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(54) **CARBON FIBER MANUFACTURING APPARATUS**

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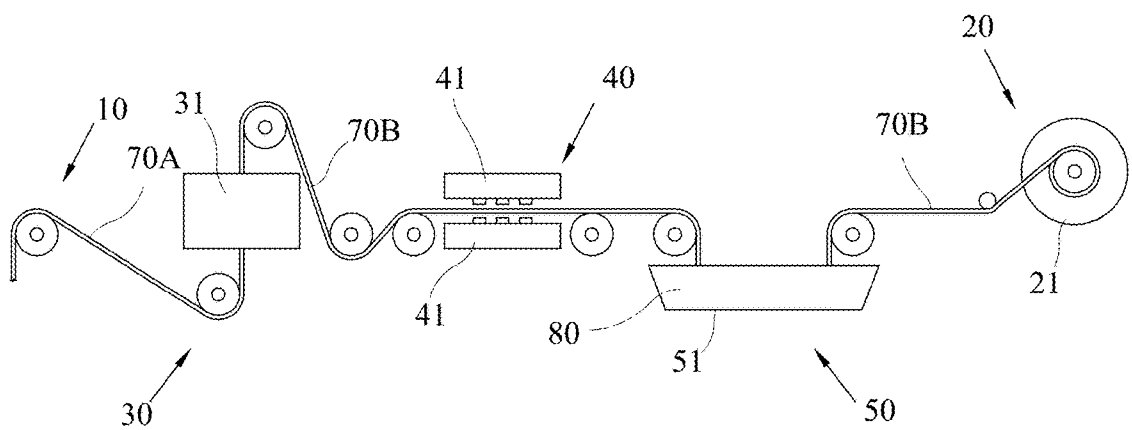
(57) **ABSTRACT**

A carbon fiber manufacturing apparatus includes a feeding module, a high-temperature carbonization module, a plasma surface treatment module, a sizing module, and a receiving module. A carbon fiber precursor fiber bundle released from the feeding module is sequentially processed at a predetermined speed to perform high-temperature carbonization, plasma surface treatment, sizing, and so on. The carbon fiber precursor fiber bundle is heated to form a carbon fiber, and then the surface of the carbon fiber is coated with a resin oiling agent. Particularly, through the plasma surface treatment module, the surface of the carbon fiber is roughened and provided with functional groups, which is beneficial to enhance the interface bonding of the resin oiling agent and the carbon fiber. The structure of the carbon fiber is more stable and reliable. The cost of the carbon fiber production equipment and the working time can be reduced effectively.



