Laser Melting of High Thermal Conductivity Steel (HTCS) Surface

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Abstract. This paper presents a laser melting of high thermal conductivity steel (HTCS) dies for surface properties modification due to die failures during operations. Sample were cut from as-received die without any defect or crack. Melting process was conducted using Nd:YAG laser system with pulse mode at 50 W average power. The laser beam was defocused to a spot size of 1 mm on the sample surface. Parameters controlled in this study were peak power of 800 and 1200 W, and pulse repetition frequency of 80 and 90 Hz. Metallographic study and chemical composition analysis were conducted using Hitachi TM3030Plus scanning electron microscope (SEM) and energy dispersive x-ray spectrometer (EDXS). Surface roughness was measured using Mitutoyo SURFTEST SJ-410 stylus profilometer. Hardness properties of the modified layer were characterized by Wilson Hardness tester at 100 N force. The metallographic study showed high porosity at partially melted zone (PMZ) area. From overall findings, laser processing parameter affected hardness properties and surface roughness of modified layer. Where the surface roughness value obtained is between 1.49 and 3.15 µm, while the hardness value is between 550.9 and 610.9 HV0.1. These findings are significant to parameters selection for hot stamping die surface repair and prolong its service.

Introduction

Laser surface modification is widely used as a remanufacturing process, especially for repairing cracks in mold and dies surface. It produces new properties on the surface of substrate which improves toughness, hardness and corrosion thus reduce wear resistance and thermal stress [1, 2]. Laser surface processing provides a unique tool for the high precision surface modification with micron size heat source. Laser surface modification can improve surface properties such as hardness, wear resistance, toughness and corrosion due to homogenous and ultrafine structure due to localized rapid heating and cooling [3-5]. Heating and cooling during laser melting process depend on processing parameter which affected chemical composition, microstructures and properties [6, 7]. Laser melting of cracked surface on hot work tool steel SKD6 die casting resulted in an effective method to expand life of the damaged tool [8].

Some study of surface modification using laser technique such as melting, cladding, alloying, heat treatment and welding indicate some problem of this technique. Laser cladding process on H13 tool steel and turbine blade shown crack, porosity and decreased hardness at clad zone [9-11]. While, laser melting on H13 and AISI D2 tool steel show defects such as shrinkage cracking, hardness decreased with increased thermal cycle and coarse grain at melted zone [12, 13]. Laser modification of powder metallurgy materials using laser cladding, laser tempering and laser melting also shows porosity, crack, decreased hardness at clad zone and coarser microstructure on the modified surface [14-16]. From the problem on laser processing stated, more studies needed on laser surface modification of powder metallurgy materials. In this study, surface of HTCS-150 die steel was modified using laser melting process to improve die life in hot press forming process.