composites lab to bridge the gaps between industry and academia

The main theme of the paper is to bridge the gap between industry and academia, specifically in the area of composites materials. This paper aims to address the following:

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Abstract

The main theme of the paper is to bridge the gap between industry and academia, specifically in the area of composites materials. This paper aims to address the following:

- Assuage the apprehension in the academia towards the practical aspects of composite materials
- Bridge the gap in the composites 'know-how' between industry and academia
- Make engineering students industry employable or research ready with composites
- Build a 'Closed Loop Composites System' involving academia, suppliers, and industry
- Enable Indian academia to attract a higher number of interested overseas students, by building up infrastructure for composite knowledge transfer

In order to achieve the stated objectives, a three step approach of developing a composite lab within an academic institution is proposed. We start this journey with a small step, i.e. the starting of a very simple composites laboratory, which is economically affordable, easily scalable and the end goal of which is to enable engineers to think, design, and work with composite materials.

The paper discusses the following:

- India's position in the world composites industry – Market study
- Benefits of the composites lab to the academia/research
- Bridging the gap between industry and academia in the composites context
- Proposing three types of labs (Basic, Intermediate and Advanced) within the academia
- Transition requirements and pathway, from Basic to Intermediate, and Intermediate to Advanced
- Special discussions including suppliers, raw material standards, minimum quantity purchases, equipments and maintenance, certified and uncertified trainings to Engineers/Staff, Operation Health and Safety (OHS) issues.

It is strongly believed that, by using the proposed model to build the composites lab within the educational institutions, there would be a 'win-win' situation for both academia and industry.

Introduction

Over the last thirty years composite materials, plastics and ceramics have been the dominant emerging materials. The volume and number of applications of composite materials have grown steadily, penetrating and conquering new markets relentlessly. Modern composite materials constitute a significant proportion of the engineered materials market, ranging from everyday products to sophisticated niche applications.

Composites Industry in India

The very first use of fibre reinforced plastics (FRP) started in 1962 in India for manufacturing roofing sheets by Praga Industries, Coimbatore. During the year 1964, Chemical Process Equipments Pvt. Ltd. Mumbai started fabricating composite tanks for chemical industries. Production of polyester resins was first started by Bakelite Hylem Ltd., Hyderabad in 1973. Availability of these essential raw materials triggered setting up of several small-scale units in India for making composite products using hand lay-up process. During last three decades, more than 1200 small-scale industries have been established in the country. More than 98% of them use hand lay-up technique for composite fabrication. Improvements in volume growth only started in early 2000 as a result of the globalisation of the Indian economy. Indian composites market has been growing rapidly with newer products manufactured with the gradual induction of modern technology. The analysis of India's composite market reveals that although many small fabricators are using hand lay-up methods for manufacturing composite products, the use of computer controlled advanced fabrication equipment such as filament winding system, pultrusion, Resin Transfer Moulding (RTM), Vacuum Assisted Resin Transfer Moulding (VARTM), and other equipments is growing rapidly.

There is a huge potential for use of composites in Indian automobile industry, especially in catering to the transportation needs of growing middle class population. There is a good market for bumpers, hoods, cabs, frames, leaf springs, and cargo containers that could be used as part of these locally built vehicles. The business opportunities for Indian composites industry also include air intake manifold, composite fishing trawlers, refrigerated freight containers, pressure vessel for gas, motor driven carts, concrete pillar jacketing, components for electrical industry (glass fibre composites only), theme park rides casings, storage light houses, thermoformed components for automotive applications, walkways & piles for building foundation, RCC casting shutters, etc.

Figure 1 shows the current distribution of composites among various industries in India. Building, automotive and infrastructure take up the major share whereas pipes, and electrical appliances also have a strong presence. Wind energy and marine areas are opening up opportunities, but may need government support to prosper.

