EXPRESSION OF INTEREST FOR CARBON FIBER FACILITY

PACKAGE # 3:

SETTING UP A COMPLETE FACILITY
FOR
HEAT TREATMENT PROCESS LINE

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1. OBJECTIVE

Mishra Dhatu Nigam Limited (MIDHANI), a public sector company under Ministry of Defence has been playing a very active role in development and manufacture of strategic materials for various sectors like Space, Energy, Aero, Defence, etc. MIDHANI is a unique integrated metallurgical plant located in Hyderabad, Telangana, India and presently setting up a facility for Armour business at Rohtak, Haryana and Aluminium Alloy Rolled Product facility at Nellore, Andhra Pradesh.

MIDHANI has wide manufacturing facilities for manufacture of low alloy steels, high alloy steels, special steels, stainless steels, super alloys, titanium and titanium alloys in various forms and sizes. More information can be found on www.midhani-india.in

MIDHANI desires to augment its manufacturing facility by setting up a carbon fiber plant for strategic applications under "Make in India" initiative program of the Government of India. MIDHANI is considering for establishing production facilities for carbon fiber of capacity 60 TPA of various grades of carbon fiber utilizing the technology developed by CSIR-NAL. The facility shall be located in the present premises of MIDHANI at Kanchanbagh, Hyderabad. Hence Midhani is desirous of identifying established equipment manufacturers for carrying out the detailed design, manufacture, supply, erection and commissioning of associated line equipment for the carbon fiber facility. The brief of the Project and scope of the package pertaining to this EOI is described below.

2. BASIC INFORMATION OF THE FACILITY TO BE ESTABLISHED

Polyacrylonitrile (PAN) based Carbon Fiber Manufacturing facility is planned to be established at MIDHANI. PAN copolymer is prepared by processing a mixture of Acrylonitrile (AN) and Comonomer (CM) in a Continuous Stirred Tank Reactor (CSTR) along with water and other reagents. Reaction is carried out at a constant temperature and pH. The polymer slurry is passed through a monomer stripper column to recover the unreacted monomer followed by filtration in a centrifuge / drum filter to produce wet polymer cake. The wet cake is dried, granulated and stored at appropriate condition for use.

PAN polymer is subsequently dissolved in Dimethylacetamide (DMAc) solvent in a high shear mixer at 80-85 deg C temperature. The polymer solution (spin dope) is passed through agitated thin film evaporator under vacuum for removal of trapped air bubble. The spin dope is further passed through multistage filtration to remove any foreign/gel particles. The filtered spin dope is extruded through spinneret dipped in coagulation bath. The bunch of freshly formed filaments (fiber yarn) in the coagulation bath is forwarded to subsequent hot water (40-90 deg C) baths through the fiber forwarding rollers for washing and stretching. These wet drawn fibers are taken through a spin finish bath consist of emulsion of water and modified silicon oil. These fibers are then dried and densified on hot rollers. The required diameter of fiber is obtained by stretching them finally at 140 deg C. The fiber yarn (termed as special acrylic fiber) is collected as spool using precision winders.
DMAc solvent used for dissolution and coagulation gets diluted with water in the process. This DMAc-water mixture is collected in tank. The pure DMAc is recovered by distillation and recycled in subsequent batches.

The special acrylic fibers (SAF) are converted to carbon fibers by continuously forwarding into a sequence of heat treatment processes at various temperatures and processing conditions which includes Pre-treatment with steam, thermo-oxidative

stabilization (200-280 ^{o}C) in air, followed by Pre-Carbonization (400-850 ^{o}C) and Carbonization (900-1500 ^{o}C) under nitrogen environment. These fibers are passed through a bath containing electrolyte solution for surface treatment followed by washing in water bath and drying in air. These fibers are taken through a sizing bath and then dried at 140-160 deg C. The dried carbon fibers are collected in the form of long continuous tows wound on suitable core using precision winders.
The establishment of an integrated facility to run the above processes includes following work packages:

