Development of novel in-situ polymer-derived low carbon steel metal matrix composite using friction stir processing

Govind Kumar[a], Satish Vasu Kailas[a] ,Satyam Suwas[b]

[a]*Department of Mechanical Engineering ,Indian Institute Of Science,Bangalore 560012,Karnataka ,India*

[b]*Department of Materials Engineering ,Indian Institute Of Science,Bangalore 560012, Karnataka ,India*

[a]*satvk@iisc.ac.in*

Metal matrix composites have potential applications in the diverse fields of science and engineering. There are many techniques to fabricate composite materials, but an agglomeration of particles and fragmentation of ceramic particles is a grave issue. In this work, a Friction stir processing (FSP) technique has been employed to form a new class of steel metal matrix composites known as polymer-derived ceramic (PDC) composites. In these composites, a special kind of polymer precursor was introduced into the low carbon steel matrix through FSP. The processed sample was then treated at elevated temperatures to carry out the in-situ pyrolysis process. The pyrolysis process involved a transformation of organic polymer into inorganic ceramic. Post-pyrolysis-pass was required to eradicate the porosity from the composite, if any. The pyrolysis process also enhances the compatibility of mixing polymer-derived ceramic particles with the metal matrix during the post pyrolysis FSP pass. Characterization of the developed composite material was carried out using an optical microscope and scanning electron microscope (SEM). A uniform distribution of the ceramic particles into the steel matrix can be observed from the micrographs. The developed composite exhibits a threefold increase in the yield strength (310 MPa) of the material which could be attributed to the nanoscale dispersion of the polymer-derived ceramic particles. The proposed methodology could be very promising for the development of a new class of nanocomposite steels with high strength and ductility.

Keywords: Metal matrix composites; friction stir processing; polymer-derived ceramic; pyrolysis; low carbon steel