Processing of carbon-carbon composites through Pitch Impregnation, Carbonization, Graphitization (High Temperature Treatment), and Intermediate Machining

Two part quotation containing
I.) Techno – commercial part without cost aspects  
II.) A price bid shall be submitted separately

1. **Introduction:**
Vikram Sarabhai Space Centre (VSSC), Thiruvananthapuram develops and realizes carbon-carbon (C-C) composite products for various programs of Indian Space Research Organization (ISRO). Processing of C-C composites require a combination of different processes to obtain the final product. VSSC is looking forward for participation of public/private sector industries to carry out few types of processing works (pitch impregnation, carbonization, graphitization and intermediate machining) utilizing their process facilities and resources for C-C composites provided. Considering the long cycle duration of C-C processing, it is intended to carry out above mentioned works with a party having all facilities in one area.

2. **Scope of Work:**
Following four types of processing works are estimated for carbon-carbon composites over a period of **2 years**.

- Pitch impregnation - 90 cycles
- Carbonization - 30 cycles
- Graphitization - 50 cycles
- Intermediate Machining - 50 cycles

2.1. **Pitch Impregnation:**
Carbon-Carbon composites require pitch impregnation process under vacuum or pneumatic pressure condition. C-C composites contained in metallic container will be provided by VSSC for carrying out the pitch impregnation process. Depending upon the product requirements, vacuum of the order of 700mm Hg or pressure up to 2 bar, will be required under maximum temperature of 250°C. A typical pitch impregnation cycle will require 2 days work cumulatively. Party shall meet the following requirements to carry out pitch impregnation process of C-C composites provided by VSSC:
2.1.1. Coaltar pitch of following specification shall be arranged by the party for use in the pitch impregnation process:

- Average softening point: 80 – 90 °C
- Quinoline insoluble (QI): 0.2 – 0.3%
- Toluene insoluble (TI): 16 – 18%
- Specific gravity at 35°C: 1.27 – 1.30
- Coke yield: 45 – 55%
- Viscosity at 176°C: 150 – 170 cps
- Flash point: 230 – 250°C
- Ash content: 0.05 – 0.1%

2.1.2. A sample of coaltar pitch shall be tested before each process cycle. Testing shall be done at party’s site or at any NABL accredited laboratory. A copy of the test report shall be provided to VSSC.

2.1.3. Suitable process facility shall be available to carry out pitch impregnation process under vacuum (better than 700mm Hg) or pneumatic pressure (up to 2 bar) condition under maximum temperature of 250°C. Furnace may be heated by resistance method and it shall maintain temperature uniformity within ±10°C inside the furnace. Work zone size shall be adequate to accommodate C-C composites of size Ø800mm×800mm height (maximum envelope).

2.1.4. The furnace shall have facility for evacuation which may be used before heating the furnace and during the impregnation process.

2.1.5. The furnace shall have affluent management system to address pollution in the surroundings.

2.1.6. Thermocouples may be used to measure temperatures of furnace and C-C products during pitch impregnation process.

2.1.7. C-C composites shall be loaded/unloaded to/from the furnace as per VSSC guidelines. The process shall be carried out as per the specification/input given by VSSC for a particular cycle.

2.1.8. All the process data (temperature, vacuum, pressure etc.) shall be monitored and logged during the pitch impregnation process. A copy of process log shall be provided to VSSC.

2.1.9. A summary report (with authorized signature) on the completed pitch impregnation cycle shall be submitted to VSSC.

2.1.10. Skilled and experienced people shall be engaged for doing the pitch impregnation process of C-C composites.

2.2. Carbonization:

For pyrolysis of coaltar pitch / phenolic resin, carbon-carbon composites require Carbonization process under inert atmosphere of Nitrogen/Argon gas. C-C composites impregnated with coaltar pitch or phenolic resin and contained in metallic container will be provided by VSSC for carrying out the Carbonization process. Depending upon the product requirements, maximum temperature of
carbonization may vary from 800°C to 900°C. Heating/cooling rates may vary from 2 °C/h to 75 °C/h in different temperature ranges. A typical carbonization cycle will require 12 – 16 days work cumulatively. After the process, C-C composite products need to be extracted and cleaned properly for further processes. Party shall meet the following requirements to carry out Carbonization process of C-C composites provided by VSSC:

2.2.1. Suitable process facility (high temperature furnace) shall be available to carry out carbonization process under inert atmosphere. Furnace may be heated by resistance method and it shall maintain temperature uniformity within ±10°C inside the furnace zone. Work zone size shall be adequate to accommodate C-C composites of size Ø800mm×800mm height (maximum envelope).

2.2.2. The furnace shall have provision for connecting minimum three thermocouples to C-C products at different locations inside work zone.

2.2.3. The furnace shall have facility for evacuation which may be used before heating the furnace.

2.2.4. The furnace shall have safety alarm system to indicate low flow of inert gas to the work zone.

2.2.5. The furnace shall have affluent management system to address pollution in the surroundings.

2.2.6. Inert gases (Nitrogen, Argon) of purity >99.99% shall be arranged by party. A copy of purity certificate shall be provided to VSSC.

