Project Title: Computation techniques and discrete optimization techniques for material selection

Research Thrust Area: Computational techniques and discrete optimization techniques for material selection.


Need and Industrial Relevance:

The proliferation and the broad range of materials available today for the fabrication of composite parts has grown astronomically today. The designer finds it difficult, if not impossible, to choose the right material for the structural design. In earlier designs once the material was chosen, all its mechanical and thermal properties would be fixed. With composites these properties can be tailored as the loading requirements and so as an example, we can have elastic modulus different in different directions. As more and more composite materials are used in a variety of industries, the designers need for methods to arrive at the correct material is critical. As an example, the following chart shows how the elastic modulus of a graphite/Epoxy composite can change based on the fraction of zero degree, ninety degree and 45 degree plies. Modulus can be as low as 10 GPA and as high as 180 GPa. Similar carpet plots are available for other properties also.
Project Goals:
The project goal is to develop data bases and necessary software to access this data base and calculate the various desired properties, based on the material combination. We will focus on density, stiffness, strength, ductility, and toughness.

Objectives:
Objective is to make the material and structural designer choices broad enough that they can arrive at the best alternative in least amount of time. This data base can be a place where the designers will be able to change and calculate the material properties as desired.

Approach and Methods:
The data bases available on the web and elsewhere will be collected and a data base will be prepared. Then micro-mechanics techniques will be used to develop algorithms to calculate the mechanical and thermal properties in any combination of directional and, weight ratios. The material choice is more of a discrete optimization type of analysis and hence discrete techniques will be used. In a layered composite, the laminate properties depend on the number of plies and the fiber orientation individual plies. The number of plies falls in the realm of discrete optimization but then the fiber orientation is a continuous varying design factor. In general, the matrix in the composite is the weaker link and various additives are used to change its properties. These filler materials again are continuous function and the optimum ratio of mixing is important. So once the material combinations have been chosen, gradient based or Genetic Algorithms will be very useful. Material combinations, layer order and orientation make this a very complex material design problem which can be solved using some advanced optimization tools.

Outcome/Deliverables:

Key deliverables: Data bases of materials. Algorithms to calculate material properties based on available micro-mechanics models.

Impact: It will give the designers a great tool for improving the quality of their products. It will broaden their material choice and design efficiency.

Project Duration (plan and timeline):

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Proposed Budget:

Budget includes 2 graduate students, computer and software totaling $91,000