Effect of Heat Treatment and Carburizing on the Microstructure and Wear Behavior of CMT-Fabricated ER70S-6 Steel

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***Abstract*—** This study investigates the combined effect of a preliminary heat treatment (850 °C for 45 minutes) and gas carburizing on the microstructural, mechanical, and tribological behavior of ER70S-6 steel produced by Cold Metal Transfer (CMT) additive manufacturing. The objective is to understand how thermal and thermochemical treatments influence the microstructure and surface performance of this low-alloy steel. Microstructural analysis before and after heat treatment revealed a significant transformation from acicular ferrite to polygonal ferrite. This evolution is attributed to static recrystallization induced by homogenization annealing at 850 °C, which eliminates the internal substructures inherited from the CMT process. While this transformation improves microstructural uniformity and carbon diffusion during carburizing, it may slightly reduce the initial hardness due to grain coarsening. X-ray diffraction (XRD) analysis confirmed the formation of oxide phases on the steel surface, mainly Fe_2O_3 and Fe_3O_4, after carburizing. These oxide layers contributed to a relative reduction in the intensity of martensite peaks, likely caused by either signal attenuation due to a thick oxide scale or a reduced amount of martensite in the outermost layers. Microhardness profiles clearly demonstrated the effectiveness of carburizing in increasing surface hardness in both BC (Brut carburized / carburized-only) and TC (Treated carburized / heat-treated and carburized) samples. However, tribological performance did not correlate directly with this hardness increase. Friction coefficient and wear volume measurements revealed that carburized samples, particularly BC, exhibited lower wear resistance compared to the untreated base metal (Brut / Br), despite having higher surface hardness. This counterintuitive behavior is mainly linked to the presence of a fragile oxide layer, which acts as a mechanically unstable barrier that cracks and detaches during sliding, promoting abrasive wear mechanisms.

***Keywords*—** CMT, ER70S-6, Heat treatment, Gas carburizing

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