

# National Conference on Recent Advances in Composites (NCRAC-2012)

## Development of Carbon-Carbon Brake Discs for Light Combat Aircraft-Tejas

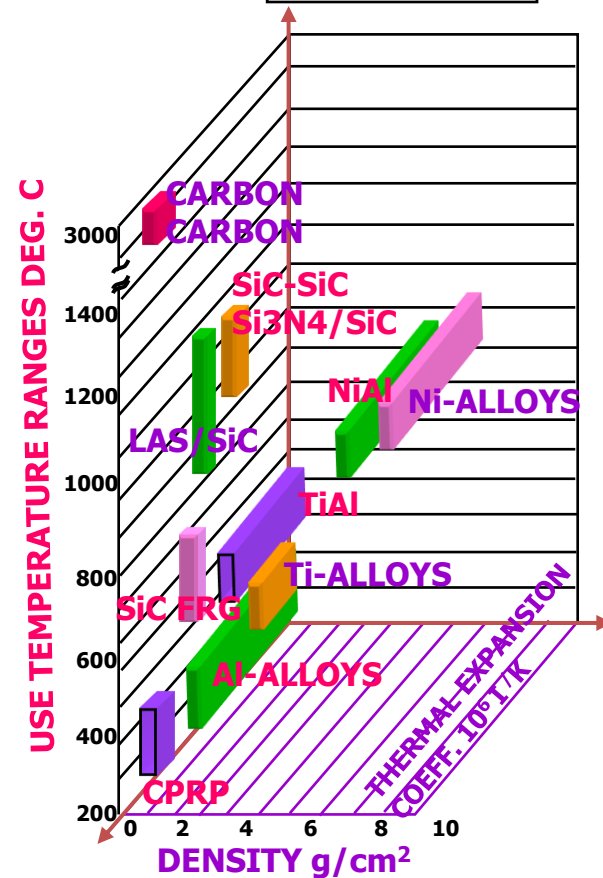
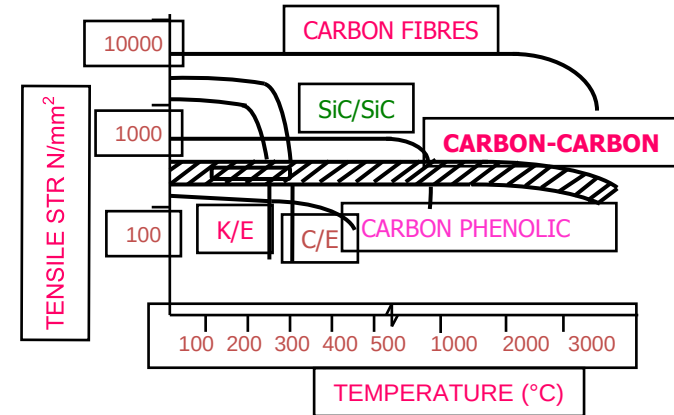
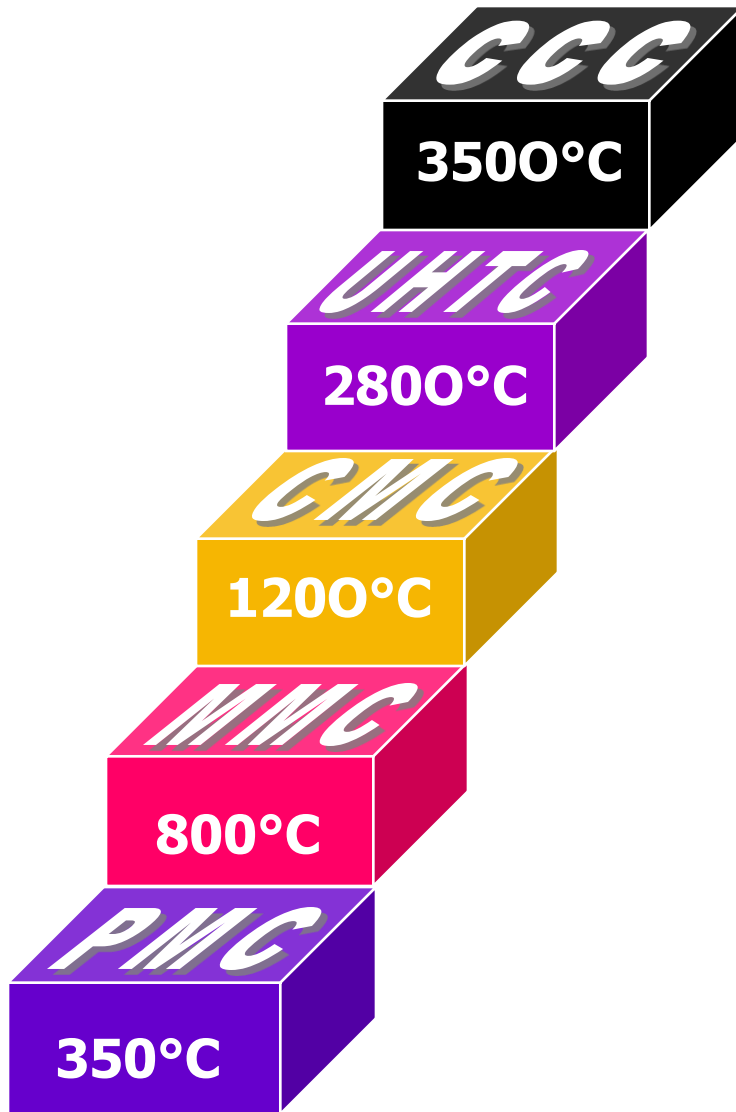
By

