Cavitation erosion resistance of Carbon Steels Implanted with Nitrogen and Chromium ions

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Abstract

Due to its good mechanical properties, medium carbon steel is widely used to manufacture the mechanical components in high-speed hydraulic machinery. However, severe cavitation erosions always occur on those component surfaces and even cause the failure of the hydraulic machinery. To improve its surface cavitation erosion resistances, the ion implantation method is preferred to be used because of its many advantages. In this paper, N+ implantation, Cr+ implantation and N+/Cr+ co-implantations were carried out on 1045 carbon steels, their surface cavitation erosion resistances and corrosion resistances were measured by using a rotating disk cavitation test bench and an electrochemical system. To elucidate the modification mechanism of the ion-implanted 1045 carbon steel, the detailed surface chemical states and structures of the ion-implanted caron steel samples were investigated. The polished 1045 steels were implanted with chromium, nitrogen and chromium/nitrogen ions at fluence of 2×1017 ions/cm2, 2×1017 ions/cm2 and 4×1017 ions/cm2, respectively. To evaluate the surface cavitation erosion resistance of the ion-implanted samples, cavitation pit densities for the samples were analyzed. The results showed that relative to the initial 1045 steel, the surface cavitation erosion resistances and corrosion resistances corresponding to the ion-implanted 1045 steel samples are all improved to varying degrees. Among the samples, the chromium/nitrogen ion co-implantation one shows the best anti-cavitation and anti-corrosion resistances. By means of X-ray diffraction and X-ray photoelectron spectroscopy, the phase structures and the chemical states of the steel samples implanted with chromium, nitrogen and chromium/nitrogen were studied. The results indicated that the implanted atoms exist according to the Gaussian distribution along with the depth of the samples. Some new strengthening phases form and their distributions also vary with implanting depth. In addition, due to the carbon diffusions of the ion-implanted samples, various phases related to carbon atoms appear on the sample surfaces. New phases are the domination factors that have contributions to the improvements of the surface properties of the carbon steels.

Keywords: carbon steel, ion implantation, cavitation erosion, surface structures

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