ABSTRACT

The present study is aimed at investigating the effect of WC/C (carbon based, tungsten carbide doped) coating on the fatigue behavior of case carburized low-alloy steels, viz. SAE8620, 20MnCr5, EN353 and SCM420. For this purpose, 2 µm thick coating of WC/C was deposited on case carburized and tempered steel specimens by means of ion-sputtering physical vapour deposition process. The coating process was found to have negligible effect on the mechanical properties of hardness and tensile strength.

Microstructural observations on case carburized specimens revealed dominance of plate martensite within the case and lath martensite in the core. The residual stresses in the outermost layers were estimated by X-ray diffraction technique. All steels in the case carburized condition were found to possess residual compressive stresses within the carburized case, whose magnitude nearly doubled upon WC/C coating.

Four-point rotating bending fatigue tests were conducted on standard fatigue specimens at various stress levels to obtain S-N curves for steels in various states, viz. (i) green, (ii) case carburized and tempered (uncoated) and (iii) case carburized, tempered and WC/C coated. The data obtained through fatigue tests for finite life was processed according to the procedures prescribed in ASTM E 739 standard. The endurance limits were estimated by means of staircase tests, whose data was analyzed by Dixon-Mood method. The influence of case carburization as well as subsequent deposition of WC/C layer on the fatigue performance of various steels was quantified by comparing the fatigue strengths of case carburized (uncoated) and case carburized – WC/C coated specimens with those of the specimens in green state.

Fractographic observations on specimens failed under fatigue were made by means of optical as well as scanning electron microscopes. Fracture surfaces of steels with low chromium content were found to be dominated by transgranular mode of crack propagation, while the crack in steels with relatively high chromium content was observed to propagate
mainly through intergranular decohesion cracking. Identical crack propagation mechanisms were found to be operative in uncoated and coated specimens failed at almost the same number of stress cycles. Fracture toughness of the substrate material was estimated by means of quantitative measurements made over the regions of stable crack propagation.

In all the steels investigated, the coating was found to have detrimental effect on low cycle fatigue performance. This was attributed to the formation of multiple cracks in the hard and brittle coating due to significant straining of the specimens under low-cycle fatigue. The coating was found to have a favourable influence on the high cycle fatigue performance and endurance limit of the steel specimens possessing higher fracture toughness.