- Package #1: Setting up a complete facility for synthesis of Polyacrylonitrile (PAN)
- Package #2: Setting up a complete facility for fiber Spinning and DMAc Recovery
- Package #3: Setting up a complete facility for Heat Treatment

In order to provide required utilities to run the above processes and to manage the waste and effluents generated from different process, a separate work package is required, as mentioned below

- Package #4 : Setting up a Effluent Treatment Plant
- Package #5 : Setting up complete Utility Systems

3. THE PROJECT SCOPE

The scope of work covers basic and detail engineering design, manufacture, assembly, testing at manufacturer's works, painting, delivery F.O.R. site, erection as per approved layout drawings, testing and commissioning of Equipment inclusive of associated control, electrical and all accessories required for this package of Carbon Fiber Plant for safe and successful operation & maintenance. The equipment shall meet the specified performance to the satisfaction of the Purchaser.

The supplier shall include in its scope all accessories and auxiliaries, interconnecting piping, measuring and control instruments, all internal and interconnecting cables and wires, safety devices, compressor and materials which are not specifically mentioned here but are otherwise required to complete functioning of the equipment package offered in every respect for its satisfactory performance and safe operation.

The erection & commissioning of equipment including supervision shall be carried out by equipment supplier. Successful bidder shall arrange themselves necessary unskilled and semi-skilled labours, tools, tackles for erection. The successful Bidder of equipment shall provide procedure for erection, skilled manpower for supervision for timely completion of erection & commissioning.

The supplier shall arrange necessary material handling equipment at his own cost (for handling, storage and erection of equipment).

The Purchaser shall provide all the civil works such as Building for the shop, civil foundations for equipment, drains, pipe & cable trenches, conduits, etc. based on the detailed civil assignment drawing including information of loads from package supplier/successful bidder. After handover of site, the successful bidder shall erect / install equipment in the building / foundation provided by the Purchaser. The foundation

base and pockets for foundation bolts shall be cast as per the foundation assignment drawing furnished by the successful Bidder.

The required foundation material & embedded steel/inserts (viz. foundation bolt / leveling wedge / anchor system) shall be included as essential part of package supply. The foundation bolts/anchoring system shall be supplied by the bidder prior to execution of civil work by the purchaser. Intimation in this regard shall be sent to the bidder well in advance for supply of these items.

Minor civil works such as chipping and chiseling, alignment and grouting of foundation bolts, etc. for the erection / installation of Plant and Equipment is included in the scope of successful bidder.

All the engineering drawing / data and details e.g. foundation dimensions, foundation load data, foundation profile and levels of concreting, drawing/ catalogue of machine anchorage system, working instruction for mounting / grouting bolt / anchor / wedge etc. for carrying out the required Civil foundation work by the Purchaser shall be provided by the successful bidder.

The successful bidder shall provide two years spares for operation and maintenance including commissioning spares if required. The first fill of hydraulic oil, grease, coolant, lubricant etc. if required for startup and commissioning the machine shall form essential part of supply. Similarly, for demonstrating operational test on the machine, clamping unit, dowel pins & bush, consumables shall be supplied with the equipment (as applicable). Supply of oil, grease etc. shall be the responsibility of the bidder till the commissioning of the machine.

Purchaser shall provide two number of Power feeders at 415V, 50 Hz. within 20m radius from the equipment foundation. Further Power distribution and conversion / generation of any other voltage level, as required, shall be in bidder's scope of supply. All necessary supplies of Power and control cables, cable termination kits, laying and termination of all associated power and control cables from the outgoing terminals of Purchaser PCC (415 V) to the main PDB (being supplied by the Bidder) shall be in Bidders scope. Internal power distribution for various drives / accessories etc. of the machine shall be through machine control panel which shall be built in part of the machine.

The supplier shall provide required electrical earthing for his supplied equipment/ items and furnish the relevant drawing / data to the purchaser/buyer.

All accessories including electrics, instrumentation, etc., shall also be considered in the scope of supply along with equipment. The interconnecting piping along with fittings and any specific filter/instrumentation/valve (if required) for connecting the machine to the media shall form essential part of supply.