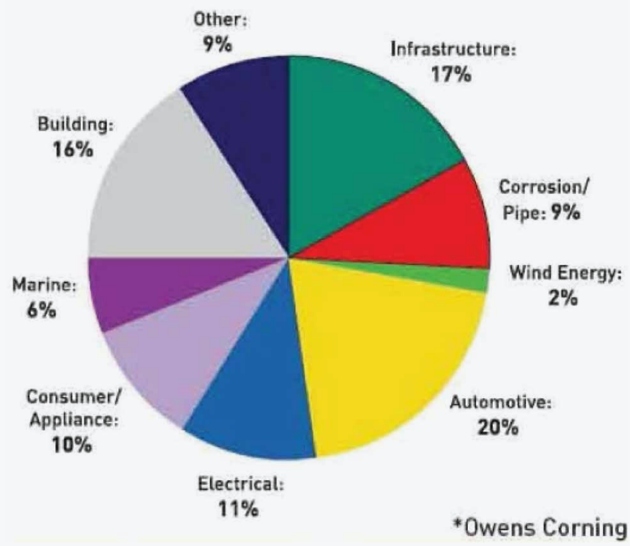


Figure1: Current distribution of Composites in India (Courtesy: JEC Composites)

The Indian composites industry, which is a global enterprise with fragmented markets, finds itself passing through a period of transformation. Profit margins have been shrinking and the recent Eurozone recession has worsened the problems. Growth in the Indian composites industry has been driven by an increased penetration of composite materials in pipes and tanks, renewable energy, railways, industrial, aerospace/defence, entertainment, sporting goods, oil & gas and chemical Industry. The market has been growing rapidly driven by the shift of North America and European manufacturing bases to China and India as well as an increased demand for 'Made in India' composites from the developing countries. There is also a wide variety of other applications, unique to the Indian market, where composites have excellent demand, for example, Compressed Natural Gas (CNG) tanks, Sheet Moulding Compound (SMC) and Bulk Moulding Compound (BMC), dairy, agriculture, pharmaceuticals and Liquified Petroleum Gas (LPG) cylinders.

The future of the Indian composites industry looks very prosperous through 2014 and beyond. Demand for composite materials in India is expected to grow to $1400 Million in 2014 at a Compound Annual Growth Rate (CAGR) of 17.4% as shown in Figure 2. End user segment growth contributes greatly to this increase. More interestingly, however, the role of growth from metals replacement and new applications, which have been on the verge of possibility for a very long time, is increasing.

India offers many opportunities in the composites industry for new entrants as well as existing and expanding companies. This is the ideal time for industrialists to take part in the rapid and systematic growth that is expected in the Indian composites industry in the next few years.

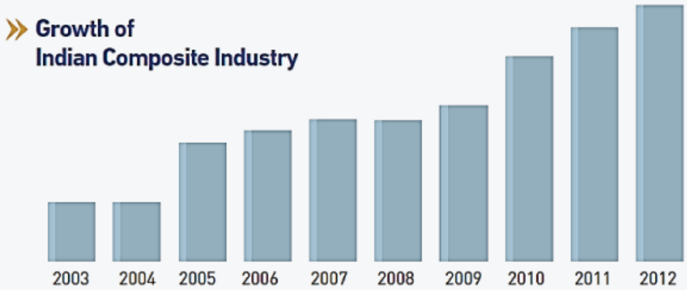


Figure 2: Growth of Indian Composites Industry from 2003-2012 (Courtesy: India Composites Show-2013)

The per capita composites consumption has increased from 0.1 Kg to 0.2 Kg between 2005 and 2011. However, pipes & tanks, transportation, and wind energy sector represent the highest growth rate while there is some traction towards construction, Electrical and Electronics (E&E), and aerospace/defence. Unsaturated Polyester Resins (UPR) is the most dominant resin used in the Indian composites industry, capturing 83% share of total resins used in composites, followed by vinyl-ester and epoxy.

There is a definite need for interaction between Indian and global composite community, for the benefit of both. Whilst the industries in the advanced countries can promote their raw materials, process know-how, process machinery and technology, the Indian industry will benefit by improving its technology, production processes and products. The Indian industry has opened many windows for international players to market in the country via channel partners and distributors.

