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Procedia Technology 1 (2012) 211 – 216
Procedia Technology

INSODE 2011

Strategy for introducing 3D fiber reinforced composites weaving technology

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Abstract

Conventional textile is no more a profitable business even after huge investments, due to highly competitive market. Therefore, it is understandable for a country to seek technological up-gradation for competitive edge. It is also believed that the intelligent application of new technologies can certainly boost up the processes of economic growth of a country. Many countries consider technical textile, particularly 3D fiber reinforced composites weaving as a strategic industry for economic strength and technological advancement. The aim of this paper is to conduct an exploratory research on 3D fiber reinforced composite weaving technology, through a review of series of research papers on 3D weaving, fiber reinforced composites and textile industry. This paper tries to identify the strengths, weaknesses, opportunities and threats of the proposed technology. It also evaluates risks involved in introducing a new technology and provides new investment opportunities for the local as well as global investors.

Keywords: Introducing 3D composite weaving; 3D composite weaving strategy; 3D fiber reinforced composites;

1. Introduction

Textile plays a fundamental role in meeting man's basic needs. Initially, textiles were used for wearing and decoration purposes only but now textiles and clothing are truly global industries and therefore play a vital role in modern economic development. In last 50 years, a drastic change has come in the application of textiles and therefore it has attracted the attention of scientists and technologists to do more and more research in this industry. Moreover, at the same time a new concept has come up in the field of textile, known as "technical textiles" due to its interesting properties and new fields of applications. In order to remain competitive in the changing textile market trends, it is necessary for a country to adopt new emerging technologies as well as new textile designing and manufacturing techniques.

General definition of textile refers to production of any product from fibers. Various techniques are being used for manufacturing fabric/product from fibers, such as, weaving, knitting, stitching and braiding. Weaving is widely used as a process for single layer and broadcloth fabric manufacturing within the textile industry, but knitting, felting, net making and non-woven processes or a combination of these also exist in the industry. Three dimensional woven technical textile structures are developed and produced by using advanced manufacturing techniques like 3D weaving, 3D braiding, 3D knitting and 3D stitching etc. This paper reviews the concept of 3D fiber reinforced composites weaving technology and proposes a strategy for introducing the technology.

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doi:10.1016/j.protcy.2012.02.046

2. Literature Review

Nowadays, the conventional textile is no more a profitable business even after huge investments, due to high competitive market and in such kind of business it is nearly impossible to sustain remarkable profitability for a longer period of time [2], particularly in those developing countries where production cost is increasing continuously due to various reasons. So there is a dire need of technological revolution for economic development of such countries. It is also believed that the intelligent application of new technologies in developing countries like Indonesia, India, Brazil and Pakistan etc. can certainly boost up their processes of economic growth [8] but first of all they have to develop their strong SME sector because this sector has the ability to respond quickly to technological changes and most of the developed countries manufacture these products under the SME sector [2].

The application of textile material in technical textiles has given a thrust to fiber technology so as to realize the advancement in needs of the society. Technical textile materials and products manufactured are quite different from non-technical textiles because of their technical and performance properties rather than their aesthetic or decorative characteristics [2], [4]. Few of the application of technical textiles are clothing, medical and health care products, automotive components, aircraft, shuttle and satellite components, building material, Geo-textiles, agriculture, sport and leisurewear, filter media, environmental protection, etc. [Source: Technitex 2006].

World consumption of technical textiles by product types is given in Table-1; World consumption of technical textile by region is given in Table-2 and World consumption of technical textile by application is given in Table-3.

Table.1 World Wide Consumption of Technical Textiles (By Products), Quantity: tonnes, Value: US $ Million

Product	Quantity		Growth % per Annum	Value		Growth % per Annum
	2000	2005		2000	2005	
Fabrics	3,760	4,100	1.7	26,710	29,870	2.2
Non-woven	3,333	4,300	5.4	14,640	19,250	5.6
Composites	1,970	2,580	5.5	5,960	9,160	5.6
Other Textiles	7,687	8,703	3.4	12,950	14,060	3.3
Total	16,750	19,683	3.9	60,260	72,340	3.7
Source: David Rigby Associates/ Techtextil						

Table 1 [4] shows that there is a continuous annual growth in consumption of technical textiles by product i.e. fabrics, non-woven, composites and other textiles. There is not much increase in the consumption of fabric but still there is increased by 1.7% followed by non-woven products which are increased by 5.4%. The increase in consumption of composites is highest as compared to all other products which are reported to be 5.5% from the year 2000 to 2005. In the end other textiles and total products are increased by almost 3.4 and 3.9% respectively from year 2000 to 2005. Along with the increase in growth %age of technical textile, the value of product in US $ Million has also increased so there is good investment opportunities for new countries.