Bidder shall indicate the requirement (Quantity) of utilities for the package like water, compressed air, nitrogen, steam, fuel gas (if required), etc.& and any other services requirement for the offered package. Purchaser will provide the utility at a building column one meter above the ground level. The necessary isolation valve along with interconnecting piping & fittings as required for above utilities shall be in the scope of supply.

The erection, commissioning, testing including supervision of erection and demonstration of performance test of machine / equipment shall be undertaken by successful bidder.

The successful bidder will have to undertake comprehensive insurance policy and maintain its validity till commissioning and handing over of the equipment to Purchaser.

All the equipment supplied shall comply with the requirements of all recognized design and manufacturers standards applicable to that type of equipment, including American Petroleum Institute (API), American National Institute (ANSI), Tubular Exchangers Manufacturers Associations (TEMA), National Association of Corrosion Engineers (NACE), Occupational Safety and Health Agency (OSHA), National Electrical Code, Institute of Electrical Electronics Engineers (IEEE), American Society of Mechanical Engineers (ASME), Indian Boiler Regulations (IBR), Indian Standards (IS), European Industrial Gases Associations (EIGA) and MSIHC (Manufacture, Storage and Import of Hazardous Chemicals) Rules.

All vents supplied shall be of Flame arrestors where pure Acrylonitrile (AN) and Dimethylacetamide (DMAc) are being used.

All material used in the supplied equipment shall be compatible with all conditions of the processes using Acrylonitrile (AN) and Dimethylacetamide (DMAc)

4. BATTERY LIMIT & EXCLUSION

Particularly and unless otherwise stated in the Scope of Supply and Services, the following list of items are not included in scope of supplier:

- Civil foundation work
- Dismantling of any existing equipment
- 11 KV Switchboard
- FDA & Fire Fighting System
- Illumination System
- Cranes, hoists & other material handling system with its electrics, control &power feed system
- Primary Earthing System.
- Intercommunication systems (telephone, loud speaking communication system, CCTV system etc.).
- Water Supply system
- Air conditioning and ventilation facility
- All utilities piping and cabling till the agreed TOP
- Supply of utilities - compressed air, water, steam, nitrogen, etc.

Takeover point for Utility fluids (Water, compressed air, etc.) supply is considered at the nearest building column (max. 20m away from the equipment).The column nos. will be discussed and mutually agreed during layout finalization. All interconnecting piping from the TOP and upto the consuming point of supplied equipment will be in the scope of supplier. TOP for Electrical part is defined separately in Electrical Section.

5. BASIC INFORMATION OF THE PACKAGE #3

Heat Treatment Process Line is described in **ANNEXURE - I**

6. ELIGIBILITY CRITERIA PACKAGE #3

Only those organizations that meet the following criteria are eligible to participate.

Sl. No.	Criteria	Documents for confirmation
1	Should have a minimum average annual turnover of INR 37.5 Crore (INR Thirty Seven Crores and Fifty Lakhs) in previous three financial years (FY 2015-16, 2016-17,2017-18)	Certified copies of annual account statements to be submitted.
2	Should have carried out ***similar work** of 50% of proposed Package capacity including design, manufacturing, supply & commissioning in last 10 years solely or in consortium.	Contract reference & other documentary evidence to be submitted.
3	Should have positive net worth in each of the previous three financial years (FY 2015-16, 2016-17,2017-18) OR Submission of solvency certificate for Rs.15 crores issued not earlier than 6 months from the date of EOI	Certified copies of annual account statements to be submitted. OR Issued by nationalized or scheduled bank.
4	Should have been established and operating since at least 5 years before the date of this advertisement	Certificate of Incorporation issued by the Registrars of Companies clearly stating the year of establishment
5	Should have PAN, TAN, TIN & GST numbers with Income tax in case of Indian Companies. In case of Foreign parties, Relevant Tax Registration and PAN No. shall be submitted after placement of Order	a) Copy of registration certificates for Indian parties. b) In case of foreign parties, relevant tax registration certificate from the countries where the company is registered. Undertaking for obtaining PAN shall be submitted.
6	Should not be a trading company	Self-certified document to be submitted
7	Acceptance of all Commercial Terms & Conditions	Self-certified document to be submitted

