## CARBON FIBRE- General Perspective

Aerospace industry has been the prime driving force for the continued growth of Carbon Fibre Technology. The use of carbon fibre (CF) based composite materials is also increasing in other areas like wind energy, automotive, off shore, infrastructure industries etc. Today various grades of CF with a range of modulus and strength are commercially available for specific uses. The production of CF currently (2005) in the world is estimated to be 35,000 tonnes per annum. In the year 2007, the CF production will increase to about 48,000 tonnes per annum.

## DEMAND GROWTH

### Aerospace Industries

- Airbus uses 25-30 tonnes of composites in its new generation passenger aircraft: A 380, and ~14-15 tonnes in A 350. Earlier only 7 tonnes of composites were used in airbus A 340/500 and A340/600 aeroplanes. [*Adv. Comp. Bull. Newsletter,* June 2005].
- Boeing, in its dream liners B787-3, B787-8 and 9 versions, uses composite materials to as high an extent as 50% of the total structural weight. [*Adv.Comp.Bull.Newsletter,* Aug 2005].
- An all composite body 8-9-seater light business aircraft called Spectrum 33 has been developed [*Adv.Comp.Bull. Newsletter,* April 2006].
- Lockheed's F/A -22 fighter aircraft and F-35 joint strike fighter use 20% and 35% of airframe weight in composites respectively. Cytec Engineered materials (CEM) has got a contract worth $750 million from US Air Force to supply composite materials for fighter aircraft production [*Adv. Comp. Bull. Newsletter,* May 2006], www.cytec. com.
- LCA (India) uses roughly 45% of composites in its airframe.
- Approved 5th generation military aircraft programs and new models have half of the airframes by weight of composites.
- Hexel supplies CF products for use in satellite launch vehicles such as Delta, Titan and the Arianne programmes. More than 1000 satellites are expected to be launched in the next 10 years. The lightest 1 m antenna used in satellites weighs 22 kg and is made out of CF materials.

### Automotive Industries

- All Formula One race cars are made of CF reinforced composites.
- BMW has shown several concept vehicles using considerable amounts of CF. A major production as high as 100 cars per day is expected.
- Vermount Composite Industries VCI-USA secured contract from GM-Inc., to produce 14,000 CFP materials for bumpers. An intelligent multimode transportation system bus, the body of which is entirely made of CF materials has been jointly developed by Alcan Composite Corp, USA, Toyota Motor car, Toho Tenax and Mitsubishi Rayon Co. [*Adv. Comp. Bull. Newsletter,* Mar 2006]
- Good Year is deploying a CF based insert in the out board sidewall of its Eagle tyres with response edge technology. [*Adv. Comp.Bull.Newsletter,* April 2006]

### Wind Energy

- CF is now recognized as the only material that is suitable for the development of bigger and powerful generators.
- Zoltek Inc. signed a long term strategic supply agreement with Vestas wind systems for $ 80-100 million worth CF/CFP materials. [www.zoltek.com]

### Offshore Applications

- For enhanced stiffness, pultruded CFP rods [48k tow Zoltek CF] of over 3000 m continuous lengths are used in offshore umbilicals.
- Pultruded CFP rods are recommended by Deep Sea Engineering and Mgt. as an alternative to polyester mooring ropes for anchoring drilling units.
- CFP composites spoolable pipeline with themoplastic liners are being used for onshore and offshore applications. [6 million ft have been installed in N America] [*High performance Composites,* March 2006]

### Infrastructure

- CF reinforced precast technology is currently under use for highly sustainable building designs.
- CF wrap systems are used for repairing existing bridge columns to balance shear strength loss. [*Adv.Comp.Bull. Newsletter,* March 2006]
- ACU advanced composite groups and its partner NESCO developed 46 x 8.1m road bridge constructed with CFP beams. [*Adv.Comp.Bull.Newsletter*, November 2005]

### Announced Expansion Programmes

The world's top three CF manufacturers are increasing production capacity to meet rapidly increasing demand from the various sectors mentioned above.

## TORAY Ind., Inc Japan [www.toray.co.jp]

TORAY Ind., Inc. Japan the world's largest producer of CF with an estimated 37% share of the global market is a significant supplier to the aerospace sector. [*Adv. Comp. Bull. Newsletter* July 2005, March 2006, June 2006]. The company is investing about $210 million on three production lines, two for carbon fibre and other for prepreg products. The company is also spending $67 million capacity expansion at its French subsidiary Soficar. Total CF production will be enhanced from 4700 tonnes to 6900 tonnes, Prepreg capacity will also be doubled, from 10,200 thousand sq.metres to 22,200 thousand sq.metres.

## Toho Tenax, Japan

Toho Tenax, the world's second largest CF producer is expanding capacity of PAN based CF and is planning to install a carbonization line with annual production capacity of 2.7 kilotonnes in its plant in Japan with the start up schedule in 2008 to reach an annual production of 11.8 kilotonnes by 2008. [*Adv.Comp.Bull.Newsletter,* June 2006]

## Mitsubishi Rayon, Japan [www.grafil.com]

Mitsubishi Rayon is increasing its capacities in Japan, USA and France, aiming for an annual production of 8,000 tonnes by September 2007. [*Adv.Comp.Bull.Newsletter,* June 2006]. Grafil, a subsidiary of Mitsubishi Rayon is going for expansion of high strength carbon fibre in USA to produce 2 million kg per annum and set up integrated facility for prepregs and finished products. [www.grafil.com]

## Zoltek,USA www.zoltek.com]

Zoltek, a US based CF producer is expanding its facility at its plant in Hungary. The company aims to make the plant the world's largest CF production facility. [*Adv.Comp.Bull. Newsletter,* June 2006]. By the end of 2009, Zoltek expects rated annual CF production at its Hungary plant to reach at least 8,160 tonnes compared to 900 tones at the beginning of 2005.

