Development of an innovative repair system for metallic aircraft structures using a novel shape memory alloy

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Despite the tremendous increase in the application of advanced composites on recently developed aircraft, a large number of in service aviation fleets are comprised of aircraft made of mainly metallic structures. Operators of both civil and military aircraft often suffer from the aging problem of metallic structures [1]. Thin-walled aircraft structures are susceptible to fatigue cracking, damage tolerance design principles are therefore adopted to ensure the structural integrity. A fatigue crack has to be detected and repaired before it reaches the critical length and leads to a catastrophic failure

The repair of fatigue cracked structures to restore the residual strength plays a central role in the damage tolerance design philosophy. The two main state-of-art repairing methods for metallic aircraft components, however, face complications. Riveting aluminium patch does not provide sufficient fatigue crack retardation, and application of bonded composites raises concerns related to the long term performance of the adhesively bonded metal-composites joints [2].

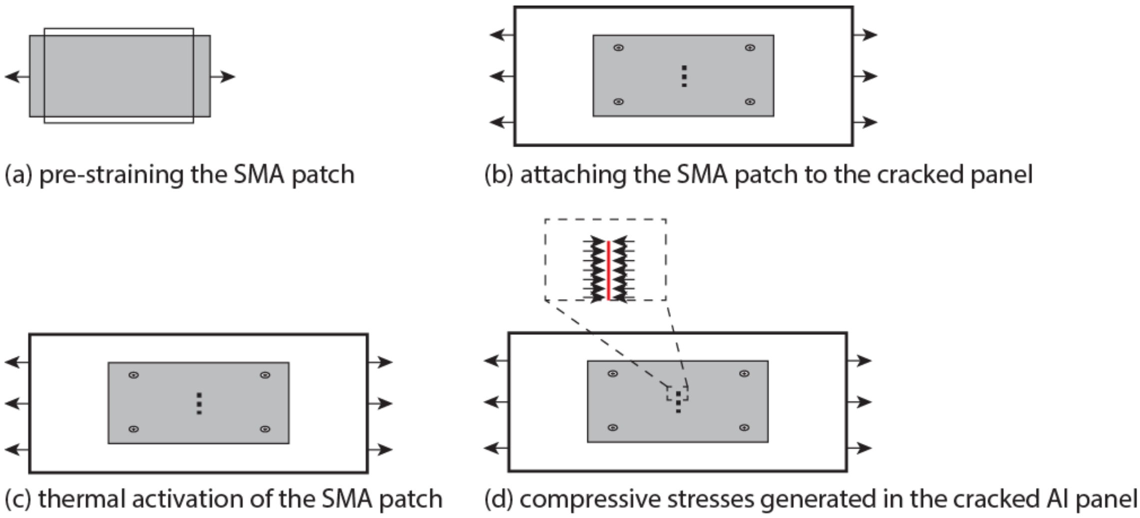

Figure 1. Schematic view of the proposed repair technique for cracked aluminium panels.

An innovative repair method using novel shape memory alloy (SMA) is therefore proposed in this study. An iron-based SMA has been developed at Empa, Switzerland, for the repair of metallic infrastructures [3]. As shown in Figure 1, before attaching the SMA patch to cracked metallic structures, the patch is pre-strained in tension. The attached SMA patch will try to recover its shape when it is activated. The activation procedure includes a heating process followed by a cooling process, which generates compressive stresses in the repaired structure [4]. The repaired structure is thus pre-stressed to have the crack in a compressive stress field. The compressive stresses generated in thin-walled metallic aircraft members with existing cracks are highly desirable since they can further reduce the crack growth rate (FCG) or result in a complete crack arrest.

A comparison of the fatigue crack growth feature after repairing with different methods is illustrated in Figure 2. Utilizing SMA patches can thus achieve much more extension of the service life of aging metallic aircraft than the aluminium or composite patch. In this study, the preliminary results of an ongoing study on fatigue strengthening of aluminium members using pre-stressed Fe-SMA members will be presented and discussed.

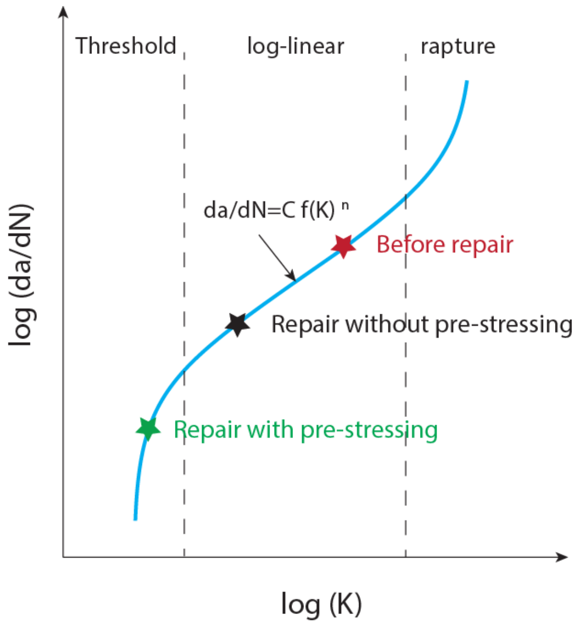

Figure 2.Fatigue crack retardation effect of the smart patch

Keywords: Innovative repair system, shape memory alloy, crack arrest/retardation, compressive stresses

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