***Similar work means work of Fiber forwarding and tension controlling system, Heat treatment process line including Air circulated multi zone oven, Metallic furnace, Graphite furnace (upto 1600 deg C) for continuous processing of running fiber tows.**

7. SELECTION OF BIDDER

Bidders who fulfil **all** the eligibility criteria and accept **all** the commercial terms and conditions as outlined in this EOI shall be considered as eligible bidders.
Selection of bidder shall be as per the following process-

a. Based on information provided in response to Eligibility Criteria, bidder will be evaluated by Midhani and eligible bidders will be informed within 15 days from last date of EOI submission.
b. MIDHANI may organize a bidder's meet within fifteen days from date of declaration of eligible bidders for answering any clarifications on Technical Specification.
c. All eligible bidders will be provided with a Technical Specification containing more information of the package requirement along with price bid format and detail commercial terms & conditions.
d. Bidders have to submit their technical offer with detailed technical specifications and price bid as per price bid format within 28 days from issue date of documents as indicated under the clause 7(c).
e. L1 bidder will be decided for each package after technical evaluation of submitted bids

8. PROJECT TIME SCHEDULE

It is expected that the following schedule will be maintained by both, bidder and Midhani

A. Tentative time line for the Carbon Fiber Project is 12 months from the effective date of contract**.**
B. Sequence of Evaluation of EOI response with tentative time line is as under:

Sequence. No.	**Activity**	**Description**	**Response by Date**
1	Release of EOI	EOI is released in news papers within India & MIDHANI web site. The date of release shall be considered as the zero date for response.	Zero date
2	Response to EOI	Bidders to recognize the eligibility requirements and understand the project needs. Any clarifications required at this stage may be communicated by mail to purchase department	15 days from Release of EOI
3	Evaluation of EOI	Submitted documents towards eligibility and bidders acceptance of commercial terms as given in EOI will be scrutinized.	Midhani will declare eligible bidders within 15 days after Response to EOI
4	Site visit & Bidders conference	Bidders are encouraged to visit site and attend bidders conference for seeking any clarification on the Project. Discussions will be recorded and will	To be completed within 15 days after issue of Technical specification &

		become part of the technical specifications.	commercial document.
5	Issue of Technical Specification containing more information about the requirement , price bid format & Commercial conditions	Technical Specification containing more information about the requirement and Commercial terms & Conditions will be given to all declared eligible bidders.	Within 15 days after eligible bidders meet.
6	Detailed Technical Specification & Price Bid Submission	Bidders to submit the acceptance of Technical specification as discussed during the bidders conference along with detailed Techno-commercial offer of the Package & firm price bid and other document as per tender	To be submitted within 28 days after issue of technical specification & Price Bid Format.
7	Selection of Successful bidder	The Package wise L1 eligible bidder will be declared as the successful bidder.	Within 21 days after submission of price bid.

9. COMMERCIAL CONDITIONS

A	**Payment Terms** **A1. For Plant, Machinery and Equipment including Design, Engineering and Training**
a.	10 % of contract price after signing of contract agreement /release of P.O against BG along with 14% interest having validity till dispatch of FOR stage of last consignment.
b.	10% of contract price after submission of specified documents & Drawings against BG along with 14% interest valid till dispatch of FOR stage of last consignment and acceptance of the same by Midhani
c.	60 % of the value of each and every part dispatch of Equipment payable against the presentation of necessary negotiable documents proving that the goods are dispatched FOR site. In case of part delivery, BG of equal mount with validity till last delivery is to be submitted
d.	10 % of the contract price after completion of erection-commissioning and issue of Provisional Acceptance Certificate by Midhani
e.	10 % of the contract price on issue of Final Acceptance Certificate or 10 % after PAC against BG for the same amount having validity till defect liability period.
	A2 Complete Erection, Start and Putting into Commissioning including supervision:

