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Optimization of process parameters for spark plasma sintering of nano-structured UNS 32205 composite

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Statement of the Problem: Conventional Duplex Stainless Steel (DSS, grade UNS 32205) used in applications pose many unsolved problems; among them are, degradation of mechanical properties at high temperatures, poor resistance to creep and fatigue. Attempts to solve these problems have involved dispersing second phase particles into DSS matrix grain. Powder metallurgy route have been used to fabricate dispersion strengthened DSS but the challenge to obtain fully dense composites and avoid grain growth with nano particles is of great importance and could be carefully resolved by appropriate selection of sintering process parameters. Spark plasma sintering (SPS) have attracted attention due to its low energy consumption and short sintering time. Several works have been reported on the SPS of stainless steel based composites but nano particle dispersion strengthening of DSS has received little attention from researchers. This research seek to optimize process parameters to develop nano structured DSS with varying nanoTiN additions via spark plasma sintering (SPS).

Methodology & Theoretical Orientation: Automated spark plasma sintering machine (model HHPD-25, FCT GmbH Germany) was used to fabricate the composites. Characterization was performed using X-ray diffraction and Scanning Electron Microscopy. Density, hardness and wear properties of the composites were investigated.

Findings: The XRD results indicated that FeN0.068 was formed. The SEM/EDS confirmed the presence of nano ranged particles of TiN evenly distributed at the grain boundaries of DSS matrix. The results obtained indicated that the optimum properties were obtained at sintering temperature of 1150 °C, holding time 10 minutes and heating rate of 100°C/min. Densities of the 2205 DSS-TiN composites increased with sintering temperature but decrease with the TiN content. Nano-hardness of the 2205 DSS-TiN composite is enhanced by diffusion and reaction of Fe and N at the grain boundaries. The addition of TiN increases the elastic modulus of the composites.

Conclusion & Significance: The properties and microstructure of the sintered composites largely depend on the SPS process parameters and nanoTiN additions.

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Modification of four layers through the thickness woven structure for improved impact resistance

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In the current research, the four layers, orthogonal through the thickness, 2D woven, 3D fabric structure was modified to improve the impact resistance of 3D fabric reinforced composites. This was achieved by imparting the auxeticity into four layers through the thickness woven structure. A comparison was made between the standard and modified four layers through the thickness woven structure in terms of auxeticty, penetration and impact resistance. It was found that the modified structure showed auxeticty in both warp and weft direction. It was also found that the penetration resistance of modified sample was less as compared to the standard structure but impact resistance was improved up to 6.7% of modified four layers through the thickness woven structure.

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