Modification of the surface layer structure and properties with phosphorus addition

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Abstract

Statement of the Problem: The addition sulfur, phosphorus or oxygen to the carburizing or nitriding atmosphere enables the synthesis of some beneficial precipitates in the layer. Thus a diffusive layer on a steel becomes a matrix whereas ceramics precipitattes is a reinforcement modifying structure and properties of the layer. That composition of the layer and the particular reinforcement may be regardet as a composite diffusive layer reinforced by ceramic particles. Structure and properties of such a layer reinforced by iron phosphides are considered here. The purpose of the work is consideration of the role of phosphorus in iron alloys surface and relations of the iron phosphides layers growth parameters in the processes of phosphorising, phosphorcarburising and phosphonitriding with their structure and properties. The layers were generated on a base of Armco iron and 0.4%C, 1.1%Cr steel as a result of annealing in a mixture of argon or carburising and nitriding atmosphere and phosphorus vapours in: temperature T = 700 - 1170 K, phosphorus partial pressure p = 0.1 - 20 kPa, process duration t = 3.6 - 21.6 ks. The diffusion layers were investigated by means of the methods: metallographic, X - Ray structural analysis, microanalysis, Vickers and wear dry friction resistance tests. Findings:

Conclusion & Significance: Formation of compact layer of phosphides with the adjustable relation of Fe_3P to Fe_2P was described; means of growth and kinetics of iron phosphides layers and phosphocarburised and phosphonitrided were explained, it was found that iron phosphides presence in steel surface increases its hardness and resistance to wear. It was found that nucleation Fe_3P crystals starts in areas of surface being found in a certain distance from iron grains boundaries and the growth process of iron phosphide continuous layers is an effect of iron diffusion through phosphide layer from the core towards the surface. In advanced phases of the of iron phosphide layer growth, a gap between the layer and the base is created as a process of degradation of the base layer interface. It was found that the obtained layers are new kind of composites diffusive layers with iron phosphide particles generated as a result of phosphorising, phosphorcarburising or phosphonitriding with very promising tribobiological properties. Description of the elementary processes, structure and properties of the layers. formation was done. Depending on the partial pressure of phosphorus in an inert atmosphere, the formation of compact layer of phosphides with the adjustable relation of Fe3P to Fe2P is possible. Growth of thin iron phosphides layers begins by Fe_3P crystals nucleation in areas of surface being found in a certain distance from iron grains boundaries. Growth of iron phosphide continuous layers is an effect of iron diffusion through phosphide layer from the core towards the surface. In advanced phases of the of iron phosphide layer growth, a gap between the layer and the base is created as a process of degradation of the base layer interface what decreases the lyer wear resistance. The gap creation process is analogous to a dissociation gap creation during high temperature oxidation.

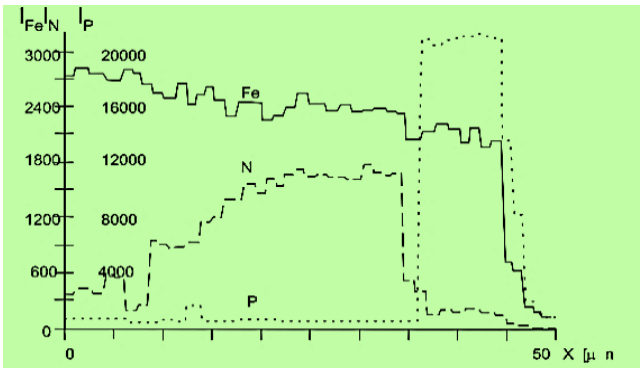

Fig. 1. Concentration of the phosphorus - P, nitrogen - N and iron - Fe in the phospho-nitrided layer; process parameters: T = 893 K, p = 180 Pa, t = 21.6 ks.

Recent Publications

1. J. Koutsky, Modelling of heterogenous structure materials – important contribution to the optimalisation of forming and hest treatment of structural steels, Journal of Achievements in Materials and Manufacturing Engineering 20 (2007) 579-584.
2. Wustenfeld, Verfaren zur Eindiffusio der Elemente Bor, Silizium und Phosphor in Metaloberflache, Patent Germany Nr. 2429948.
3. W. Schluchter, Method of Rust-Proofing Iron or Steel, Patent USA, Nr 1. 761. 963.
4. J. Nowacki, The Means of Thermochemical Treatment of Steel and Cast Iron Machine Elements, Patent PL 164780 B1.
5. J. Nowacki, Nucleation, growth and properties of thin layers of iron phosphides, Surface Coatings Technology 151 (2002) 114-117.

Photograph

Biography

Prof. Ph. D. Jerzy Nowacki, IWE graduated 1973, PhD - 1978, habilitation awarded with the minister's award – 1987, Professor title - 1996. Vice-Dean of the Mechanical Engineering Faculty of Lodz University of Technology -1990-1996, scientific editor at the Publishing House of Lodz University of Technology. Activities: surface layer, sinters, composites, joining processes. Achievements: over 300 publications, 12 books, 25 patents, 32 industrial implementations. He supervised 11 doctors. Selected functions: Deputy director of the Institute of Materials Science and Engineering at the West Pomeranian University of Technology in Szczecin, Welding Technology Reviev - editor-in-chief, Non-Destructive Testing and Diagnostics - editor-in-chief, SIMP W-wa Publishing Agency - director, Archiv. of Materials Science and Engineering – assistant editor-in-chief, World Academy of Materials and Manufacturing Engineering - vice president, SciFed Journ. of Quantum Physics – ed., Committee on Materials Science of the Polish Academy of Sciences – Section in Poznań - chairman. Selected decorations: Order of Polonia Restituta, Medal of National Education, Gold and Silver Cross of Merit. Winner of the West Pomeranian Nobel Prize and the West Pomeranian Marshal's Science Award, Academic Subsidy from the Foundation for Polish Science.

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