Reformulation of Cruciform Specimen Design Optimisation for Ultrasonic Fatigue Testing

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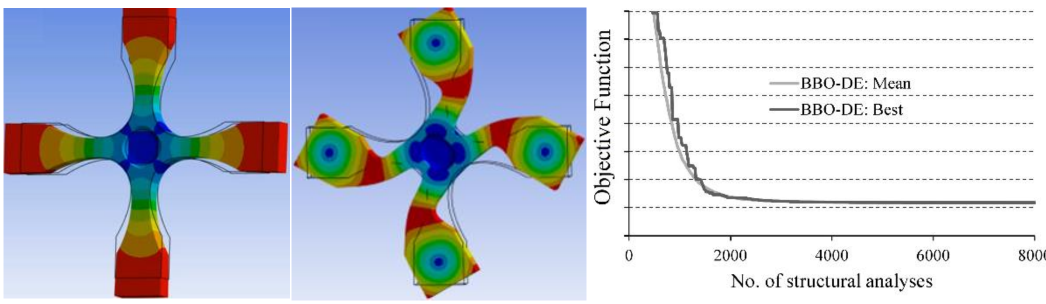
Abstract This work reformulates the design optimisation problem of cruciform specimen to achieve predetermined vibrational characteristics essential for ultrasonic fatigue testing. In the presented shape optimisation problem, the geometrical parameters of the cruciform specimen are the design variables. A new objective function is defined based on the Modal Assurance Criterion (MAC) and penalty functions, which attempts to achieve a target modal shape (Figure 1a) within a predefined frequency interval. The design constraints are formulated to ensure that the target modal shape is excited during ultrasonic fatigue testing of the cruciform specimen. The formulation is also aimed at reducing the interference of other modal shapes (Figure 1b) with the target modal shape by maximising the frequency gaps. The boundary constraints for the design variables are also adjusted to make sure that the optimum designs will be feasible from mathematical and manufacturing viewpoints. To solve the design optimisation problem, a stochastic hybrid meta-heuristic approach, called BBO-DE algorithm, is adapted which can locate the optimum design under nonlinear frequency constraints (Figure 1c). The numerical results reveal the effectiveness of the new approach in achieving the optimal shape of cruciform specimen. Ultimately, the new formulation automates the design of specimen under multiaxial loading.



(a) (b) (c)

Figure 1 - *Design optimisation of cruciform specimen: a) intended mode shape, b) unintended mode shape, c) convergence curve*