2.2.7. Thermocouples may be used to measure temperatures of furnace and C-C products during the carbonization process.

2.2.8. C-C composites shall be loaded/unloaded to/from the furnace as per VSSC guidelines. The process shall be carried out as per the specification/input given by VSSC for a particular cycle.

2.2.9. All the process data (temperature, gas flow rate etc.) shall be monitored and logged during the carbonization process. A copy of process log shall be provided to VSSC.

2.2.10. A summary report (with authorized signature) on the completed carbonization cycle shall be submitted to VSSC.

2.2.11. C-C composite products shall be extracted and cleaned after the carbonization process.

2.2.12. Skilled and experienced people shall be engaged for doing the carbonization process of C-C composites.

2.3. Graphitization (High Temperature Treatment):

C-C composites require Graphitization (high temperature treatment) process under inert atmosphere or vacuum condition. Depending upon the product requirements, maximum graphitization temperature may vary from 1800°C to 2600°C for inert atmosphere and 1700°C to 2500°C for vacuum condition. Similarly, heating/cooling rates may vary from 30 °C/h to 200 °C/h in different
temperature ranges. A typical graphitization cycle of C-C composites will require 60 hours of controlled heating followed by 100 hours of controlled/natural cooling. Each graphitization cycle may require 10 - 12 days work cumulatively. 

Party shall meet the following requirements to carry out Graphitization process of C-C composites provided by VSSC:

2.3.1. Suitable process facility (high temperature furnace) shall be available to carry out graphitization process under inert atmosphere or vacuum condition. Furnace may be heated by resistance or induction method, and it shall maintain temperature uniformity within ±15°C inside the furnace zone. Work zone size shall be adequate to accommodate C-C composites of size Ø600mm×600mm height (maximum envelope).

2.3.2. Inert gases (Nitrogen, Argon) of purity >99.99% shall be arranged by party. A copy of purity certificate shall be provided to VSSC.

2.3.3. Thermocouples or pyrometers may be used to measure temperatures of furnace and C-C products during the graphitization process.

2.3.4. C-C composites shall be loaded/unloaded to/from the furnace as per VSSC guidelines. The process shall be carried out as per the specification/input given by VSSC for a particular cycle.

2.3.5. All the process data (temperature, gas flow rate etc.) shall be monitored and logged during the graphitization process. A copy of process log shall be provided to VSSC.

2.3.6. A summary report (with authorized signature) on the completed graphitization cycle shall be submitted to VSSC.

2.3.7. Skilled and experienced people shall be engaged for doing the graphitization process of C-C composites.

2.4. Intermediate Machining:

C-C composites require machining (by milling operation) at intermediate stages of processing. Party shall meet the following requirements to carry out Intermediate Machining process of C-C composites provided by VSSC:

2.4.1. Suitable milling machine to accommodate C-C composites of size Ø800mm×800mm height (maximum envelope) shall be available with party to carry out machining process of C-C composites.

2.4.2. For quantification purpose, each cycle of machining will involve 1000 cc volume of material removal (1 m² surface area × 1 mm depth) from C-C composites. Number of machining cycles will be counted based on the volume of material to be machined from actually provided C-C composites, irrespective of the number of C-C components.

2.4.3. C-C composites will be of standard shapes like rectangular or cylindrical. All the fixtures required for machining shall be realized by the party.

2.4.4. General inspection shall be done before and after machining.

2.4.5. A summary report (with authorized signature) on the completed machining cycle shall be submitted to VSSC.
2.4.6. Skilled and experienced people shall be engaged for doing the machining process of C-C composites.

3. **Scope of VSSC:**

3.1. On submission of Bank Guarantee by the party, Carbon-Carbon Composites will be provided as free issue material (FIM) by VSSC for processing at the party’s facilities.

3.2. Metallic/graphite/composite fixtures required for carrying out pitch impregnation/carbonization/graphitization processes will be provided by VSSC. However, the fixtures/tooling required for machining process will **not** be provided.

3.3. Depending on the material handling criticalities, transportation of C-C composites and metallic/graphite/composite fixtures to & from the party’s site **may be** taken care by VSSC. In general, party shall collect the FIM (C-C composites) and metallic/graphite/composite fixtures from VSSC and send back the materials after processing.

3.4. The procedure for loading and unloading of C-C products, process parameters, and important guidelines for processing will be provided by VSSC. It will be mandatory for the party to follow such inputs provided by VSSC.

3.5. The C-C composite products may be of different shapes and sizes. In single process cycle of pitch impregnation/carbonization/graphitization, multiple products may be processed together as per the plan provided by VSSC.

3.6. VSSC representatives may inspect and verify the processes being done on real-time including overtime (holiday/night hours). Also, the relevant documents submitted by the party will be verified for acceptance of the process cycles.