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Hyderabad

# CLASSIFICATION OF COMPOSITES

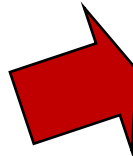


# CARBON-CARBON COMPOSITES

**CARBON FIBRE  
REINFORCEMENTS**



**CARBON MATRIX**



**CARBON-CARBON  
COMPOSITES**

## CARBON FIBRE

- PAN based
- Rayon based
- Pitch based

## CARBON MATRIX

- Pitch Derived Carbon
- Resin Derived Carbon
- Pyrolytic carbon

# TYPICAL CHARACTERISTICS OF CARBON-CARBON COMPOSITES

## Excellent Thermo-Structural Properties

- Retention of Mechanical properties up to 2500 °C
- Tailorable mechanical properties
- Range of properties

## Excellent Thermal Properties

- Thermal Stability
- High Thermal Shock Properties
- High Specific Heat

## Frictional Characteristics

- High & Stable Friction Co-efficient
- Low Wear

- Bio Compatibility
- Chemical Inertness

# APPLICATIONS OF CARBON-CARBON COMPOSITES

## AEROSPACE AND DEFENCE

- Brake discs for aircraft/ spacecraft
- Missile & Space Shuttle Nose tips/Leading Edges
- Structural parts of Hypersonic Vehicles
- Combustion Liners
- Nozzle Throats and exit cones
- Jet Engine Components
- Vanes
- Laser Barriers

## INDUSTRIAL

- Heating Elements
- Metal forming Moulds
- High Temperature Mechanical Fasteners (Bolts, Nuts, Screws)
- Piston Connecting Rods for internal combustion engines
- High Temperature crucibles/Hardware for plasma CVD
- Brake discs for racing cars, high speed trains and off road vehicles
- Electrode connecting parts in electrical arc furnace
- Interceptors for glass bottle molding

## MEDICAL

- Hip Bone Prosthetics
- Artificial heart valve with glassy or pyrolytic carbon
- Bone Plates

