Statement of purpose

Research Area

I want to do my PhD research on the topic "Modelling of void formation in composites during resin infusion across different compaction levels".

Challenge and opportunity: As we know that the formation of the voids is the most common defect produce during infusion across different compaction levels in the composite laminate. Due to the considerable effect on the physical and thermomechanical properties of composite so controlling voids is essential to get the required performance and long-term durability of the composite structure. As we know that formation and evolution of the voids are different in different processing of fiber-reinforced composites (FRCs) due to different rheological and thermodynamic phenomena occur in different processing like Liquid composite molding (LCM) and Prepreg technology.

There are different techniques use for characterization of void such as Microscopy, Ultrasonic testing, Density determination and X-Ray micro-Computed Tomography (CT) used to get the content, morphology, size, location and spatial distribution of voids in the composite laminates so that we can find the effect of voids on mechanical properties such as Inter-laminar fracture toughness, Inter laminar shear strength, Tensile & Compressive properties, Inter-laminar fracture toughness, Impact performance, Fatigue behavior, Flexural properties and Hygrothermal effect on mechanical properties. In this project, I will try to find out the noble techniques for "Modelling of void formation in composite during resin infusion across different compaction levels" to overcome challenges in formation of composite laminates.

Research Background

My master's thesis title is "Fabrication and Testing of Ballistic Material for Bullet and Blast Resistance Solution" under Prof. Naresh Bhatnagar in IIT Delhi. While working on ballistic material I faced a number of challenges at each step after overcoming every problem. The material used during experiment was combination of different grades of UHMWPE (Ultra High Molecular Weight Polyethene) Spectra (3126, 5143 and 6472) of hybrid material. I learnt new concept and techniques about fabrication, testing and analysis of composite material. After finding the ABD matrix of a hybrid laminate of different grade of Spectra (3126, 5143 and 6472), I observed that the Matrix A (extensional and shear stiffnesses) and D (bending and torsional stiffnesses) were the same after changing the sequence of grade but matrix B (bending-extension coupling matrix) was different for different sequence and it was non zero in hybrid laminate. As we know the presence of nonzero elements in the coupling matrix B indicates that composite laminate will exhibit bending and twisting, even if the external moment on it is perfectly zero and composite laminate will exhibit extensional and shear

strains, even if external resultant forces on it are zero. So here, I optimized the B and D matrix results so that back face deformation after bullet hitting come out to be minimum (according to BIS standard, BFS≤25). The machines such as Vacuum Compression Moulding Machine, Autoclave, CNC, Water jet abrasive cutting, Single-stage Gas gun etc. were used for experiments. While testing on Single-stage Gas Gun, brass bullet projectiles were used with the help of nitrogen gas. Also, a mechanical drop test apparatus was designed and fabricated on the basis of NIJ Standard-0101.07 for the fragmentation testing of ceramic ($B4C$ and SiC) tiles.

During my course work of masters at IIT Delhi, I worked on many projects such as effect of process parameter on Selective Laser Sintering (SLS) process, design optimization of mechanical components using MATLAB, solving 2D Transient Heat Conduction in the FGMs, designing and testing analysis of Split Hopkinson Pressure Bar and fabrication of forging die. During working on composite material, I realised that this is the area where I can contribute myself in the best way for enrichment of composite field research.

Scholastic achievement

I have necessary skill sets of working on different software like MATLAB, LabView, Creo and LS DYNA. I have a strong academic background in the field of design, fabrication and testing of composite material. I received an outstanding performance grade in "Processing and Mechanics of Composite" course under Professor Naresh Bhatnagar in IIT Delhi. I cleared GATE (Graduate Aptitude Test in Engineering) exam, got a position in the top one per cent among 1.6 lac students who appeared in this exam so that I was awarded a Master Degree fellowship at IIT Delhi in Production Engineering (Mechanical Department). During my bachelor degree, I cofounded the racing team and designed and fabricated two lightweight Go Kart (four-wheel racing vehicle), with the optimized performance of power train, and aesthetics. I used carbon fibre reinforced polymer-based composites in front and rear bumper because of its high, strength to weight ratio, high stiffness and high modulus of elasticity, and participated in the national level event "NATIONAL KART RACING CHAMPIONSHIP" and was placed among top 15 teams in India.

Learning opportunity

Since we know that composite is anisotropic material, so designing, fabrication and testing is not simple as in case of conventional isotropic material as its properties also change at high strain rate testing. There are several areas of improvement in composite field like Deign modelling, Numerical and Experimental analysis, and quasi static and dynamic testing analysis.

I believe that my interest coupled with my skills and previous project experience qualify me as a right candidate for this PhD program. Thanking you in advance for your consideration.

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