## Hexcelcorp.,USA [www.hexel.com]

Hexcel Corp., USA, is investing $20 billion in prepreg production to meet the growing demands of the European aerospace industry for its expansion programme in Spain, Germany and France and is expected to be operational by December 2006. Hexcel is also expanding its CF manufacture facility in USA. [*Adv.Comp.Bull.Newsletter*, January 2006]

## General references

- www.intertechusa.com/cf.html
- www .performance - materials.net
- www.global composites.com

Carbon fibre future trends google search

Report on "Growth opportunities in carbon fibres 2004-2010" prepared by e-composites marketing group. Available on payment. Contact for order form- david.kaiser @ e-composites.com Fax. 877-883-5140 [Features: 456 pages, 377 figures / charts / tables providing all the latest as well as critical issues, covering materials and technology related to the carbon fibre industries

## FIXED CAPITAL INVESTMENTS AND MANUFACTURING COST ESTIMATION FOR HIGHER CAPACITIES OF CARBON FIBRE PLANT

Basis: 20 TPA pilot plant data

Fixed capital investment estimation for similar kind of plant:

$$C_{FC,b} = C_{FC,a} \left( r_{mb} / r_{ma} \right)^{0.7} \quad \ldots\ldots(1)$$

Where,

$r_{ma}$ = monthly production rate of plant a

$r_{mb}$ = monthly production rate of plant b

$C_{FC,a}$ = Fixed capital investment of plant a

$C_{FC,b}$ = Fixed capital investment of plant b

This method is an adaptation of the six-tenth-factor rule, which applies for use in estimation of equipment cost. A similar rule is applied to fixed capital investment except that the absolute value of the power term is governed by following conditions:

- For the average chemical process, the power term will be 0.7 as shown in equation.
- For very small installation or for processes employing extreme conditions of temperature or pressure, the value of power term will be from 0.3 to 0.5
- For plant achieving higher capacities through the employment of a high proportion of multiple units rather than large-sized equipment, the term will be 0.8.

## Manufacturing cost estimation for carbon fiber plant:

$$A_p = 0.09*C_{FC} + 16200*c_L*N + A_U \quad \ldots\ldots(2)$$

Where,

$A_p$ = Annual processing cost

$C_{FC}$ = Fixed capital investment

$c_L$ = Labour charges (Rs/hr)

$N$ = Number of persons working per shift

$A_U$ = Annual utility and raw material cost

$A_p$ = 0.09*125000000 + 16200* (300/24)*25 + 150000*300
= 3100 / year for 20000 kg of carbon fibres
= 3100 Rs/kg of carbon fibre

The annual processing cost for $A_{p2}$ for a similar plant of a different size designed for annual production rate $R_2$ can be approximately calculated by

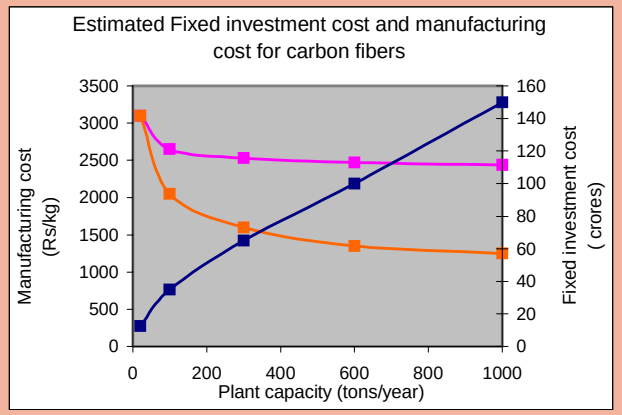
$$A_{p2} = 0.09*C_{FC1} (R_2/R_1)^{0.7} + 16200*c_L*N1 (R_2/R_1)^{0.25} + A_{U1}(R_2/R_1) \quad \ldots.(3)$$

A similar approach for estimating manufacturing cost with a power factor of 0.8 for utilities is as

$$A_{p2} = 0.09*C_{FC1} (R_2/R_1)^{0.7} + 16200*c_L*N1 (R_2/R_1)^{0.25} + A_{U1}(R_2/R_1)^{0.8} \quad \ldots.(4)$$

Estimated fixed capital investment (excluding land, building and fire hydrant system)

| *Plant capacity of carbon fibres (Tons/Year)* | *Estimated fixed capital investment (Crores)* | *Estimated manufacturing cost of carbon fibres (Rs/kg)* From Eq. (3) | From Eq. (4) |
|---|---|---|---|
| 20 | 12.5 | 3100 | 3100 |
| 100 | 35 | 2650 | 2050 |
| 300 | 65 | 2532 | 1600 |
| 600 | 100 | 2472 | 1350 |
| 1000 | 150 | 2437 | 1250 |




## References


1. Robert H. Perry, Perry's Chemical Engineer's Handbook.
2. Robert S. Aries, Chemical Engineering Cost Estimation.


# CARBON FIBRES: GENERAL PERSPECTIVE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