Continuing to be a fast growing economy, India offers opportunities for international trade and investments in the composite sector. Composites have made an entry into diverse end-user segments, with ongoing developmental efforts for finding newer composites for existing & novel applications. This growth is much evident, owing to the increasing demand of composite products, majorly from aerospace, automobile, defence, railway, mass transportation, renewable & wind energy, chemical and infrastructure.

Newer markets for composites in India

There are three main sectors that are growing in India: marine with +25% expected growth, wind energy with +28%, railways with 20% per year, while the automotive and aerospace industry is not far behind. The use of composites in aerospace and defence sectors have shown rapid technological developments. Extensive use of composites in applications such as rockets, satellites, missiles, light combat aircraft, advanced light helicopter and trainer air craft reinstates that India is at almost on par with the advanced countries in the development and use of composites in this area.

The building and construction sector could do more to make optimum use of composite materials. Composed of environment friendly resins and reinforcements (bio-composites) are very efficient for applications that do not require high resistance. In construction, they can be used in building interiors and decoration. Applications of composites also include the rehabilitation of infrastructures such as bridges, cabling under constraints, old or historical buildings, etc. An emerging interest is the development of a new texture and touch to construction materials. This is a new field being increasingly explored by architects and designers.

The Indian composites industry has grown significantly in the last two decades to cater to the requirements from the various sectors. The Indian composites market, currently at about Rs. 16,000 Crores, has been on an upswing over the last five years with a growth of 15.6%, spurred by a strong demand in pipes & tanks, renewable energy (wind & solar energy), mass transit, automotive, trucks, and power sector.

India's consumption of composites, which is expected to grow by 1.5 times from 2012 to 2017, undoubtedly presents a host of new opportunities as well as challenges to the supply chain. In India, composites consumption per capita is very low as compared to other leading countries like China, US, and the European Union, but demand upsides could take this higher.

There is a great scope in the global export market, where India can cater to untapped opportunities abroad. This will boost India's composites foothold by 2017. India has potential to become one of the leading exporting countries to the Middle East and North Africa (MENA) countries, South East Asia (SEA), and South Asia. However, it needs to improve its current industrial hierarchy and set a concrete vision. The amount of money spent on research & development, and Intellectual Property Rights (IPR) portfolio in composites is negligible and government should consider resources for the composites industry as well as start pure applied courses in composites science and technology. Currently, there are no/very limited courses with regard to composites science and technology in India, which needs to be addressed at a quicker rate. The proposed composites market in the Indian scenario is presented in Figure 3.

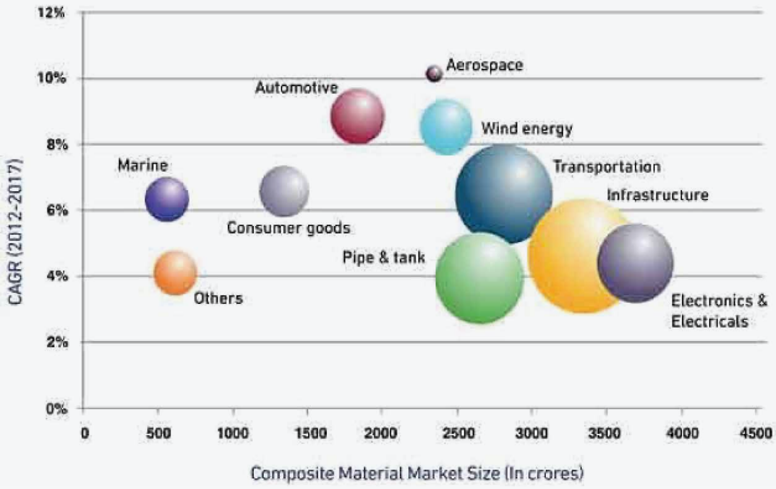


Figure 3: Indian Composite Market Future Opportunities (Courtesy: India Composites Show)

Bridging the Gap Between Academia and Industry

Over the past 60 years, the composites industry has progressed and advanced beyond science fiction to become a reality in a wide range of applications, processes, manufacturing processes, design, analysis and testing methods. The composites industries has a good handle on most of the aforementioned elements, and is now concentrating on sustaining the research impetus on new materials, and develop well documented procedures, manuals and guidelines towards product development.