a.	Ninety (90) per cent of the Contract Price for installation and commissioning along with 100% Service Tax shall be paid on issue of Provisional Acceptance certificate (PAC).
b.	10 % of the contract price for installation and commissioning on issue of Final Acceptance Certificate or 10 % after PAC against BG for the same amount having validity till defect liability period.
B	**Security Deposit**
a.	10 % of contract value shall be deposited within 30 (thirty) days of Agreement signing.
b.	The Security Deposit shall be in relation to the scope of work till the completion of installation and commissioning of the plant, machinery and equipment and issuance of PAC upon successful completion of the PG Test.
c.	Security Deposit shall be given in the form of Demand Draft or Bank Guarantee from a nationalized Bank or Scheduled Bank encashable in India
C	**Delivery Schedule**
a.	The delivery schedule should match with overall project schedule
D	**Liquidated Damage**
a.	Liquidated Damages be levied against Joint Developer in case of unsatisfactory supply/ execution of contract or delay in supply of materials/ execution of agreement beyond the date of delivery/ completion of job specified in the Agreement. LD is leviable @ 1% per week or part thereof subject to a maximum of 10% of Contract price with Taxes, Duties, levies, cess etc including Erection & Commissioning charges.
E	**Performance Guarantee Tests and Provisional Acceptance**
a.	The supplier shall be responsible for carrying out performance guarantee tests as per the Agreement / Specification in the presence of Midhani representative on Package facility plant, machinery and equipment supplied by him. This responsibility shall rest with the supplier regardless of whether the erection has been carried out by him or any other agency.
b.	The date of completion of performance guarantee test shall be considered to be the date of the PAC, and the plant, machinery & equipment is ready for commencement of commercial production.
F	**Defect Liability Period and Final Acceptance**
a.	The supplier shall warrant that the Package facilities or any part thereof shall be free from defects in the design, engineering, materials and workmanship of the plant, machinery and equipment and structures and refractory's supplied and of the work executed for twelve (12) months from the date of issue of Provisional Acceptance Certificate.
b.	After satisfactory completion of guarantee period (i.e 12 months) Midhani will issue the Final Acceptance Certificate (FAC) to supplier.

10. DISCLAIMER

Bidders shall study carefully eligibility requirements and Project Package scope given in the EOI and understand himself of the requirements sought. Claims and objections due to unawareness on the subject shall not be considered.

Eligible bidders to study carefully all documents, Technical Specification & Commercial conditions referred to herein before accepting the same. He shall fully satisfy himself of the appropriateness of the equipment and layout as indicated in this EOI considering the conditions of working at and around the construction Site. Further he shall take full responsibility for development in design, manufacturing and supply and safe and efficient operation and guarantee quality of the plant, machinery and equipment supplied and specified output. Claims and objections due to ignorance on the subject shall not be considered after submission of the response to EOI.

MIDHANI reserve the right to cancel the EOI either wholly or in part, without any entitlement or compensation to the bidders and without assigning any reason there off.

11. INTEGRITY PACT

All eligible bidders shall sign the Integrity Pact along with submission of his acceptance of technical specification & commercial terms & conditions. Non signatory of Integrity Pact shall disqualify the bidder.

12. CONTACT DETAIL

For Commercial queries-
AGM-Purchase Department: Mr. Anand Kumar,
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anandakumar@midhani-india.in

For Technical Queries-
GM- Projects, Debasish Dutta
Cell +919177387087
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ANNEXURE – I

SETTING UP A COMPLETE SETUP FOR HEAT TREATMENT PROCESS LINE

1. Process Description

The special acrylic precursor fibers (SAF) are converted to carbon fibers by continuously forwarding into a sequence of heat treatment processes at various temperatures and processing conditions. There are three major heat treatment processes followed by surface treatment, sizing and drying before collection in the form of a long continuous tows wound on suitable core. The precursor tows are loaded into unwinder creels from where they are let-off into a horizontal band of tows. The tow is subjected to steam heating prior to introduction into the first heat treatment namely the thermos-oxidative stabilization.

