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Concurrent Multiscale Topology Optimization for Designing Displacement Inverter

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Structural light-weighting is vital for increasing energy efficiency and reducing CO_2 emissions. One of the mechanical structures that are used in numerous applications and can utilize lightweight is the displacement invertor. Displacement inverter is producing mechanical reaction as the reverse of the input actuating action. In this research, multiscale topology optimization of compliance mechanism is used to design lightweight displacement invertor. This is because compliant mechanisms, and in contrast to typical mechanisms that are coupled by rigid bodies, are flexible single-piece systems that achieve the desired movement through elastic deformation. Furthermore, reduced friction, wear, noise, and the ability to provide novel actuation, as well as ease of fabrication and assembly, are among the advantages of the use of compliant mechanism design concepts. Under the constraint conditions of the total area of the microstructures distributed in the macrostructure, the elastic response of the macrostructure, and the homogenization set of the periodic unit cells are used associated with the rigidity control rational problem (the ratio of the output and input displacements) of the design domain which is used as the objective function for topology optimization method. Topology optimization for material distribution is a crucial stage in the design of compliant systems. It aids designers in extending and fine-tuning a design with the optimal material distribution. It entails determining the shape and placement of a structure's cellular units, as well as the domain's connectivity. Binarization and intermediate pseudo density were investigated for the concurrent multiscale optimization of the rigidity control structures using solid isotropic material with penalization (SIMP) and evolutionary structural optimization (ESO). As a result, the effective properties obtained using the homogenization for the microstructure are evaluated with a dedicated finite element model, while the macrostructure's effective properties are calculated using a different finite element model. The adjoint approach is used to implement the sensitivity analysis efficiently for the concurrent design function in this study, which reduces the computational cost. The numerical examples showed a good design response of the microscale design with the spatial configuration and the boundary condition of the design domain on both macro and microstructure. Furthermore, this study found that addressing microscale design with the concurrent optimization process, it is possible to get a desirable spatial configuration of materials while reducing weight. the spatial arrangements for the various scenarios revealed an elaboration for distributing strain energy in the most efficient manner possible in relation to macrostructure design. As a result, the proposed design process has the potential to produce durable and new lightweight and porous displacement inverters' designs with unique and high adaptability of elastic property.

REFERENCES

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