Table 2 World Wide Consumption of Technical Textiles (By Region), Quantity in 000 tonnes

Region	1995	2000	2005	2010
North America	3,584	4,184	4,774	5,591
South America	705	847	1,004	1,230
West Europe	3,002	3,614	4,107	4,760
East Europe	493	584	666	817
Asia Excl-China	3,895	4,449	5,220	6,348
China	1,515	2,155	2,871	3,808
Other Countries	778	917	1,041	1,219
Total	13,972	16,750	19,683	23,773
Source: Technical Textiles and Industrial Nonwovens: World Market forecasts to 2010, David Rigby Associates, 2002				

Table 2 [4] demonstrates the actual and expected annual consumption of technical textile by region for the year 1995, 2000, 2005 and 2010. Asia, North America, West Europe and China are among the leading consumers of technical textile products by region. From the above table it is clear that the consumer market has shown a good trend in consumption of technical textile and which is expected to increase more in future.

Table 3 World Wide Consumption of Technical Textiles (By Application), Quantity: 000 tonnes, Value: US $ Million

	2000		2005	
Area of Application	Quantity	Value	Quantity	Value
Transport Textiles (Auto, Marine, Aero)	2,220	13,080	2,480	14,370
Industrial Products & Components	1,880	9,290	2,340	11,560
Medical & Hygiene Textiles	1,380	7,290	1,650	9,530
Home Textiles, Domestic Equipments	1,800	7,780	2,260	9,680
Clothing Components (Thread, Interlinings)	730	6,800	820	7,640
Agriculture, Horticulture & Fishing	900	4,260	1,020	4,940
Construction Building & Roofing	1,030	3,390	1,270	4,320
Packing and Contamination	530	2,320	660	2,920
Sports & Leisure (Excluding Apparel)	310	2,030	390	2,210
Geo Textiles, Civil Engineering	400	1,860	570	2,360
Protective & Safety Clothing	160	1,640	220	2,230
All Others	5,410	520	6,003	3,580
Total	16,750	60,260	19,683	75,340

Source: Technical Textiles and Industrial Nonwovens: David Rigby Associates, 2002

Table 3 [4] shows the worldwide annual consumption of technical textiles by application in different industries, total of which is increased by almost 3% from the year 2000 to 2005. A continuous increase in the demand for technical textile in each of the industry has been observed which means that scope of the application of technical textiles will increase in the future.

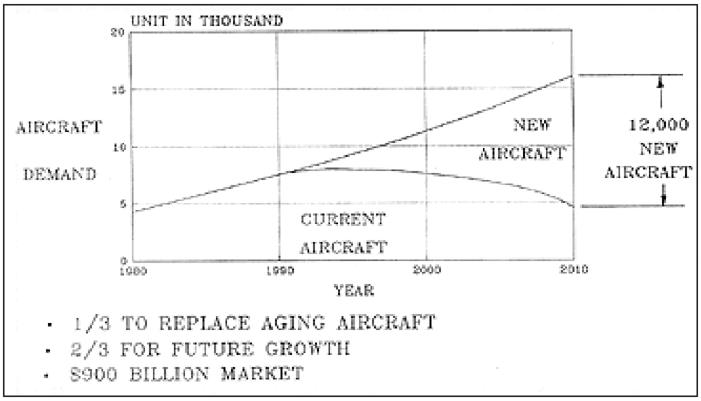

Fig.1. Commercial Aircraft Demand by the Year 2010

Fig. 1 shows the expected new world market demand of the aircraft, which is expected to be almost 12000 new aircraft by the year 2010 [National Aerospace Laboratory (NAL), 6-13-1, Ohsawa, Mitaka, Tokyo 181, Japan, December 7, 1992]. Aircraft is one of the industries which have vast application of technical textiles (composites). So the increase in aircraft demand means that there would also be increase in the demand of composites usage in future. From the above tables and fig, it is understandable for a country to seek technological revolution in the field of textile composites particularly 3D fiber reinforced composites because of their high tech nature for competitive position.

2.1. 2D and 3D fiber reinforced composites

Figure 2 [10] illustrates the hierarchy of textile fiber reinforced composite production. The first step is the formation of yarns from fibers. In the second step, the yarns are woven into fabric structure. The fabrics are then laid up into required shape and then stitched together to create a structured preform. Finally, through consolidation process composite part is infiltrated by resin and then curing in a mould.