While there has been tremendous progress towards the end goal of making the performance of composite structures repeatable, reliable and affordable, there still exists a fair gap between the industry and academia in India, which needs to be bridged. The theoretical aspects of composites are well defined, and are being imparted to the students through a structured course-work. However, the hands-on experience still eludes the young engineer in varying degrees. In the authors' opinion, this has been the result of a general mind-set in the academia that composite materials are difficult to work with and expensive.

The academia needs to realize that there is a wide range of research opportunities in composites, across a wide range of industries such as aerospace, marine, automotive, construction, interior decoration, machineries, etc. in the field of new product development as well as repairs of existing composites.

In order to bring the academia closer to the industry, this paper proposes a three step approach of building a composites laboratory, with the end goal of enabling engineers to think, design, build, break, understand, and work with composite materials. The three stages involve the building of a basic, intermediate, and an advanced composites laboratory. Along the journey, the engineer will also grasp the importance of adherence to processes, and be able appreciate and relate the concepts taught in class to his hands-on experience, thereby making him/her ready for the industry. The approach presented in this section is not limited to composites, but can in fact be applied to any other field as well, such as embedded electronics, robotics, fuel cells, etc.

The following table (Table 1) gives an overview of the requirements for the three types of labs proposed.

No.	Parameters	Basic	Intermediate	Advanced
1	Estimated start-up capital required (INR)*	2.5 Lakh +	5.5 Lakh +	10.0 Lakh +
2	Space Required	10*12	12*20	20*30
3	Manufacturing Methods	Hand-Layup	Vacuum Bagging	Pre-preg/Vacuum bagging
4	Post-processing	Hand saw	Band Saw, Sanding M/c	Band Saw/ Sanding M/c, Drilling, Water jet M/c
5	Post-Curing types	Room Temp/Oven	Oven	Oven/Autoclave
6	General Equipments	Bench Vice	Vice, Vacuum Cleaner	Vice, Vacuum Cleaner
7	Personnel required	1	2	2
8	Fibre Type	Glass Fibre	Glass/Carbon	Glass/Carbon/Kevlar
9	Resin Types	Vinylester	Vinylester	Vinylester/Epoxy
10	Safety equipment	Disposable Gloves, safety glasses	Disposable masks	Overalls, face masks, etc.

*Cost may vary significantly due to fluctuations in currencies

Table 1: Three types of Composites Lab for Academia

Stage 1: Basic Composites Lab Set-Up - Parameters to be considered

The basic composite lab provides an introduction of composites to the student, and imparts very basic hands-on skills, usually restricted to the wet layup process.

The following are some of the parameters to be considered before setting up a Composites Lab.

1. **CAD:** A CAD system may be required for generating original drawings, or shop drawings from blueprints.
2. **Ordering System:** Even a basic composites lab involves ordering many different materials and supplies, which necessitates a method for tracking the orders. A database needs to be created for tracking orders placed, received, and paid; and for keeping a contact list of sales reps.
3. **Receiving System:** When the materials arrive, the f ollowing needs to be considered before they go into storage.
    a. Loading dock and receiving area. Are the shipments big enough to require a separate receiving facility? Does it required surface level or thorough inspection?
    b. Receiving office – This may not be a separate physical office, but it might be required to log received goods into the database and transfer paperwork (Material safety data sheets, packing lists, etc.) to the files. A few handling equipment, like hand dollies, storage boxes, etc. may also be required.
4. **Storage:** Once the materials are in, the following need to be put in place for storage.
    a. Cages and warehouse facilities, for large pieces of tooling.
    b. Chemical cabinets, for resins, solvents, release agents, etc.
    c. Shelving and bins, for stock items such as mixing cups, fasteners, tools, etc.
    d. Racks, for roll items such as fabrics, release films, bagging, etc. Remember, most of these should be stored horizontally, with no weight on the actual material.
    e. Freezers, for prepregs and film adhesives. Alarms with automatic pagers or phone diallers, for those times when the freezers fail might be needed.

