ON SURFACE TEXTURE AND INTEGRITY IN MACHINED SURFACES

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Fundamental understanding and modeling of surface texture and residual stresses induced in materials by the machining process is of great importance as it plays a significant role in the fatigue life and service life of these machined components. The goal of the presented research is to evaluate means by which *surface integrity and residual stresses are engineered at the manufacturing process planning stage* by careful selection of appropriate machining tools and conditions. Typically, manufacturing process planners chose conditions that will enhance other factors such as material removal rate and increased tool-life. However, we find that such selected conditions lead to a sub-optimal level of surface integrity. This leads to the need for additional expensive or time consuming post-processing techniques such as laser shock processing (LSP) and low plasticity burnishing (LPB) to correct the flaws in the sub-surface induced by poor selection of machining conditions. Our research throws new insight on means of engineering desired residual stress profiles by optimized selection of tooling and operating conditions based on experimental measurements and fundamental modeling of the machining process. The specific goal of this presented work is to investigate the effects of cutting tool geometry, tool-coatings, and lubrication conditions on the surface integrity, surface texture, and machining performance of two different machined materials: Aluminum alloy 7075-T6 and AISI 1045 carbon steel.

Machining experiments are conducted on these specimens using different cutting tools (diamond-based tools and carbide tools with thin-film wear resistant coatings). Different lubrication conditions (dry, minimal quantity lubrication (MQL) and flood) were also tested. MQL application involved the use of minimal amounts of cutting fluid to the cutting zone at a flow rate of 30 ml/hr and flood lubrication involved cutting fluid application at a high flow rate of 9 l/min. The measured responses were machining forces, residual stresses and surface texture. The surface texture was evaluated using an optical interferometry based surface characterization system. The residual stresses were characterized using a suite of different measurement techniques. The machining process was also modeled using two computational techniques: an explicit finite-element method (FEM) and the material point method (MPM). The resulting residual stress in the machined materials are predicted and compared with experimental measurements. It was observed that small changes in machining conditions (tool geometry, tool surface features, tool coatings, application of varying levels of lubricant or coolant) result in varying levels of surface texture and integrity.

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