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Development and Modeling of the Process of Narrow-seam Laser Welding of Ni-Superalloy in a Hard-to-Reach Place

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Abstract : For the manufacture of critical hollow products, a laser narrow-seam welding scheme based on the supply of a laser beam into the inner cavity has been developed. The report presents the results of comprehensive studies aimed at creating a sealed weld that repeats the geometric shape of the inner cavity using a rotary mirror. Laser welding of hard-to-reach places requires preliminary modeling of the process to identify defect-free modes performed at the highest possible welding speed. Optimization of the technological modes of the welded joint with a ratio of the seam width to its depth equal to 1/5 of the thickness of the Ni superalloy 6.0 mm was performed using the Verhulst limited growth model in a discrete representation. This mathematical model in the form of a recurrence relation made it possible to numerically investigate the entire variety of laser melting modes: chaotic; self-oscillating; stationary and attenuated. The control parameters and the parameter of the order to which other variables of the technological system of laser welding are subordinated are established. In it, the coefficient of relative heat capacity of the melt bath was used as a control parameter, characterizing the competition between the heat input by the laser and the heat sink into the surrounding metal. The parameter of the order of the narrow–seam laser welding process, in this interpretation, is a dimensionless value of the penetration depth, which is an argument of the function of the desired logistic equation. Experimental studies of narrow-seam welding were performed using a copper, water-cooled mirror by radiation from a powerful fiber laser. The obtained results were used to validate the evolutionary mathematical model of the laser welding process.

Keywords : laser welding, internal cavity, limited growth model, ni-superalloy
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