1. Introduction

Inconel 718 is a precipitation hardenable Ni and Fe-based superalloy widely used in high-temperature applications in aerospace, gas turbines, power and nuclear industries, pumps, and tooling due to its excellent corrosion and oxidation resistance at a temperature up to 650 ℃. The Ni-based superalloy was mainly strengthened by precipitation hardened cubic or spherical shaped $Ni_3(Al, Ti)$ coherent precipitates having an ordered FCC L12 crystal structure prior to Inconel 718 [1]. The $Ni_3(Al, Ti)$ coherent precipitates experienced a rapid precipitation of hardened phase when subjected to an intermediate temperature range. This rapid precipitation of hardened phase results in heat treatment associated cracking, which has been observed in the Ni-based superalloy such as Waspaloy, Rene 41, Inconel X750, and Udimet 700 [2]. On the other hand, Inconel 718 exhibits good weldability because of slow precipitation of the principle strengthening precipitate γ''-Ni_3Nb phase having a lens like a disc shaped body-centered tetragonal structure. This coherent precipitate provides more time for the alloy to obtain the required hardness and causes stress to be relieved or relaxed before hardening. This slow aging characteristic of Inconel 718 enhances its resistance to cracking during post weld heat treatment. However, the addition of Nb in the alloy significantly reduces the strain age cracking problem, but it arises another problem of liquation cracking (microfissuring) in HAZ [3, 4]. The microfissures usually occur perpendicular to fusion boundary or under the tail head. The combination of grain boundary liquation and tensile stresses results in microfissure in the heat affected zone (HAZ) of Inconel 718 weld [5]. Another main problem for Inconel 718 alloy is the segregation of element Nb and consequently the formation of Nb-rich Laves phases, a brittle intermetallic compound found inside the weld and at the boundary in the HAZ. It can be denoted by a nominal formula of MN_2. Here Nb, Mo, and Ti are assigned to represent the larger M atom and Ni, Fe, and Cr the N-type atom [6]. It has been reported that formation of Laves phases is detrimental to weld mechanical properties because (i) it depletes the main matrix from the principal strengthening elements by consuming significant amount of these strengthening elements, (ii) it forms a weak zone microstructure between the Laves phase and matrix interface, (iii) it acts as a nucleating site for crack initiation and propagation because of its inherent brittle nature, and deteriorates the mechanical properties of weld metal like tensile ductility, fracture toughness, fatigue and creep rupture properties [7–10]. As the presence of Laves phases in Inconel 718 weld is detrimental, efforts should be made to minimize the formation of Laves phases by reducing the segregation during weld metal solidification. The comparison of Nb segregation and formation of Laves phases in gas tungsten arc (GTA) and electron beam (EB) welding of Inconel 718 has been reported by Radhakrishna and Rao [11, 12]. The authors have discussed the advantages of using lower heat input processes for welding alloy to reduce the Laves phases in the weld metal. Murthy [13] discussed the advantages of oscillation beam technique for controlling Nb segregation and Laves formation in alloy 718 EB weld. Ram et al. [9] illustrated the advantage of using pulsed laser welding for controlling Nb segregation and consequently the formation of Laves phases at different post-weld heat treatment.