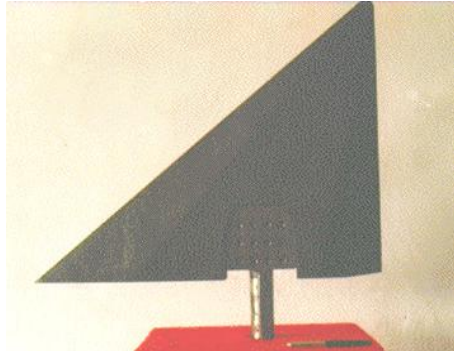
## NUCLEAR

- Heat exchanger tubes in Nuclear reactor
- Plasma Facing Material

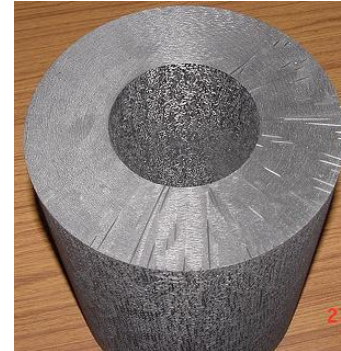
# HIGH TEMPERATURE COMPOSITE PRODUCTS MADE AT ASL



**C/C Nose Tip**



**C/C RECS**



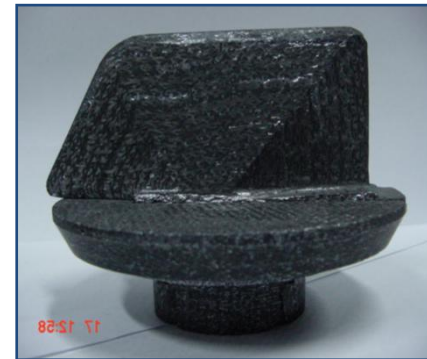
**C/C Throat**



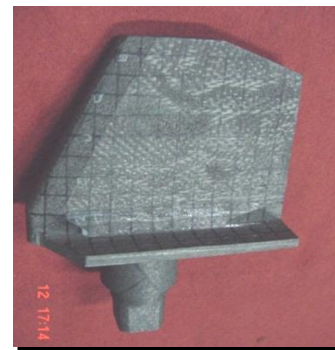
**C/C Nut and Bolt**



**C/C Aircraft Brakes**



**C/SiC Jet Vanes**



# CARBON-CARBON COMPOSITE PROCESSING

**PRECURSOR  
FIBRE**

**CARBON FIBRE REINFORCEMENT**

**REINFORCEMENT FORM (2D, 3D, nD )**

**PRECURSOR  
MATRIX**

**RESIN**

**PITCH**

**GASEOUS  
HYDROCARBON**

**IMPREGNATION**

**IMPREGNATION**

**CHEMICAL VAPOUR  
INFILTRATION (CVI)**

**PROCESS**

**CARBONIZATION  
(UP TO 1000 °C)**

**CARBONIZATION  
(UP TO 800 °C,  
Press. Ambi/1000 bar)**

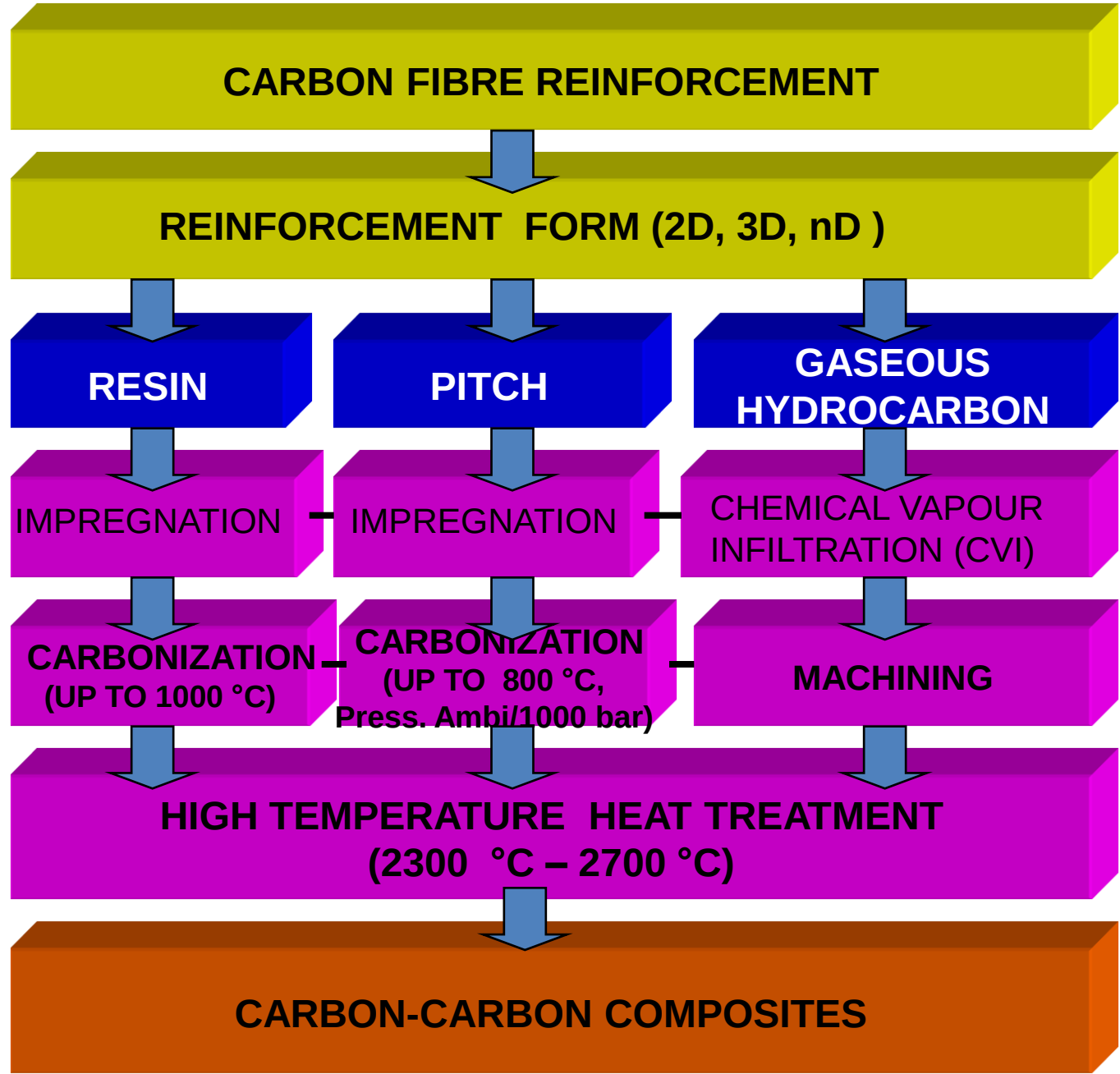
**MACHINING**

n times

