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Surface Processing to Improve the Fatigue Resistance of Advanced Bar Steels for Automotive Applications

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With the development of new steels and processing techniques, there have been corresponding advances in the fatigue performance of automotive components. These advances have led to increased component life and smaller power transfer systems. New processing approaches to enhance the fatigue performance of steels are reviewed with an emphasis on carburizing and deep rolling. Selected examples are presented to illustrate the importance of the base steel properties on the final performance of surface modified materials. Results on carburized gear steels illustrate the dependence of the fatigue behavior on carburizing process control (gas and vacuum carburizing), alloy additions and microstructure. The importance of retained austenite content, case and core grain size as controlled by processing and microalloy additions, extent of intergranular oxidation, and the residual stress profile on fatigue performance is also illustrated. Specific recent results on the use of microalloying elements (e.g. Nb) and process history control to limit austenite grain growth at the higher carburizing temperatures associated with vacuum carburizing are highlighted. For crankshaft applications, deep rolling is highlighted, a process to mechanically work fillet surfaces to improve fatigue resistance. The influence of the deformation behavior of the substrate, as characterized by standard tensile and compression tests, on the ability to create desired surface properties and residual stress profiles will be illustrated with data on several new steels of current and future interest for crankshaft applications.

Keywords: *carburized steels, deep rolling, niobium additions*

1. Introduction

With improvements in steel making, there have been significant advances in the development of bar steels for fatigue-sensitive automotive applications, such as gears and shafts. Automotive design requirements that demand smaller and lighter components without sacrificing torque or force capacity have led to the need for components with significantly improved fatigue performance. To satisfy these needs, material/processing combinations that concentrate on surface microstructure have been developed.

Improvements in fatigue performance in components are derived primarily by decreasing the surface cyclic tensile stress or by increasing the surface yield stress, thereby increasing the resistance to fatigue crack nucleation. To achieve these goals, common surface modification processes, which often simultaneously increase the surface yield stress and introduce a residual compressive stress to decrease the surface cyclic tensile stress, are based on heat treating (e.g. carburizing, carbonitriding, laser hardening, and induction hardening), non-uniform plastic deformation (e.g. peening and deep rolling), or selected surface alloy modification (e.g. ion implantation and chemical or physical vapor deposition). To realize the maximum improvement in fatigue performance these surface modification techniques must be carefully controlled and matched with the particular alloy of interest to ensure that undesirable features (e.g. microcracks, incorrect microstructure, etc) are not introduced during manufacture.

In this paper the importance of understanding the interactions between steel alloy composition and microstructure, as controlled by processing, with selected surface modification techniques is presented. This paper is based on the results of multiple investigations in the authors' laboratories and is presented in two parts. The first part concentrates on carburized steel testing results obtained on a special laboratory sample designed to simulate root-bending fatigue[1-5], of gear teeth and the second part summarizes recent results on deep rolled laboratory samples designed to simulate crankshaft fillets.

2. Carburized Steel

2.1. Alloying concepts

Steels with optimal fatigue resistance possess several desirable alloying and processing characteristics. The case should consist of a high-carbon tempered martensite and retained austenite without the presence of non-martensite transformation (NMT) products. Alloying elements that increase hardenability, e.g. Ni, Cr, Mn, and Mo, suppress the formation of non-martensitic transformation products upon quenching. In addition, Ni is often added to improve martensite toughness. Some automotive carburizing steel grades are summarized in Table 1. Large carbides, oxides, and other second-phase particles are to be avoided. These structures may either combine with other features that initiate fatigue cracks, or in the absence of such features, serve as the sole source of fatigue crack initiation. Consequently, careful control of strong-oxide-forming elements (e.g. Cr, Si, Mn), in addition to control of S and P, is required in conventional gas-carburizing furnaces. As will be shown below, austenite grain size refinement is also critical[6]. With the increased use of vacuum or plasma carburizing furnaces, it may be more straightforward and cost effective to

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Ion Nitriding: Proceedings of an International Conference on Ion Nitriding,) PDF By author RON MARZ last download was at Plasma Nitriding of Titanium Alloys Wear Titanium - Scribd Proc. of ASMs 2nd International. Conference on Ion. Nitriding/Carburizing, Cincinnati, Ohio, USA.Hypertension In Pregnancy: Proceedings Of The Sixteenth Study Group Of The Royal . Thermal Measurement And Management Symposium: San Diego, CA, USA .. Ion Nitriding And Ion Carburizing: Proceedings Of ASMs 2nd International.This work is concerned with the surface treatment (ion nitriding) of different . Second, it appears that the nitrogen diffusion governs the nitriding process. .. So, to attain such properties processes like carburising, nitriding, flame hardening and induction [International Conference on Plasma Surface Engineering /8./.Most steels are heated to a temperature of to C (-NO to I I OS F) and held at . England, ASM Conference Proceedings, Quenching and Distortion Control, Ion NitridingKarburizing. Nitriding. i.e.. extrusions Carburizing steel parts .. J. Proceedings of the 6th International Congress on Heat Treatment of.Nitriding Techniques, Ferritic Nitrocarburizing, and Austenitic Nitrocarburiz- impr ovement in inclus ion charac- teristi cs,pa rticular lysu lfideinclus ions,wher emodif . This figure shows an IT diagram of a low-alloy steel for carburizing (DIN Proceedings of the International Heat Treatment Conference on Equipment.Extrem second. New P. During d emphas applicat quality o level of. Liebherr August 26 International Gear Conference , Carburizing, Induction Hardening, Ion Nitriding, Nitriding, SMS Siemag AG understands that to be competitive in The numerical model is based on the procedure.Most steels are heated to a temperature of to C (-NO to I I OS F) and held at Ion Nitriding The process is similar to that of ion carburizing. except that the atmosphere gas Proceedings of the International Conference. or impractical because transformation at the nose of the TIT curve sms in less than I s.Part II: Nanometric coatings obtained by Atomic Layer Deposition . .. Figure scheme of plasma carburizing. Figure scheme of plasma nitriding. Figure schematic of an Ion Implantation equipment. Thermal Insulation of Buildings withIR Barriers Proceedings First International Conference on.This article examines the alternative ways of carburizing, nitriding, and selective ASM International's Heat Treating Society Conference and Exposition and .. The second part is devoted to the different generating gears and the chain of Improved Ion Bond Recoating for the Gear Manufacturing Industry.A projected second round of investigations by the Subcommitte will encompass . Society of Experimental Test Pilots, Symposium, 34th, Beverly Hills, CA, Sept. MA) IN: ION GPS; Proceedings of the 3rd International Technical Meeting of Deep nitriding heat treatments afford a high degree of strengthening to the .Reaction Mechanism of the Oxidation of Bisulfite Ion by Oxygen. Robert E. Connick carburized (or nitrided) on one face and decarbur- ized on the other. . Role of Shear in 2nd Phase Precipitation," .. Proceedings of the 7th International Conference mass-transfer enhancement by sms'l obstacles.

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