The stabilization process is carried out at temperatures upto 280^{o}C in re-circulated hot air. In this process the fiber undergoes reactions with oxygen and becomes infusible. This process is exothermic in nature and the heat evolved must be quickly dissipated from the fiber surface into the flowing air to prevent fiber damage. The reaction rate and hence the heat evolution rate are strongly dependent on the process temperature. Therefore to achieve a good level of stabilization reaction at an economical rate, the fibers are forwarded sequentially into multiple isothermal stages with temperature increasing at every stage.

The oxidized fibers are then pyrolysed upto 850^{o}C in nitrogen atmosphere in the pre-carbonization process. Much of the non carbon elements are removed as gaseous effluents in this process. The effluents are cracked into their respective oxides by heating them in fuel fired incinerator. The pre-carbonized fibers are then pyrolysed at higher temperatures up to 1600^{o}C in nitrogen atmosphere during carbonization process. The fiber attains high strength and stiffness after carbonization. Subsequently the fibers are surface treated by electrochemical oxidation followed by drying and sizing with an epoxy resin. The sized fibers are dried before winding.

Note:

i. System capacity design should have flexibility for ±10% variance.
ii. During design bidder may offer superior technology if known/available after reviewing with client for safe and efficient operation

2. Input Materials

Heat Treatment process line manufacturing facilities to be established under package #3 is capable of manufacturing of carbon fibers using the following raw materials as raw materials:

Sl No	*Material*	*Grade*	*Concentration/ Purity*
1	Acrylic precursor fiber	Density: 1.17-1.19 g/cc Mass per unit Length:0.45-0.8 g/m Filaments count- 6000	
2	Ammonium bicarbonate	Laboratory grade	≥ 99%
3	Epoxy solution	Lab grade	≥ 40% epoxy in water

