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A Method for Improving Compressive Residual Stress of Small Holes Surface by Water-jet Cavitation Peening

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Abstract: As a novel surface strengthening technique, Water-jet cavitation peening has been applied to improve the fatigue life by inducing the compressive residual stress in the near surface layer of mechanical components. Compared with conventional shot peening, one advantage of WCP is that the complicated and tiny surface can be peened more easily. In this study, the small holes with various diameters and depths in the SUS304 stainless steel specimens were treated by WCP. In order to estimate its strengthening capability to the small holes, the surface residual stress and the depth distributions in the near surface layer of the small holes were measured by X-ray diffraction method. The experimental results show that WCP can successfully improve the near surface compressive residual stress of small holes. The maximum of surface compressive residual stress of WCP state is up to around –450 MPa. The dept of compressive residual stress zone is up to around 125 μm.

Introduction

It is recognized that the introduction of residual stress have significant effects on fatigue performance of engineering components, especially, compressive residual stress have positive effects on high cyclic fatigue life. A method of inducing compressive residual stress is by bombarding the material surface by high-velocity solid shots, which is called shot peing. Recently, the novel application has been introduced, and such method is termed water-jet cavitaion peening (WCP), cavitation shotless peening (CSP), and oil jet peening (OJP). In the method, a high-speed submerged jet pressurized by a plunger pump is used. When the high pressure water or oil is jetted through a jet nozzle to the metallic component, the uniform big bubble cloud can be generated, and the bubble collapse on the surface of the component will produce impact effect just like shot peening. This method of surface strengthening treatment has produce similar or superior performance to conventional shot peening.

Cavitation impact, which are generally considered as the negative factor inducing the cavitation erosion in hydraulic machinery [1–5]; therefore, most previous studies on cavitation have focused on the damage problem of mechanism. On the other hand, it has been verified that cavitation peeing also can be applied to improve the fatigue life inducing compressive stress in the near layer of mechanical components [6–12]. Recently, cavitation peening technology has been successfully developed. Soyama et al. successfully achieved a cavitating jet in air by injecting a high-speed water jet into a low-speed water jet injected into air by using a concentric nozzle, which introduced high compressive stress into the surface of components [13, 14]. Qin et al. designed a new ventilation nozzle by which the suitable air can be aerated into the extra high-velocity flow in the nozzle throat, the tremendous pressure gradient between the upstream and the downstream flow has formed [15]. Moreover, Sahaya Grinspan et al. successfully realized oil cavitation jet peening by