Some additional considerations when planning storage facilities are:

a. Many materials must be stored in a clean or climate-controlled room.
b. Government regulations may dictate storage and disposal requirements for chemicals.

5. **Preparation:** Some preparation work is required before the start of any layup. This work is, of course is highly dependent on the manufacturing method, but here are some things to consider:
   a. Tool preparation - Tools must be cleaned and mould released prior to layup. Ideally, the initial prep is done outside the layup area, to avoid contamination of materials and facilities.
   b. Cutting - Materials, whether they are prepregs, fabrics, or consumables, must be cut to size. Both cutting tools and tables would be needed. For large-scale productions, automated cutting equipment may be required. Frozen prepregs must also be brought to room temperature before the bags are opened. Cut materials are usually kitted and stored in a container to keep them clean.
   c. Resin Mixing - Resins must be mixed in proper proportions, requiring metering or weighing equipment. Depending on the size of the operation, disposable cups and stirring sticks, or automated mixing equipment would be required.

6. **Layup:** With all the tools, cleaning and releasing agents ready, and as much material kitted as possible, the actual layup room needs to be designed.
   a. Layup room - Most layups, whether prepreg, wet, or even moulded, are performed in a clean room. The room must be large enough to accommodate the part, and it must have sufficient access to move the tooling in and out.
   b. Local storage - Tables or shelves in the layup room may be required for temporary storage of kits, tools, and consumables.
   c. Climate control - Is temperature and humidity controls required? Is it required to monitor and keep a record of conditions?
   d. Cleanliness control - Likewise, do cleanliness specifications require any special measures such as positive air pressure, tacky mats, hair nets, gloves, etc.?
   e. Lighting - This is often overlooked, but of course need good lighting id required. Light fixtures should be sealed and recessed so they don't gather dust.
   f. Material handling - Does the lab need any power equipment for handling materials or moving tooling? Depending on the size of the operation, a forklift or an overhead crane might be required.
   g. Equipment - For anything other than hand layups, the facility may need to accommodate large equipment such as filament winders, fibre placement machines, presses, chopper guns, RTM dispensers and moulds, etc. Even for hand layups, equipments such as laser alignment systems may be used.

7. **Mould:** For a basic lab, simple shapes offer a good starting point. However, the complexity can be increased from basic shapes such as panels, to relatively complex shapes such as a frisbee, to a more complicated shape like a crash helmet. Moulds for the intended shapes need to be either developed in house (if a machine tool lab already exists), or have to be procured.

8. **Inspection:** Completed parts usually go through an inspection process. Specific inspections depend on customer and internal requirements but for a basic lab might include:
   a. Visual inspection for obvious flaws such as resin-rich or resin-starved areas, cracks, pinholes, etc.
   b. Tap test to identify potential delaminations.
   c. Dimensional inspection to verify the part meets the specifications as set out in the engineering drawings.

Advantages of a Basic Composites Lab

a. Students get an introduction to various types of resins/reinforcements, resin gel time, hand layup techniques, compacting, etc.
b. Institution takes the ‘first step’ towards making its students Industry ready, and lays the foundations for a bigger and better lab.
c. Industry can offload excess material (past shelf life) to such labs and contribute to the dissemination of knowledge among aspiring students, thus fostering interest in composite materials.

Transition to Intermediate and Advanced Lab

In most of the cases, academic institutions do decide to take the composites lab further and make it more advanced. The following sections give an overall guide of how to achieve this. It is proposed that the progress to an advanced lab be broken down again into two stages, i.e., Stage-2 involving the development of an Intermediate lab, following by Stage-3, which involves adding more capabilities to make the lab 'Advanced'.

Stage 2: The Intermediate Lab

The following are to be considered during the transformation of a basic lab (Stage-1) to an intermediate lab (Stage-2).

