

THE INFLUENCE OF ELECTRO-DISCHARGE MACHINING AND ITS MITIGATION BY SURFACE MODIFICATION ON THE THERMAL FATIGUE PROPERTIES

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Electro-Discharge Machining (EDM) reduces the thermal fatigue resistance compared to conventional machining operations. The detrimental influence of EDM is attributed to the damaged layers consisting of a brittle recast layer, a hardened layer and a softer tempered region as well as the tensile residual stresses.

The EDM treatments that are investigated include a high energy one step manual process and a commercial EDM treatment that uses multiple steps of decreasing energy followed by grit polishing and tempering. The corrective treatments employed are electropolishing, a proprietary shot peening and the low temperature surface thermal treatments of ion nitriding, a proprietary gaseous nitrocarburizing (Nitrotec) and a proprietary liquid salt bath nitriding (Melonite).

The thermal fatigue behavior is assessed using the average maximum crack length and the total crack areas as crack parameters on a specially designed specimen immersed in a molten aluminum. Generally, Melonite, electropolishing and some shot peening treatments improve the thermal fatigue resistance

compared to the commercial EDM treatment even though Melonite and the electropolished specimens show a slightly larger average maximum crack length. The Melonite treated sample even shows a slight improvement in total crack area compared to conventionally machined samples. This improvement is attributed to a smoother surface and elimination of the overtempered layer as well as the removal of brittle recast layer. The corrosion resistant oxide layer in Melonite treated sample also has beneficial effects on the thermal fatigue behavior. Ion nitriding and Nitrotec treatments show an even poorer thermal fatigue resistance than the high energy one step EDM process. This lower thermal fatigue resistance is attributed to the brittleness of compound surface zone.

The Charpy V-notch (CVN) impact test is employed for toughness evaluation after the treatments described above for thermal fatigue resistance. The toughness of all the commercial EDM, one step EDM, electropolished and shot peened tests are slightly higher than the conventionally machined specimen. The surface hardening treatments including ion nitriding, Nitrotec and Melonite lower the impact energy of the specimens compared to conventionally machined samples because of the high hardnesses at the surface.