Abstract

AISI 304 stainless steel is a popular material for structural applications because of its high strength to weight ratio, high toughness, and excellent corrosion behavior. However, it exhibits relatively low hardness and poor tribological properties, poor pitting and crevice corrosion resistance has limit its lifetime in service. Laser composite surfacing is a fast processing technique involving melting of the surface of metallic substrate with a high power laser beam, incorporation of ceramic particles through a feeder, its dispersion in the molten zone due to turbulent mass flow followed by solidification to form a uniformly dispersed composite zone on the surface on the substrate. Laser composite surfacing can successfully be applied to tailor tribological property of any component. Tungsten carbide has been proven to be a hard constituent which can be applied to develop metal matrix composite with improved strength and wear resistance. In the present study, laser composite surfacing has been undertaken using a continuous wave Nd-YAG laser in argon atmosphere under a varied power and scan speed combinations. Incorporation of tungsten carbide has been carried out using a co-axial nozzle by simultaneous feeding of tungsten carbide (WC) with cobalt (Co) and/or nickel chromium (NiCr) as binder in the molten zone using argon shroud. The exact compositions of the binders were 40 wt.% Co + 40 wt.% NiCr (+20wt.% WC), 80 wt.% Co (20 wt.% WC), 50 wt.% Co (50 wt.% WC), and 20 wt.% Co (80 wt.% WC). The optimum process parameters have been derived through a detailed structure-property-process parameters correlation. The depth of composite zone was found to vary with laser parameter and composition of precursor powder. Increase in applied power and decreases in scan speed increase the depth of alloying. On the other hand, the depth of alloying decreases with decrease in applied power and increase in scan speed. The variation is larger with increase in WC content in the precursor powder. Both the morphology and grain size of the microstructure of the composite layer vary with process parameters and binder composition. In general, the microstructure of the alloyed zone consists of dispersion of WC, M_6C and $M_{23}C_6$ in grain refined gamma (γ) matrix. However, the mass fraction of individual carbide varies with process parameters and composition of the precursor power. The carbides are present in the form of fine precipitate of small diameter or along the grain boundaries. In case of 20WC + 40Co + 40NiCr and 20WC + 80Co, however, there is presence of blocky carbides. On the other hand, there are flowery carbides of very large dimensions in 50WC + 50Co and 80WC + 20Co. There is introduction of large residual stress in the alloyed zone which is compressive in nature and varies from 115 MPa to -179 MPa for laser composite surfaced AISI 304 stainless steel with 20WC + 40Co + 40NiCr, from -42 MPa to -174 MPa for laser composite surfaced AISI 304 stainless steel with 20WC + 80Co, from -139 MPa to -188 MPa for laser composite surfaced AISI 304 stainless steel with 50WC + 50Co, and from -147 MPa to -192 MPa in for laser composite surfaced AISI 304 stainless steel with 80WC + 20Co. Though process parameters influence the residual stress however no specific trend of the influence of process parameter on residual stress was observed. Due to laser composite surfacing there is improvement in microhardness in alloyed zone and a highest hardness is observed when laser surface alloyed AISI 304 stainless steel with 50WC + 50Co when processed with an applied power of 1.5 kW and scan speed of 8 mm/s. There is improvement in wear resistance due to laser composite surfacing and a highest wear resistance is observed when laser processed with a power of 1.5 kW and scan speed of 8 mm/s. Furthermore, Co as a binder is superior to NiCr when wear resistance need to be improved. It was concluded that among all compositions 20WC + 40Co + 40NiCr offers a maximum improvement in corrosion resistance in terms of minimum corrosion rate when processed at an applied power of 2 kW and scan speed of 12 mm/s. On the other hand, NiCr as a binder is superior to Co when processed under similar conditions.