1. Procurement of sandwich cores for sandwich structure exposure.
2. Procurement of an oven for curing: Considering the size of the parts and how many would be cured at one time. What kind of carts would be used, if any? Other options include maximum temperature, control system, monitoring and recording system, and vacuum access. If most of the parts are large, a second, smaller oven for test coupons could be considered.
3. Addition of vacuum pumps for vacuum bagging: Does a central pump for the entire shop is required, or portable pumps for individual products? Need to consider appropriate the hoses, valves, ports, and gages.
4. Addition of a simple microscope to do visual inspection, and an ultrasound machine to do U/S inspection.
5. Addition of a band-saw/table saw for basic machining.
6. Addition of a skilled trainer to impart vacuum bagging knowledge.
7. Storage area for temporary holding until the parts can be shipped. This should include protective caging, to prevent accidental damage.

Advantages of an Intermediate Composites Lab

1. Students get exposed to sandwich structures.
2. Students are imparted with vacuum bagging skills.
3. Vacuum bagging has traditionally been a 'skilled labour' area. Industry can now hire part-time vacuum baggers among students (say 10-15 hours per week) as a cost cutting exercise.
4. Industry can now offload the following to the Academia for a fraction of the cost
   a. Test coupon dimensioning/cutting from fabricated panels.
   b. Basic visual inspection

Stage 3: The Advanced Lab

The following are to be considered during the transformation of an Intermediate lab (Stage-2) to an Advanced lab (Stage-3).

1. Procurements of Pre-pregs
2. Autoclave: Most of the considerations are the same as for ovens, but autoclaves in general are bulkier and more difficult to maintain. It may also have a gas purge system.

NOTE: There are, of course, other methods for curing, such as integral heating and e-beam curing. In general, the curing equipment takes up the most space and, unlike tooling, cannot be moved out of the way. It is important to plan the facility around this equipment from the start. If it is decided to move it later, it's not just a matter of shifting physical equipment: there are also power and gas lines to think about, as well as allowable floor loads.

3. Addition of different NDE techniques: A-Scan/C-Scan equipments, addition of an SEM/thermal or X ray imaging for advanced quality control and inspection (Alternatively, low volume testing could be done at external Testing service company).
4. Addition of environmental conditioning chambers.
5. Addition of strain gauging equipment.
6. Addition of different fixtures for different types of testings (tension, compression, v-notch rail shear, 3 point bending, bearing, etc.).
7. Addition of load frames with different load capacities.
8. Purchase of forklifts to transport big shipments.
9. Addition of drilling machine, water jet machines for precision manufacturing. This work is usually dirty, so care must be taken not to contaminate the clean layup room. Also, graphite dust can create an electrical hazard, and all composite dust is a personnel hazard.

10. Painting area: If parts must be painted, paint booth might be needed. Paints are a contaminant, so they must also be isolated from the layup room.
11. Addition of a statistical 'data reduction' group to process test data into meaningful conclusions.
12. Addition of skilled trainers for autoclaving, inspection, strain gauging and material testing.
13. Considerable investment (real estate, resources, etc.) needed for the above. Transition may take years!

Advantages of an Advanced Composites Lab

1. Students are imparted skills in the following, thus making them industry ready

a. Autoclaves
b. Precision machining
c. Non-destructive testing and inspection (NDT)
d. Environmental conditioning
e. Strain gauging
f. Material testing
g. Report writing and documentation

2. Addition of advanced NDT equipment (A-scan, C-scan) results in better confidence levels among the industry.
3. The lab can now become a full scale, independent 'test lab', with ability to manufacture and test coupons, and can work more closely with the industry in a win-win situation.
4. The academic institution can aggressively chase research grants from leading research establishments, and can contribute significantly to the available literature in composite materials.
5. Such a lab can involve 50 students (almost an entire class), leading to the students feeling more 'involved' in the learning exercise.
6. Students from other departments (other than aero/mechanical) can get involved, and take over responsibilities of statistical data reduction, strain gauging, etc.