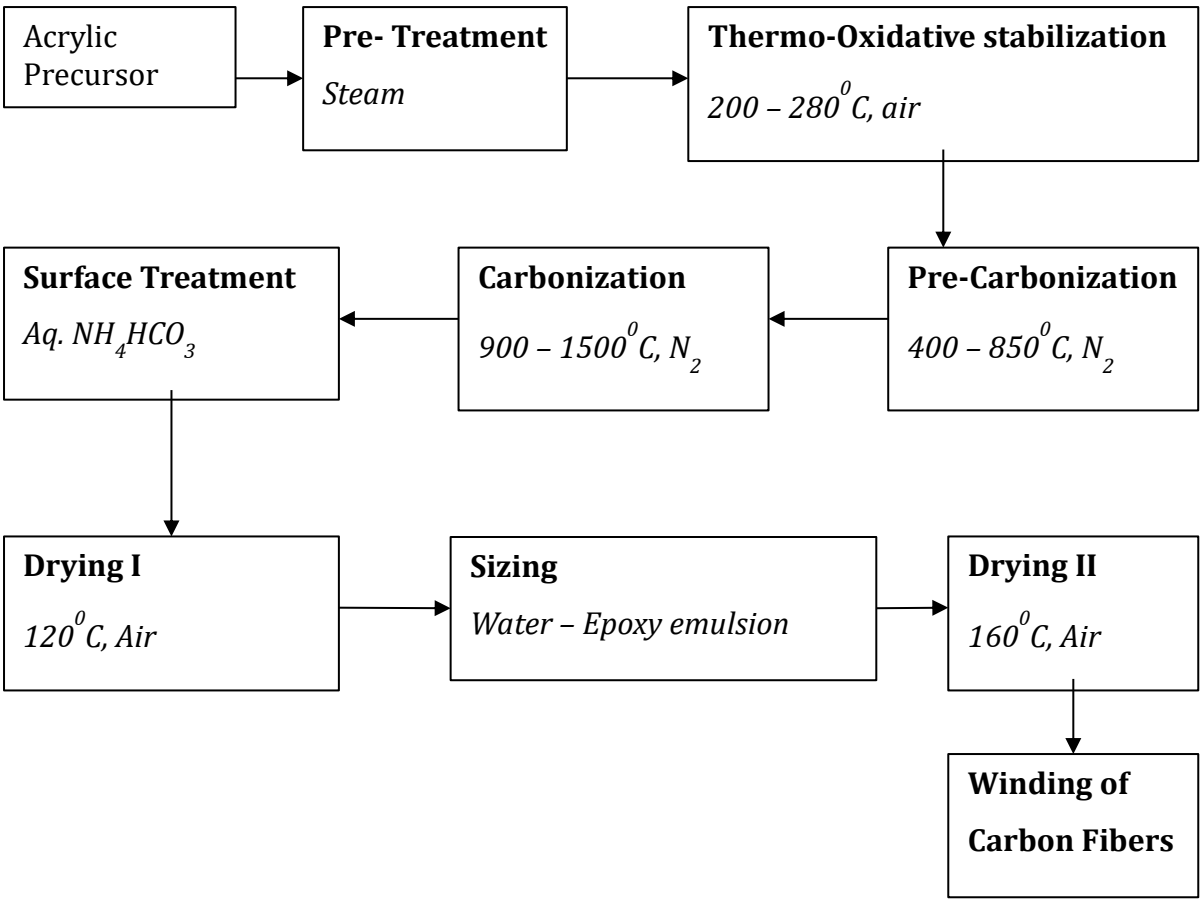
3. Output – Products & Effluents

a. Products: Carbon fiber products specifications & broad range of quality parameters are indicated below

S.No	*Property*	*Range*
1	Density	1.78 ± 0.01 g/cc
2	Linear density	0.22 – 0.44 g/m
3	Carbon content	≥ 94%
4	Sizing content	< 2.0%

Carbon fibers wound on to the bobbins with net weight of upto 10 kg. The package has to be handled carefully so as to prevent any rubbing or damages

4. Process Block Diagram



5. General Scheme

- Line speed : Typical 5m/min (variable) Max. 6m/min
- No. of tows : 140
- Tow size : 6000 (6K)
- No. of winding position : 140
- Tow to tow distance : 5mm
- Line operation through : Distributed control system. Complete supply of hardware, software, and automation system engineering for control of all the equipment in CF line

6. Broad Technical details of the Equipment

a. Unwinder Creel System: For unwinding of the precursor spool

Number of spools-: 140 No's

Weight per spool = 30kg

Specifications:

- Unwinding of precursor fibers should be smooth and tension controlled with braking mechanism and tension monitoring.
- Suitably designed support frame structure for convenient fiber routing

b. Pre-Treatment Unit: For treatment of pre-cursor fiber with steam /chemicals

Quantity: 1 Nos

Specifications:

A SS bath (approx. 2 mtr width X 2 mtr length X 0.3 mtr depth), to dip the fiber band in bath solution, with rollers at inlet/outlet to forward the band of fiber tows. An insulated SS chamber (approx.. 2 mtr width X 2 mtr length X 0.15 mtr depth) with steam sparger and rollers inlet/outlet to forward the band of fiber tows, suitable strainers, filters, pressure regulators, flow-meters, valves and steam traps etc. Entire unit will be supported on carbon steel support.

c. Multi-Zone Oven (MZO): For the thermo-oxidation of pre-cursor fiber in air.

Quantity: 3 No's

Specifications:

Heated Length : 8.0 m

Number of Modules : 3

Number of chamber per module : 2

Number of zones per chamber : 2

Operating Temperature : 180-300°C

Roll stand:

Fiber forwarding system: 04 number Roll stand assemblies, consist of sets of driven and guide rollers with tension monitoring and control system, to be provided to redirect and forward the tows within and between the modules. The roll stands are located on the outside of the oven. Stands are floor mounted, fabricated from heavy structural steel shapes and plates, adequately reinforced.

Process Exhaust:

Exhaust air from each oxidation oven is delivered to a catalytic cracker to destroy the volatile organic components (VOC).

