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Influence of nitriding process on magnetic properties of steel ball-like samples

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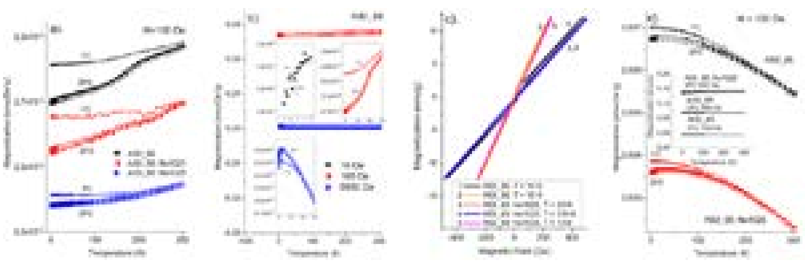
The nitriding is a thermo-chemical treatment of the steel which improves its wear resistance, corrosion resistance and hardness. Gas nitriding is a thermo-chemical processing of steel implemented in the temperature range of 400-600ºC. The nitriding process takes place in conditions of forced flow of the nitriding atmosphere. At a constant temperature, depending on the value of the nitriding potential, the subsurface iron nitride layer formed may consist of only the γ'-Fe_4N phase or a mixture of phases γ'-Fe_4N and ε-$Fe_{2-3}N$. A diffusion zone is formed under the iron nitride layer, in which nitrogen is dissolved interstitially in a ferritic matrix and carbonitrides of iron and alloying elements occur. The thickness and phase composition of the layers of iron nitrides are decisive on the resistance to corrosion and the abrasive wear of steel after nitriding. The diffusion zone, in the case of alloy steels, increases the fatigue strength of steel. The surface layer (core shell) appearing after nitriding treatment affects the magnetic and electric properties of the steel. Several AISI steel balls with different diameters and thermal treatments (Nx1021, Nx1025) were investigated using FMR and SQUID techniques. FMR spectra revealed wide and intense signals visible in temperature range from helium to room one. Position of each signal, being far from geff~2, as expected for iron magnetic ions, indicated on complex nature of responsible magnetic centers. Magnetization measurements have shown non-uniform behavior of the investigated samples with temperature variation. For most of them, having carbon content higher than 0.13 wt. %, the rise of magnetization with increasing temperature was observed, which strongly depended on applied magnetic field. For samples with carbon content lower than 0.13%, a drop in magnetization was observed with increasing temperature, as usually for AISI steel. Significant magnetic anisotropy has been revealed, decreasing with increasing temperature.



The magnetization, M(T), dependence of the AISI_85-89 samples: a). AISI_420C (88) sample: precursor, Nx1021 and Nx1025 nitriding processes for H=100 Oe, b). AISI_420C (88) sample for H=10, 50 and 5000 Oe, c). hysteresis loops for AISI_1010 (85) (14 K) and the same sample underwent to Nx1025 process (20 and 230 K), hysteresis loops for AISI_420C (88) (15 K) and AISI_1085 (89): Nx1025 (10 K), and, e). M(T) dependence of AISI_1010 (85) and AISI_1010 (85) (Nx1025) samples for H=100, 300 and 500 Oe.

Recent Publications

1. Michalski J, Fuks H, Kaczmarek S M, Leniec G, Kucharska B and Wach P (2017) The magnetic properties of steel after the gas nitriding process. Materials Engineering 4:170-176.
2. Biedunkiewicz A, Krawczyk M, Figiel P, Gabriel-Polrolniczak U, Bodziony T, Skibinski T and Kaczmarek S M (2017) A powder material with magnetic properties and the method of preparation of the powder material with magnetic properties to be used for manufacturing composite products. EP3135784 A1.

3. Fuks H, Kaczmarek SM, Leniec G, Michalski J, Kucharska B, Wach P (2018) Magnetic Properties of Steel Ball Samples, Investigated Before and After Nitriding Process. Archives of Metallurgy and Materials 63(3):1235-1242.
4. Kaczmarek S M, Biedunkiewicz A, Bodziony T, Figiel P, Skibinski T, Krawczyk M and Gabriel-Polrolniczak U (2018) Nano-structured (Mo,Ti)C-C-Ni magnetic powder. Journal of Achievements in Materials and Manufacturing Engineering 86:5-13.
5. Kaczmarek S, Bodziony T, Tran VH, Figiel P, Biedunkiewicz A and Leniec G (2018) Composites of AISI 316L stainless steel and nanocrystalline Ti-B-C ceramic powders. Advanced Materials Letters 9:696-702.

Biography

Slawomir M Kaczmarek has his expertise in evaluation and passion in materials science. He is a physicist by profession. For many years he was involved in optical and EPR spectroscopy of crystalline laser and scintillation materials produced by himself and other scientific centers in Poland, France and Japan. He mainly studied oxide materials such as garnets, lithium niobate, lithium tetraborate, melilites and fluorides doped with transition metals and rare earths. At the same time, he was a lecturer in physics, electronics and optoelectronics at the Military University of Technology in Warsaw and the West Pomeranian University in Szczecin. Recently, he became interested in the properties of powder materials, alloys, ceramics and nanomaterials, additionally conducting research on their magnetic properties using the SQUID technique. He is particularly interested in composite materials ranging from classic iron alloys to ceramic composites with nanoparticles.

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