

## Fatigue Life Optimisation of Damage Tolerant Structures using Design Space Exploration

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### Abstract

In parametric design studies, the strength of a structure is often considered as the primary design criterion, and consequently the optimal (best) structural design is often chosen as the one that minimises the maximum stress generated. However, for structures whereby failure is governed by fracture or fatigue, residual strength and fatigue life, as distinct from stress, need to be considered as the explicit design objectives.

In this study, the design space for fatigue life for different structural configurations is evaluated to demonstrate the utilities of design space exploration for damage tolerance design optimisation. This was illustrated using the problem of the optimum design of a cutout shape with boundary cracks under biaxial load. The minimum fatigue life associated with the cracks was evaluated for each cutout geometry.

The design surface for fatigue life establishes that a design based on damage tolerance parameters poses a well-behaved optimisation problem with a well-defined minimum/maximum region. The design space was found to be flat for fatigue life, enabling the specification of design tolerances. The optimum values of the fatigue life obtained from the design space agreed well with those determined using various optimisation methods. It is shown that a design space exploration can provide a systematic way to reduce the weight of a structure by adopting a 'feasible non-optimal' solution that meets the design criteria, rather than aiming for the 'optimal' (best) solution.

**Keywords:** Design space; Shape optimisation; Damage tolerance; Fatigue life; Finite element analysis.