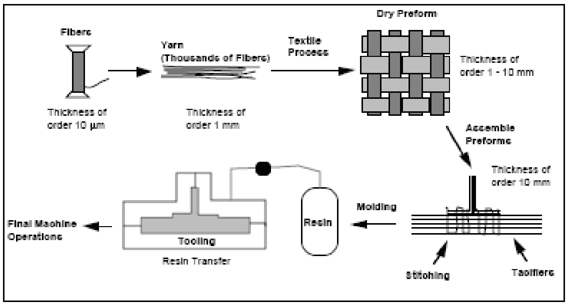

Fig.2. shows the basic steps involve in the production of textile fiber reinforced composite structure.

Fibers embedded in a rigid polymer matrix are termed as composite material [1]. Different types of fibers are being used as reinforcement material such as carbon fiber, fiber glass, Kevlar, boron and spectra etc. Initially 2D fiber reinforced composites were used for various industrial application but due to de-lamination problem and shortage of 2D laminates along with several other reasons, 3D fiber reinforced composite material were developed in late 1960s. Braiding was the first method used for 3D fiber reinforced composite manufacturing but it was not enough to meet the increasing demand of various industries, therefore from 1985 to 1997 "Advance Composite Technology Program (ATCP)" was launched and as a result of which various other techniques were invented such as 3D weaving, 3D knitting, and 3D stitching [1].

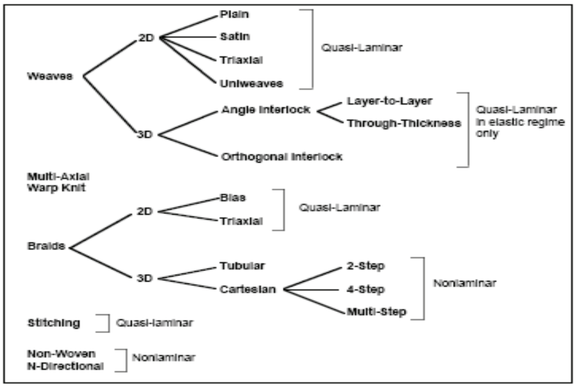

Fig.3. Categories of Textile Composites for High end Applications

Figure 3 [10] introduces the most important groups of textile composites and manufacturing techniques. Column wise from left to right, first textiles processes are categorized followed by the dimensional structure and manufacturing technique/design of the textile perform. At the end differentiate each category of 2D and 3D textile composite according to their macroscopic properties. Textile composites which do not behave as laminates and have equal load bearing capacity along the three axes are known as non-laminar and composites which behave as laminates and majority of fiber lie in plane are called as quasi-laminar [10].

Previously 3D woven performs were only manufactured in simple structures but now advance techniques are also invented [6]. Although various techniques have been developed for the manufacturing of 3D woven performs, or fabrics [6] and these performs are also considered among the technical textiles because of their high end use application like automotive, marine, civil, medical and aircraft industry [5]. Eventually, there are still very few countries which can produce such structures or which have the knowledge of these advance manufacturing techniques, so there is a dire need of transfer of these technologies to other part of the world to meet the increasing demand of the industries.

2.2. 3D Weaving

Weaving is simply producing a fabric by the interlacing of two sets of yarns i.e. warp and weft. The first major difference between conventional weaving and 3D weaving is the need to have multiple layers of warp yams to achieve the required thickness of the fabric [1]. Fig. 4 shows the view of 3D weaving of carbon fiber. Moreover 3D weaving process involves double directional shedding technique which require two sets of weft yarn one for horizontal and the other for vertical filling, a multiple layers of warp yarns and warp shed formation both row wise and column wise [6].

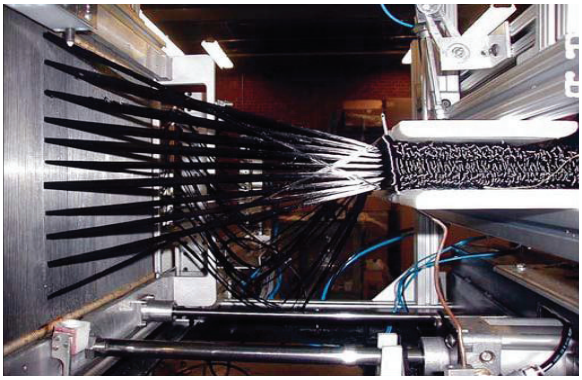

Fig.4. Three dimensional (3-D) weaving

An advantage of 3D weaving is that 3D fabrics can also be manufactured on standard industrial loom with a little modification [3], [5]. Conventional technologies like Dobby and Jacquard are the examples of standard industrial looms which can be used for manufacturing 3D woven performs [7], thereby, widening the scope of conventional technologies. There are different methods of 3D fabric formation i.e. non-interlacing, interlacing type, multi axial and double directional shedding etc [6] [7]. This paper reviews the concept of 3D weaving only and does not include the other 3D fabric manufacturing technologies.