Industry/Academia Gap Fillers

The following table lists the gaps currently existing between the Industry and Academia, and the role each of the three labs can potentially play in bridging the same.

No.	Industry/Academia Gap	Basic	Intermediate	Advanced
1	Disposal of composites past their shelf life	✓	✓	
2	Hands-on composites experience	✓	✓	✓
3	Vacuum bagging skills		✓	✓
4	Visual inspection of coupons	✓	✓	✓
5	Autoclaving skills			✓
6	Advanced NDE techniques			✓
7	Environmental conditioning capability			✓
8	Material testing and qualification			✓
9	Research experience on composites		✓	✓
10	Increased research awareness		✓	✓
11	Possible research grants for academics		✓	✓
12	Increased industrial exposure to academia		✓	✓
13	Increased Industry-academic interaction		✓	✓
14	Branding of institution about composites lab		✓	✓

15	Possibility of more MTech & PhD projects in composites		✓	✓
16	Basic understanding of composites manufacturing	✓	✓	✓
17	Acceptable quality specimen manufacturing	✓	✓	✓
18	Catering to higher end customers – Aerospace, Marine, etc.		✓	✓
19	Consulting to business firms		✓	✓
20	Students get a feel for the 'real world problems' facing the Industry	✓	✓	✓
21	Students become quality oriented	✓	✓	✓
22	Possibility of publications (Journals and Conferences) and Patents to both industry and academia			✓
23	Academia can help different companies 'come together' and pool resources to address common issues, rather than spending millions of rupees on being secretive on something which everyone is working on		✓	✓
24	Industry could setup composites lab in Academia – • Industry saves space, time, training and maintenance • Academia saves investment • More interaction between Industry and Academia		✓	✓
25	Manufacturing and testing of coupons in bulk for Industry		✓	✓
26	Higher tax benefits by investing in research labs		✓	✓
27	Industry personnel to be trained in academic lab, saving training cost to the Industry	✓	✓	✓

Table 2: Industry-academia gap fillers

Conclusions

1. The comprehensive study in Section 1 helps better understand the current composites industry scenario, within India as well as around the world.
2. The stated objectives are achieved through a methodical three step approach to set up state-of-the-art composites labs within the academia.
3. Detailed information and guidelines are provided on the various parameters involved in setting up the proposed labs. These guidelines help academic institutions both during planning as well as execution of the lab set-up.
4. Finally, the paper identifies the gaps currently existing between Indian academia and industry, and lists out how the proposed three step approach progressively helps in reducing the gaps.

The proposals in this paper are relevant to the current scenario in India. This paper presents a roadmap for making India self-sufficient and self-reliant in composites research and development, there-by making her a global leader in composites technology. Indian universities, defence establishments, as well as commercial composite-centric businesses stand to gain tremendously if the proposals made in this paper progress to completion.

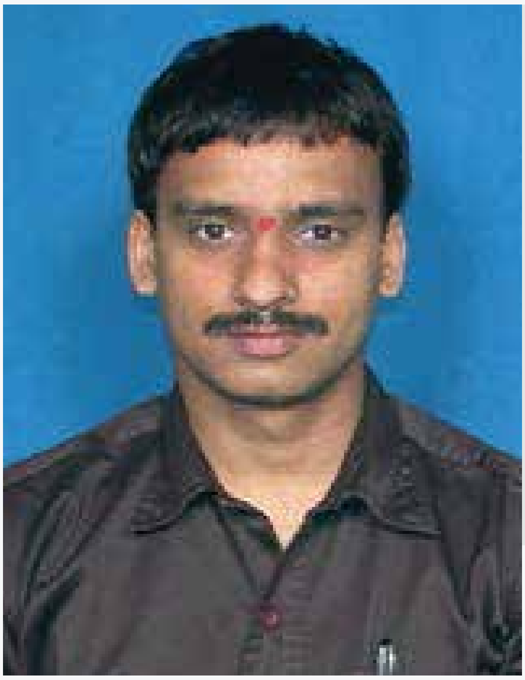
Links for additional information

A sample list of links has been provided for the composites related information/suppliers around the world:

- http://www.compositesworld.com/suppliers
- http://www.vactechcomposites.com/
- http://www.fibreglast.com/product/setting-up-a-composite-shop
- http://corvaircruiser.com/Cruiser/tools_for_setting_up_shop.htm
- http://microship.com/resources/composite-fabrication.html
- http://www.nuplexcomposites.com/australia/
- http://composite.about.com/cs/distconsumables/
- http://www.ccpcomposites.ca/product/consumables
- http://www.thomasnet.com/products/composite-equipment-16743528-1.html

- http://www.jjmechanic.com/process/equip_company.htm
- http://www.acpsales.com/home.html
- http://www.mikrosam.com/?gclid=CLGI6c2kmLkCFUgB4godPyUAnA
- http://www.compositesconsultants.com/cats/filamentwinding.php

Author Profile



Dr. Raju

Dr. Raju has been associated with QuEST for over two years working as Structural analyst, initially at GKN GDC and now at Airbus ODC, predominantly on Airbus A350 aircrafts. He has been identified as Technical Expert in 'Composite structures and Non-destructive Evaluation' at QuEST. He has published more than 30 International Journal and Conference papers and book chapters in Composites. His areas of expertise are Structural health monitoring, Progressive failure analysis, Residual strength analysis, Non-destructive evaluation Techniques, Failure prediction and Simulation of Metallic and Composite Structures. Prior joining QuEST, Dr. Raju worked as Teaching and Research academic for over 8 years at the School of Mechanical and Manufacturing Engineering, UNSW, Sydney, Australia.

Dr. Raju has a PhD in Composites and MTech in Aerospace Engineering from the University of New South Wales, Sydney, Australia. He did his Diploma and BE in Automobile Engineering from University of Mysore. He also holds an MBA in Financial Management.

Author Profile

Vinay Rao

Vinay Rao has been with QuEST for over two years now and works as a Lead Engineer at the GKN GDC India Center. He has spent his entire career in the Aerospace industry, mostly working on composite materials and structures and has adequate experience in structural stress analysis as well as coupon and sub-component level composite material testing and qualification.

Vinay is a Mechanical Engineer by qualification, with a Bachelor's degree from VTU, and a Master's degree (specializing in laminated composites) from Wichita State University.

Author Profile

Satya Iyengar

Satya Iyengar is General Manager, Airbus Wing and Pylon Design Centre at QuEST and is responsible for technical and quality standards of work done in the Airbus ODC. He also provides technical support to the planning and management of projects and work packages and ensures implementation of procedures within the Quality Management System at the ODC.

Satya is also responsible for identifying and initiating training on relevant subjects including knowledge of Airbus tools, methods, and procedures. He has worked on a variety of GKN, Airbus and Boeing projects such as the A350 spar corner bending, rib post analysis, EA2, EA3, and EA4 projects, A400M inlet ducts, A400M detailed FEM, A380 FTE, and Concessions on A380, SA, LR aircrafts. Satya holds a B. S. degree in Mechanical Engineering from Bangalore University and an M. S. degree in Mechanical Engineering from the University Of Cincinnati.

About QuEST Global

QuEST Global is a focused global engineering solutions provider with a proven track record of over 17 years serving the product development & production engineering needs of high technology companies. A pioneer in global engineering services, QuEST is a trusted, strategic and long term partner for many Fortune 500 companies in the Aero Engines, Aerospace & Defence, Transportation, Oil & Gas, Power, Healthcare and other high tech industries. The company offers mechanical, electrical, electronics, embedded, engineering software, engineering analytics, manufacturing engineering and supply chain transformative solutions across the complete engineering lifecycle.

QuEST partners with customers to continuously create value through customer-centric culture, continuous improvement mind-set, as well as domain specific engineering capability. Through its local-global model, QuEST provides maximum value engineering interactions locally, along with high quality deliveries at optimal cost from global locations. The company comprises of more than 7,000 passionate engineers of nine different nationalities intent on making a positive impact to the business of world class customers, transforming the way they do engineering.

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