**HIGH TEMPERATURE HEAT TREATMENT  
(2300 °C – 2700 °C)**

**PRODUCT**

**CARBON-CARBON COMPOSITES**





# CARBON-CARBON COMPOSITES FOR AIRCRAFT BRAKES

## BRAKE FUNCTIONS

- PROVIDE DRAG
- ABSORB KINETIC ENERGY BY CONVERTING INTO HEAT
- HOLD A/ C STATIONARY AGAINST ENGINE THRUST

## PERFORMANCE REQUIREMENTS

### HEAT SINK

HEAT SINK LOADING (KJ/Kg)

LCA

MIRAGE

AIRBUS

1140

1120

870

DISC AREA LOADING (J / CM<sup>2</sup>)

2510

2100

1700

AREA LOADING RATE (W / CM<sup>2</sup>)

96

100

85

(C<sub>p</sub>, PERMISSIBLE OPERATING TEMP.)  
(K)

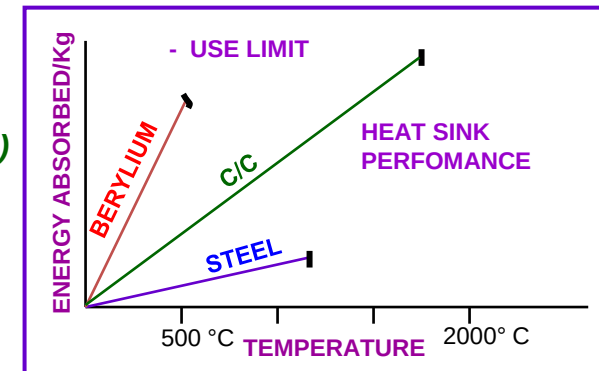
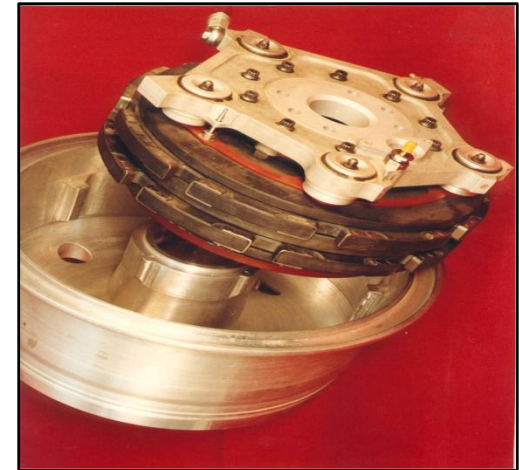
## THERMO STRUCTURAL

TORQUE TRANSMISSION

(RETENTION OF MECH. PROPERTIES)

COMPRESSIVE LOAD

THERMAL SHOCK RESISTANCE (HIGH 'K', LOW  $\alpha$ )



## FRICTIONAL

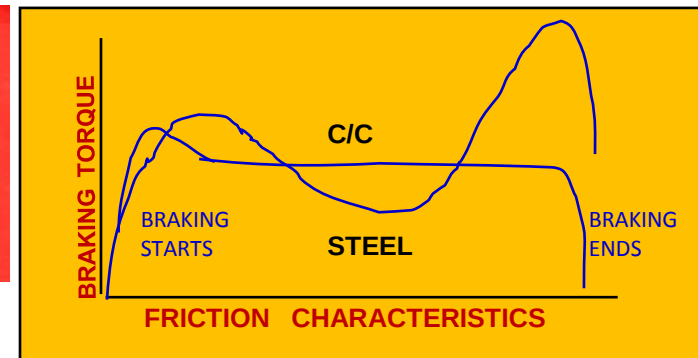
STABLE & HIGH  $\mu$   
LOW WEAR  
LIGHT WEIGHT  
(40% wt reduction)