3. Analysis & Discussion

Generally, the key need of this paper is the development of a robust strategy for introducing 3D fiber reinforced composite weaving technology to the areas of world which are lagging behind in this technology and thereby missing the opportunity for their technological advancement and economic growth. And also for countries which are already involved in composites weaving to enhance their capabilities to remain competitive in the global market. The business environment is increasingly influenced by the pace of technological development and globalisation of the world economy, which means that customers, competitors, suppliers and collaborators may be located anywhere. Thus any region can take initiative to become supplier, competitor or collaborator. In consequence the requirement for companies to constantly strengthen their capabilities and find innovative ways becomes necessary for survival. At the same time society faces numerous challenges, many of which also present an opportunity not only for companies but also for countries.

The global composites market has grown considerably in the last 10 years with current annual revenue for finished parts in excess of £2 billion. This is set to rise by another 25% in the next five years with the aerospace and advanced transport sectors. However, increasing economic growth is being achieved by regions with lower labour rates than the West [Ken Wappat, Chairman, NCN (National Composites Network) UK, April 2006].

To vision of the strategy is to maintain and grow an industry, with visionary research and technology development capability, delivered through a globally integrated academic/industry partnership.

The level of skills in the industry is high and therefore there is a need to improve advanced skills to enter and retain competitive in the industry. The more open the country is in its trade policy, more R & D culture is imported and therefore more skilled is their labour force and more its trade with the developed countries but to adapt foreign technology openness only is not enough, also there is need to learn how to apply the new technology and then improve it gradually overtime [9].

Globalisation of the composite industry has been moving forward at a significant pace with the development of worldwide partnerships by the major producers for integrated solutions and indigenous growth of low-labour cost markets.

Recent academic research has proven that engaging in overseas trade stimulates competitiveness and that those companies that are internationally active are generally more successful. Regional supply chain companies tend not to seek global business, but seek to win business from mainly regional sources of work.

Private Venture finance companies must show positive signs of targeting composite weaving as an investment opportunity. For the supply chain this may prove an attractive source of growth funding.

Steps to be taken:

To introduce 3D Fiber Reinforced Composites weaving technology in a country, following steps are to be taken;

i. To identify major players with their respective market share
ii. To develop understanding with major clients i.e. Defence Forces, Textile Industry and Automotive Industry etc.
iii. To get hold of their requirements with technical data
iv. To develop indigenous team of engineers/technicians and send them abroad for research, development and training.
v. To concentrate on major manufacturing organisations and to convince them to invest in 3D Weaving Technology.

4. Conclusion

It is a highly strategic industry with very low competition amongst the suppliers but at the same time also a very technical and advanced industry. For developing countries such technical infrastructure are expensive and need expertise and skill levels to use the benefits of such a technology by finding opportunities to export the product. Also one has to penetrate in this market by identifying a niche and gradually establishing itself.

References

1. L. Tong, A. P. Mouritz,, and M. K. Bannister, “3D fiber reinforced composites” Elsevier science limited, 2002 {Chapter 1}.
2. “How to catch up with latest textile market trends,” Pakistan, Dawn News, July17, 2006.
3. S. S. Badawi “Development of Weaving Machine and 3D Woven Spacer Structures for Lightweight Composites Material” PhD Dissertation, Dresden, 9-07-2007
4. N. A. Memon, N. Zamaan, “Pakistan lags behind in Technical Textiles” Journal of Management and Social Sciences, Vol. 3, No. 2, (Fall 2007) 120-127.
5. A. P. Mouritz, M. K. Bannister, P. J. Falzon, K. H. Leong “Review of applications for advance three-dimensional fiber textile composites” ELSEVIER, Composites: Part A 30 (1999) 1445-1461.
6. N. Gokarneshan, P. Dhanapal, “3-D Woven Preforms: Review on its Manufacture, Technical Parameters, Characterization and End uses,” Volume 88, February 2008.
7. J. A. Sodan, B. J. Hill, “Conventional Weaving of shaped performs for engineering composites.” ELSEVIER, Composites part A 29A (1998) 757- 762.
8. U. Colombo, “The technical revolution and the future of the third world,” IEEE Technology and Society Magazine, spring 1991.
9. B. M. Hoekman, K. E. Maskus, K. Saggi, “Transfer of technology to developing countries: unilateral and multilateral policy options,” ELSEVIER, World development Vol. 33, No. 10, pp. 1587- 1602, 2005.
10. B. N. Cox and G. Flanagan, “Handbook of Analytical Methods of Textile Composite” NASA Contractor Report 4750, {Chapter 2}.