc (GMAW), shielded metal arc (coated electrode), and plasma arc (PAW) welding techniques. Matching composition filler metal is recommended for joining 214 alloy. For shielded metal-arc welding, HASTELLOY® X electrodes (AMS 5799) are suggested. For dissimilar metal joining of 214® alloy to nickel- or cobalt-base materials, HAYNES® 230-W® filler metal will generally be a good selection, but HASTELLOY® S alloy (AMS 5838) or HASTELLOY® W alloy (AMS 5786, 5787) welding products may be used. For dissimilar welding to iron-base materials, HAYNES® 556® (AMS 5831) filler metal is recommended. When using a filler metal other than 214® alloy, the environmental resistances of the weld will be inferior to that of the base metal, and a cover pass using 214® alloy wire is suggested as a means to increase environmental resistance.

Base Metal Preparation

The joint surface and adjacent area should be thoroughly cleaned before welding. All grease, oil, crayon marks, sulfur compounds and other foreign matter should be removed. It is preferable that the alloy be in the solution-annealed condition when welded. One-inch wide areas along each side of the weld joint should be ground to expose bright metal before welding. Welds should also be ground between passes.

Weld Joints

A square butt joint is used for sheet material up to 7/64 inch. A V-joint is used for butt welds in thicknesses from 7/64 inch up to 3/8 inch, a double-V or a U-joint for thicknesses of 3/8 inch to 5/8 inch (a double-V joint is preferred if both sides of the plate are accessible), and a double-U joint for thicknesses over 5/8 inch. T-joints are used when required by design. Partial penetration or fillet welds are not recommended.

V-joints should be beveled to a 60° included angle for GTAW welding, (70° for SMAW), while U-joints should have bevels with an included angle of 30° and a minimum radius of ¼ inch. For coated electrodes, the joint should be opened up an additional 10 - 15°.

Weld Penetration

For full penetration, material 12-gage (7/64 inch) and heavier should be welded from both sides. Material thinner than 12-gage may be welded from one side by using proper edge spacing to allow full penetration. Care should be exercised to prevent incomplete penetration. This condition can leave undesirable crevices and voids in the underside of the joint. Incomplete penetration in material used for high-temperature applications creates stress risers for focal points of mechanical failure.

When welding from both sides is not practical, the joint spacing should be increased and a copper backing bar used. Currents slightly higher than normal are used to obtain complete penetration.

HAYNES® 214® alloy has a lower thermal conductivity than steel; therefore, when using a standard groove, it is necessary to use slightly larger clearance than would be needed for steel.

Preheating, Interpass Temperatures and Postweld Heat Treatment

Preheat is not usually required so long as base metal to be welded is above 32°F (0°C). It is critical to minimize heat input. The lowest amperage and voltage possible are preferred. Minimize weave, use stringer beads when possible. Avoid excessively slow travel speeds and out-of-position welding, which cause heat buildup. Excessively fast travel speeds result in teardrop-shaped weld puddles and should also be avoided to prevent centerline cracking. Interpass temperatures should less than 200°F. Auxiliary cooling methods, including water quenching, may be used between weld passes, as needed, providing that such methods do not introduce contaminants and the part is dried.

Postweld heat treatment for 214® alloy depends on part thickness and complexity. For 214® alloy fabrications that will be in service at 1200-1800ºF, weldments made of greater than 1/4" thickness, or those which have been welded into configurations which create significant residual stresses, a postweld annealing heat treatment is suggested. The objective of a postweld heat treatment is to minimize and eliminate residual stress in the assembly.

A heat treatment at a metal temperature between 1900ºF and 2000ºF has been successful. The metal at temperature as little as 5 minutes is usually sufficient. If no additional welding or forming is to be performed, the fabrication may be air cooled, otherwise rapid cooling is advised.

Care must be taken when annealing. Heating 214® alloy through the temperature range of 1200-1800ºF will cause gamma prime (Ni_3Al) to precipitate. This gamma prime precipitation results in a net shrinkage, as well as an increase in strength and corresponding loss of ductility. In weldments and other highly stressed components, strain-age cracking may occur. This occurs when the residual stresses from forming and welding, augmented by stresses caused by precipitation, exceed the rupture strength of the base metal. It is important to heat the material through the 1200-1800ºF temperature range as rapidly as possible. Do not stress relieve in the 1200-1800ºF temperature range.

Torch heating or heating methods employing direct flame impingement on the fabrication should be avoided. Heating has been successfully done in an air atmosphere, as well as a protective atmosphere.