Assessing Failure in Five-Axis Machined Components using Local and Non-Local Stress Based Fatigue Models

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Abstract

While casting has historically been used to make components with free-form surfaces, five-axis milling with ball end cutters is becoming increasingly common. Although this form of production enables the use of more robust billet material rather than cast material, it generates identifiable machining cusps on the component's surface. Smaller scale machine marks appear within these cusps due to machine feed and tool cutting edges. Therefore, the multi-scale nature of such component's surface roughness is a challenge during fatigue assessment. In this work, two fatigue assessment models have been compared to conduct a fatigue assessment of 5-axis machined components. First is the Analytical Strength Assessment of Materials (FKM) guideline. This model uses local hotspot stresses, stress gradient, mean stress and surface roughness factor for fatigue assessment. The second model is based on a non-local approach called the Theory of Critical distances (TCD). This method uses linear elastic stress distribution generated by the cusps, plain material, and notched material fatigue data for fatigue assessment. Results show TCD is biased towards conservative prediction while FKM tends to overpredict the fatigue life.

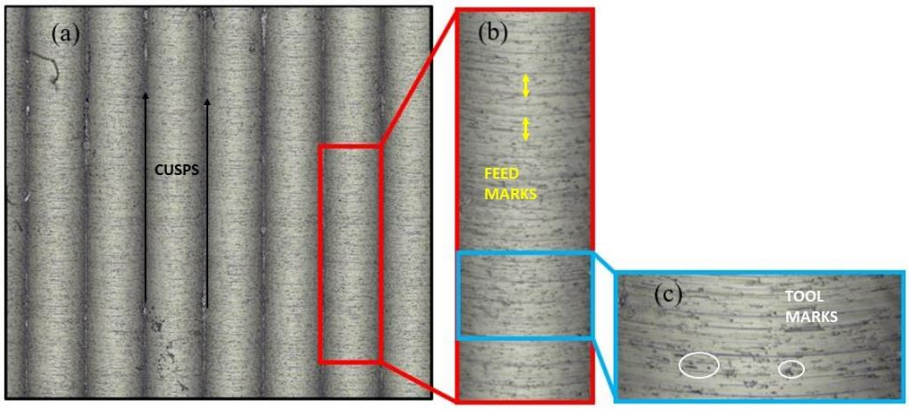

Figure 1: a) Cusps on the surface at macro scale (b) Feed marks within cusp at meso-scale (c) Tool marks within feed marks at micro-scale