4. **Scope of Party:**

4.1. The party shall have process facilities available in India for carrying out processing works as described earlier under “scope of work”. All the process facilities shall be equipped with necessary safety features. To reduce the cycle duration of C-C processing, priority will be given to parties having all the process facilities in one area. The process activities shall **not** be subcontracted to other parties.

4.2. Trained and experienced personnel including Technicians, Supervisors, and Engineers shall be engaged by the party for carrying out the processing works of C-C composites.

4.3. In general, party shall collect the FIM (C-C composites) and metallic/graphite/composite fixtures from VSSC and send back the materials after processing. Invoice for delivery/transportation charges shall be submitted separately and will be paid on actuals.

4.4. Loading and unloading of C-C composites for processing in any of the process facilities at party’s site.
4.5. Arrangement of process consumables like (coaltar pitch, nitrogen gas, argon gas etc.) for carrying out C-C processing.

4.6. Testing of pitch sample being used for the pitch impregnation process. A copy of test report shall be provided to VSSC.

4.7. Ensuring the purity of inert gases required for carbonization and graphitization processes of C-C composites. A copy of gas purity certificate may be provided to VSSC.

4.8. Carrying out the processing of C-C composites based on specification/input provided by VSSC. The processing works shall be completed within four months after receipt of FIM. The party shall ensure that all the process guidelines are strictly followed during the processes and all the process parameters are maintained in the equipments.

4.9. Monitoring and record keeping of all the process data. A copy of process log shall be provided to VSSC.

4.10. Extraction and cleaning of C-C composites after carbonization and graphitization processes.

4.11. Realization of fixtures/tooling required for machining process. VSSC will not provide any free issue material (FIM) for this purpose.

4.12. Measurement and recording of weight/dimensions of C-C products before and after any process work.

4.13. Safe handling of C-C composites and other related materials in party's premises.

4.14. Storage of C-C composites at party’s premises with proper identification. C-C composites can be stored in normal environmental condition; however party shall identify separate area for proper and safe storage of items provided by VSSC. Foreign materials like oil, grease, dirt etc. shall not come in contact with C-C composites.

4.15. The party shall ensure availability of Diesel Generator (DG) facility for power back-up during failure of regular electricity supply. DG facility shall be capable for smooth operation of process facilities and processing of C-C composites.

4.16. During processing of C-C composites, the party shall ensure 24 hours availability of maintenance team for real-time solving the problems encountered with process equipments. A stock of suitable spare parts of the process facilities shall be maintained in party’s premises.

4.17. On periodical basis, all the relevant equipments/instruments for C-C processing shall be calibrated with traceability to National standards. A copy of calibration report shall be provided to VSSC.

4.18. After completion of processing works, C-C composites shall be properly packed in suitable boxes for safe transportation. Identification details shall be displayed outside the packing boxes.

4.19. Depending upon criticality of C-C products, VSSC representatives may inspect and verify the C-C processing activities being done by the party on real-time
including overtime (holiday /night hours). The party shall make appropriate arrangements for this.

5. **Acceptance Criteria:**
The party shall carry out the process works based on input/specification provided by VSSC. General specification for the process works are given under “scope of work”. The input/specification may vary a little depending on the type of carbon-carbon products being processed. For every process cycle, party shall submit relevant documents (process log, test reports etc). After verifying the documents submitted by the party, VSSC will certify for acceptance of the process works completed. VSSC representatives may verify processing activities being done by the party on real-time basis.

6. **Commercial Aspects:**
6.1. **The party shall submit their offer in two parts.** The first part shall contain techno – commercial details without cost aspects, and the second part shall contain price bid. Price bid will be opened only for the technically qualified vendors based on the techno - commercial details.
6.2. First part of the offer shall include the technical details/capabilities about process facilities available with the party. Preference will be given to parties having all the process facilities in one area. Party shall indicate their technical compliance with respect to scope of work mentioned in this proposal (section 2, 3, and 4). Any type of non-compliance must be highlighted in the offer.
6.3. Second part of the offer shall contain separate costs for each of the four types of processes – pitch impregnation, carbonization, graphitization, and intermediate machining. Delivery/transportation charges between VSSC, Vattiyoorkavu (Thiruvananthapuram - 695013) and party’s site shall be quoted separately.
6.4. The purchase order shall be valid for 2 years duration from the date of release of purchase order.
6.5. On submission of Bank Guarantee by the party, carbon – carbon composites will be provided to the party as FIM (free issue material). The FIM costs at the rate of ₹10,000/- per kg. VSSC will ensure that FIM quantity does not exceed 300 kg at party’s site at any point of time.
6.6. The party shall submit an exclusive all risk insurance policy (standard fire and special perils policy, burglary policy and marine cargo policy) in favor of “Director, VSSC Thiruvananthapuram” for the maximum FIM cost of ₹30 Lakhs.
6.7. VSSC will make the payment on pro-rata basis after completion of any process cycle. For every process cycle, separate invoice along with relevant process logs, test certificates etc. shall be submitted to VSSC.
6.8. Delivery/transportation charges will be paid on actuals.