ABSTRACT

Conventionally quenched and tempered martensitic high carbon, and low alloy steel; popularly known as SAE 52100 steel, is a commonly used material for small, medium and large ball and roller bearings for automobile applications and several other medium and heavy duty engineering components. The strength of the martensitic matrix coupled with the high amount of primary alloy carbides provide resistance to both abrasive as well as adhesive wear encountered in bearings assembly. However, high strain and strain rate, cyclic loads warrant a greater combination of hardness, tensile strength and toughness to ensure greater resistance to rolling contact fatigue and wear.

The present study is aimed to improve selected mechanical properties of the steel by adopting an alternative processing route based on austempering followed by quenching with/without prior cold or hot (thermo-mechanical) processing of commercial SAE 52100 steel.

The experimental study is divided into three broad approaches: (a) austempering followed by quenching to get bainite + martensite duplex microstructure, (b) prior cold deformation followed by the same austempering and water quenching routine in order to determine the scope and extent of microstructural (bainitic sheaf) refinement through complete/partial recrystallisation of the deformed ferrite, and (c) controlled thermomechanical processing during various stages of austenitizing followed by austempering and water quenching to further tailor the size, morphology and distribution of the ferrite needles/sheaves to get an ultrafine bainite + martensite duplex microstructure.

Following austempering, the samples subjected to all the above three routines were characterized by optical/electron microscopy, X-ray diffraction, thermal analysis and correlated with hardness (bulk/nanohardness), tensile/impact strength and wear resistance.

Improved tensile/impact properties were demonstrated by the samples subjected to austempering as compared to the martensitic structure obtained through conventionally quenched and tempered route. Marginal improvement in the tensile strength and significant improvement in the impact properties is obtained at an optimum level of prior cold deformation by tension in comparison to that recorded in austempered condition without prior deformation. However there was no improvement in the bulk mechanical properties due any of the thermomechanical processing routines before/during/after austenitizing. This is in spite of significant improvement in nanohardness, wear resistance and elastic modulus in the thermomechanically processed samples, as compared to the austempered or prior cold deformed samples, due to higher amount of retained austenite in the microstructure. Thus it is concluded that controlled prior cold deformation followed by specific routines of austenitizing and austempering can achieve the optimum combination of hardness, strength and toughness in SAE 52100 steel.

Keywords:

Bearing steel, austempering, thermo-mechanical treatment, mechanical property