LOW ENVIRONMENTAL IMPACT COMPOSITE STRUCTURE
DESIGN OPTIMISATION USING ROBUST MULTI-OBJECTIVE
OPTIMISATION PLATFORM

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Summary. With growing global environmental concerns, new environmental regulations have focused on depletion of petroleum resources and developing new composites using green (natural/organic) materials [1]. In this paper, ecological composites are optimized to improve the mechanical properties of natural matrix: Poly 3-HydroxyButyrate-co-3-hydroxy-Valerate (PHBV). They consist of the bacterial polyester, PHBV and polypropylene (PP) matrix, with (isotropic short fiber) agro-residues such as Corn Straw (CS), Soy Stalk (SS) and Wheat Straw (WS) [2].

In this paper, multi-objective design optimisation of Eco-Composite is conducted using a Distributed/Parallel Multi-Objective Genetic Algorithm (DMOGA) that is formulated to maximise the stiffness while minimising the total weight of the Natural Fiber (NF) reinforced composite structures. The physical model considered in this paper is a quadrangular plate consisting of seven layers and its boundary condition has two sides simply supported with a central load. The stacking sequence and thickness of each layer are considered as design variables during the optimisation (fourteen design variables in total). Robust Multi-Objective Platform (RMOP) develop in CIMNE is used and it is coupled with a Finite Element Analysis (FEA) based composite structure analyser named as Compack during the optimisation [3].

Numerical results show that Pareto optimal solutions have better mechanical properties when compared to three composites using solely PHBV (two extreme and one intermediate composite) as shown in Figure 1. Pareto members 8 -12 in Zone-A and Pareto members 16 - 20 in Zone-B can replace PHBV composites with intermediate and maximum thicknesses. Table 1 compares the value of weight and displacement obtained by PHBV composites, Pareto members 1, 10 and 20. Even though, PHBV with a minimum thickness is the lightest structure due to its poor mechanical property, however its displacement is relatively high when compared to Pareto member 1 (the best solution for fitness function 1): lower displacement by 50.3%. Pareto member 10 has lower weight and displacement by 10.7% and 31.8% when compared to the intermediate PHBV case. Pareto member 20 (the best solution for fitness function 2: displacement) has 8.8% lower weight and 27.3% lower displacement compared to PHBV with maximum thickness. Numerical study has shown the potential
applications of green composite structure design optimisation using RMOP coupled with Compack that can find a set of high strength Eco-Composites with low weight. The paper will also present the environmental impact and degradation of the green composite structures.

Figure 1. Pareto optimal front for multilayered green composite structure design optimisation.

<table>
<thead>
<tr>
<th>Green-Composites</th>
<th>Weight (kg)</th>
<th>Displacement (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PHBV min thickness</td>
<td>7.291</td>
<td>0.00568</td>
</tr>
<tr>
<td>Pareto member 1 (best weight solution)</td>
<td>8.192 (+12.3%)</td>
<td>0.00282 (-50.3%)</td>
</tr>
<tr>
<td>PHBV intermediate thickness</td>
<td>14.582</td>
<td>0.00170</td>
</tr>
<tr>
<td>Pareto members 10 (intermediate solution)</td>
<td>13.024 (-10.7%)</td>
<td>0.00116 (-31.8%)</td>
</tr>
<tr>
<td>PHBV max thickness</td>
<td>24.304</td>
<td>0.00066</td>
</tr>
<tr>
<td>Pareto member 20 (best stiffness solution)</td>
<td>22.158 (-8.8%)</td>
<td>0.00048 (-27.3%)</td>
</tr>
</tbody>
</table>

Table 1. Comparison of multilayered green-composites; weight and displacement.

REFERENCES