Metal-Ceramic  
Brakes

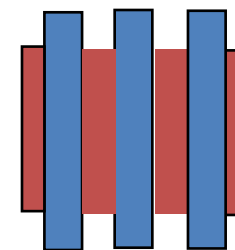


C/C brakes





# CARBON-CARBON BRAKE DISCS FOR LCA - AIRFORCE & NAVY VERSIONS



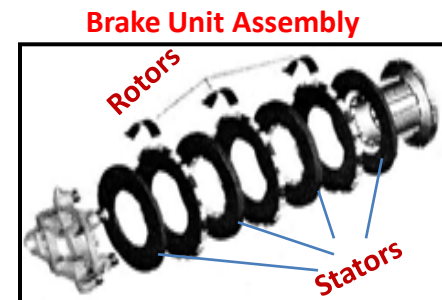
C/C Heat Pack



C/C Brakes for LCA-AF



C/C Brakes for LCA-Navy



## C/C Brakes for LCA

- Multiple disc brake configuration
- Two rear wheels of LCA are fitted with C/C brakes
- 14 nos of C/C discs make an A/C set
- Each wheel is fitted with 7 Nos of C/C discs.

|                   | Energy to be absorbed (MJ) |          | Brake Temperature (° C) |                   |
|-------------------|----------------------------|----------|-------------------------|-------------------|
|                   | LCA-AF                     | LCA-Navy | Bulk                    | Interface Surface |
| Normal Energy     | 13.0                       | 10.5     | 650-750                 | 1500              |
| Over Load Energy  | 16.0                       | 13.0     | 900-1000                |                   |
| Rejected Take off | 22.5                       | 16.0     | 1200 -1400              | 3000              |

# CARBON-CARBON BRAKE DISCS FOR LCA - AIRFORCE & NAVY VERSIONS

Third Party Inspection (CEMILAC & DGAQA)

Raw Materials  
(Carbon Fabric, Phenolic Resin)

Preforming

Post curing

Carbonization  
(1000 °C)

Densification

Machining

Testing as per TTS

UT-NDT

Clip Riveting

Anti-Oxidation Coating

Clearance by Airworthiness Agencies

Prepregging

Lay Up

Moulding

Pitch Impregnation  
(250 °C)

HIPIC  
(800 °C/1000 bar)

Graphitization  
(> 2000 °C)

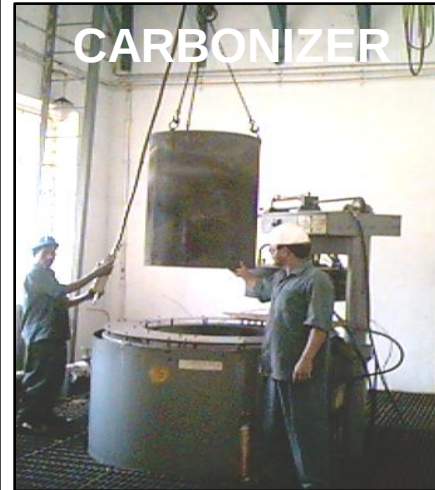
Dimensional.  
Inspection

Sample Level (Phy.,  
Mech., Ther.)

Frictional

- DOD
- Full Scale

## Important Process Equipments



## CARBON-CARBON BRAKE DISCS FOR LCA - AIRFORCE & NAVY VERSIONS

| Type of C/C Disc | Version     | Status                                             | Life of the discs<br>(No. of Landings) |
|------------------|-------------|----------------------------------------------------|----------------------------------------|
| Mark-I           | LCA-AF      | Used in initial<br>Flight Trials                   | 150-200                                |
| Mark-II          | LCA-AF      | <b>Type approved</b><br>Production<br>Discontinued | 200-250                                |
| Mark-III         | LCA-AF/Navy | <b>Type approved</b><br>Under Production           | 300                                    |
| Mark-III+        | LCA-AF/Navy | Qualified                                          | 450                                    |
| Mark-IV          | LCA-AF/Navy | Under<br>Qualification                             | 600                                    |

### Achievements

- Indigenously developed & qualified C/C braked discs for LCA-AF & LCA-Navy
- Trained the industry in fabrication of C/C brake discs
- Produced so far 50 A/C sets of discs and supplied to ADA/HAL
- 100 More A/C sets will be produced and supplied in next 2 to 3 years of time
- Indigenously developed C/C discs are used in more than 1800 landings of LCA

**THANK YOU**