Flue gases handling capacity: approx. 20 kg/h

Temperature : 400-450 deg C

d. Pre-Carbonization Furnace or Low Temperature Furnace (LTF)

Brief description of Process Oxidized fiber are processed at temperature upto 850 deg C

Quantity: 01 No's

Specifications:

Total Heated Length, Approximate : 7.5m

Number of control zones : 07

Process Atmosphere : Nitrogen

Zone Temperature : 400-850 deg C in increasing order

Equipment Description

330 alloy muffle with Ni-Cr heating elements, temperature control for all zones carbon steel shell and base, adjustable purge chambers at entrance and exit ends, Nitrogen atmosphere distribution system, exhaust system on both sides connected to single incinerator and chimney, furnace pressure monitoring and control system, roll stand with tension control, and proper insulation. Flue gases handling capacity of incinerator ~ 40 kg/h at 800 deg C.

e. Carbonization furnace or High temperature furnace (HTF)

Pre-carbonized fiber is heat treated at elevated temperature for carbonization

Quantity: 01 No's

Specifications:

Total Heated Length, Approximate : 7.5m

Zones of Control : 08

Process Atmosphere : Nitrogen

Zone Temperature : 1050 -1600 deg C

Equipment Description:

Graphite muffle with graphite heating elements, proportional power system, temperature control for all zones, carbon steel shell and base, adjustable purge chambers at entrance and exit ends, Nitrogen atmosphere distribution system, exhaust system, furnace pressure monitoring system, process gas on-line sampling system, water-cooling section at exit end, electrically heated process vents, roll stand with tension control at inlet and outlet, and proper insulation.

f. Surface Treatment Bath

Brief description of process

"The carbonized fiber from HTF is fed to the surface treatment bath (ST bath) where the fibers are oxidized by electrochemical oxidation. The electrolyte is ammonium bicarbonate solution and DC voltage is applied across the graphite anode on which the fibers pass and a carbon cathode plate immersed in the ST bath. The fiber surface undergoes micro-etching and weak outer layer is removed from the fiber surface. The surface treated fiber is then washed in demineralized water and passed to the vertical dryer I."

The system consists of following parts:

A. Surface Treatment solution preparation tank

- Material of construction : SS 316
- ST solution preparation tank volume : 4000 L

B. Surface Treatment solution recirculation tank

- Material of construction : SS 316
- ST solution recirculation tank volume : 1000 L

C. Surface treatment bath and water bath

a) Surface treatment bath

- Material of construction : Glass fiber reinforced polypropylene plastic
- No. of partitions : 3
- Overall volume : 3600 L
- Recirculation of bath liquid at 4000 LPH

b) Water wash bath with D M water spray

- Material of construction : Glass fiber reinforced polypropylene plastic
- No. of partitions :2
- Overall volume : 2400 L

c) Anode roller and Cathode

- Material of construction : Electrical grade graphite fitted over steel rollers
- Cathode : Carbon plate wrapped in thin nylon cloth

d) Immersed rollers and top rollers

- Material of construction : SS 316,

g. Vertical Dryer I: 1 No

- Material of construction: SS 316
- Operating parameters:
  - Hot air temperature range : 120-130^{o}C

h. **Sizing bath Unit**

- Sizing bath Unit: MoC – SS316
- The unit consists of
  - Sizing bath solution preparation tank (500 L) with agitator
  - Sizing bath solution make-up preparation tank (200 L)
  - Sizing bath solution make-up feed tank (200 L)
  - Fiber forwarding through driven rollers
  - Sizing recirculation tank (500 L)

i. Vertical Dryer II: 1 No

- Material of construction : SS 316

- Operating parameters:
  - Hot air temperature range : 120-130^{o}C
  - Fiber forwarding through idler rollers

j. Precision winders: 140 No's inline winding

- Material of construction : Durable light weight, rust-proof material
- Capacity : 140 Nos winders
- Operating parameters : winding tension
- Tension controlling range: 500-800 cN typically (1500 cN max)

k. Nip-roller station: For Tension isolation at intermediate stages

The tension isolation system is an assembly of driven rollers, idler rollers and nipping rollers mounted on standalone, painted steel frame with provision for mounting load cell and also to house the drive motor. Such units are placed at various positions upto high temperature furnace exit and their purpose is to isolate the tension at various processing stages.