ADVANTAGES OF C-C COMPOSITES

- Carbon is brittle and flaw sensitive like ceramics. Reinforcement of a carbon matrix allows the composite to fail gradually and also gives advantages such as ability to withstand high temperatures, low creep at high temperatures, low density, good tensile and compressive strengths, high fatigue resistance, high thermal conductivity, and high coefficient of friction.

MECHANICAL PROPERTIES OF C-C COMPOSITES

Typical Mechanical Properties of Carbon–Carbon Matrix Composites

Property	Units	C–C	Steel	Aluminum
System of units: USCS				
Specific gravity	—	1.68	7.8	2.6
Young's modulus	Msi	1.95	30	10
Ultimate tensile strength	ksi	5.180	94	40
Coefficient of thermal expansion	μin./in./°F	1.11	6.5	12.8
System of units: SI				
Specific gravity	—	1.68	7.8	2.6
Young's modulus	GPa	13.5	206.8	68.95
Ultimate strength	MPa	35.7	648.1	234.4
Coefficient of thermal expansion	μm/m/°C	2.0	11.7	23

PROCESSING A C–C COMPOSITE

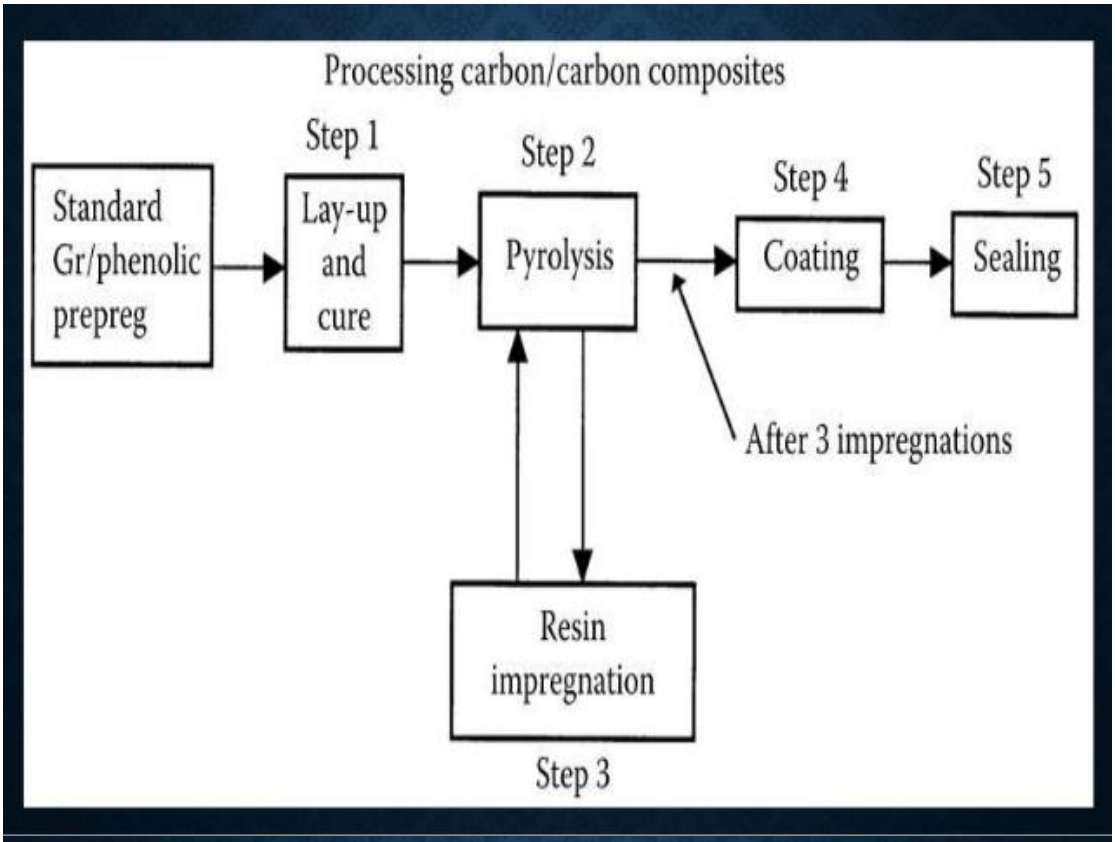
Low-pressure carbonization

A graphite cloth is taken, impregnated by resin (such as phenolic, pitch, and furfuryl ester), and laid up in layers.

It is laid in a mold, cured, and trimmed. The part is then pyrolized, converting the phenolic resin to graphite.

The composite is then impregnated by furfuryl alcohol. The process drives off the resin and any volatiles. The process is repeated three or four times until the level of porosity is reduced to an acceptable level.

Each time, this process increases its modulus and strength. Because carbon–carbon composites oxidize at temperatures as low as 450°C, an outer layer of silicon carbide may be deposited.



APPLICATIONS OF C-C COMPOSITES

- **Space shuttle nose cones:**

As the shuttle enters Earth's atmosphere, temperatures as high as 1700°C are experienced.

- **Aircraft brakes:**

The carbon–carbon brakes cost $970/kg, which is several times more than their metallic counterpart; however, the high durability (two to four times that of steel), high specific heat (2.5 times that of steel), low braking distances and braking times (three-quarters that of berylium), and large weight savings of up to 450 kg on a commercial aircraft such as Airbus A300-B2K and A300-B4 are attractive.