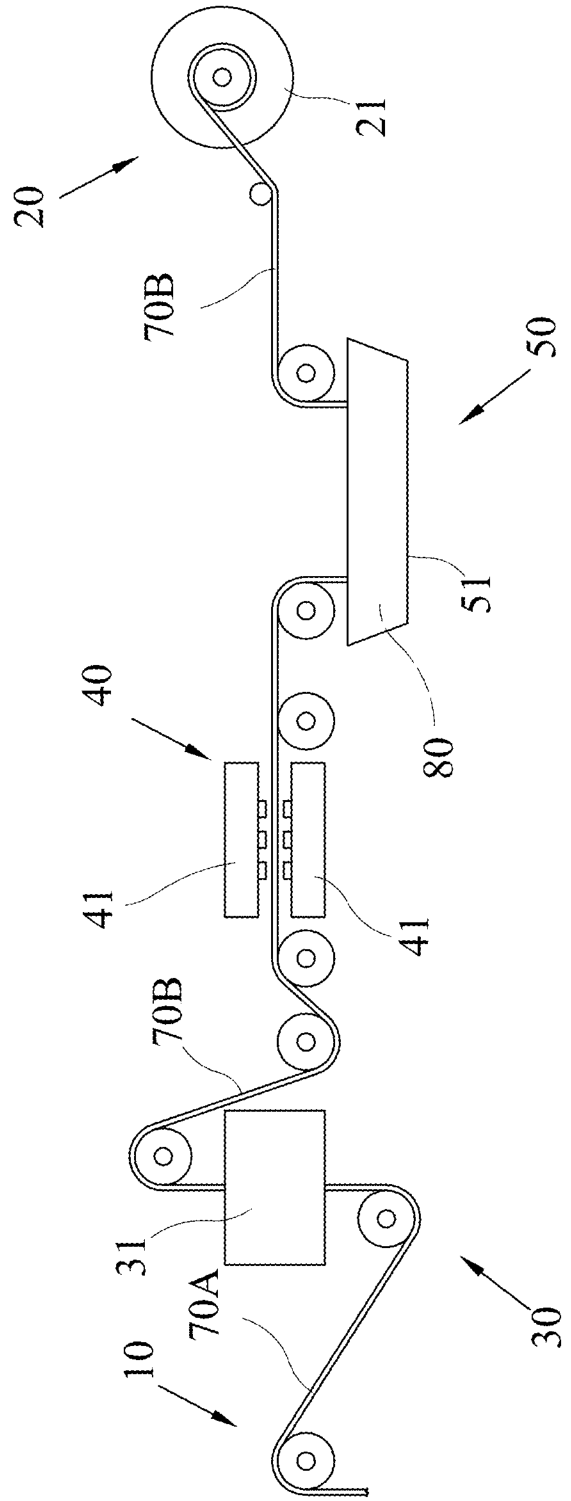


FIG. 1

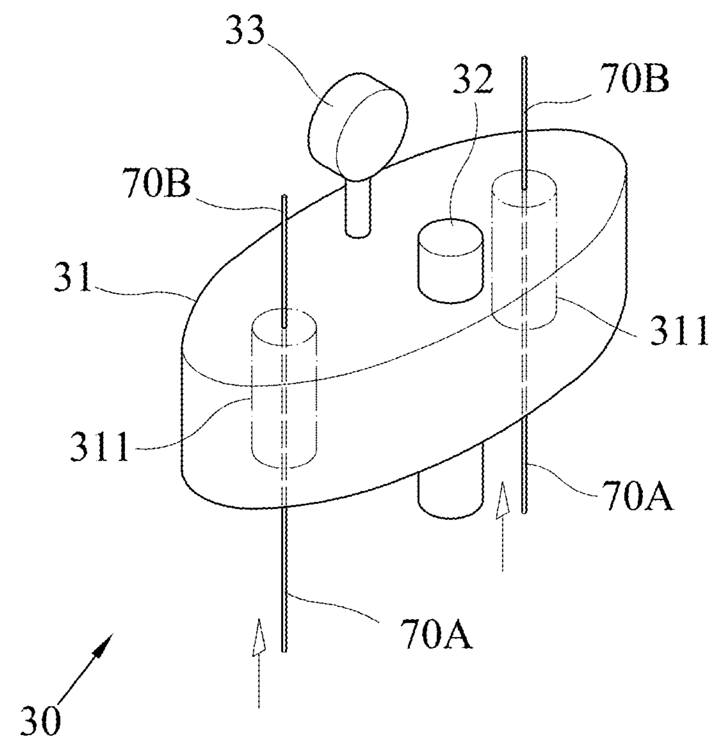


FIG.2

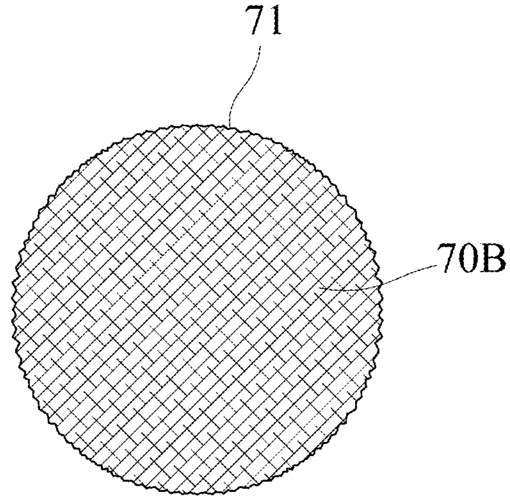


FIG.3

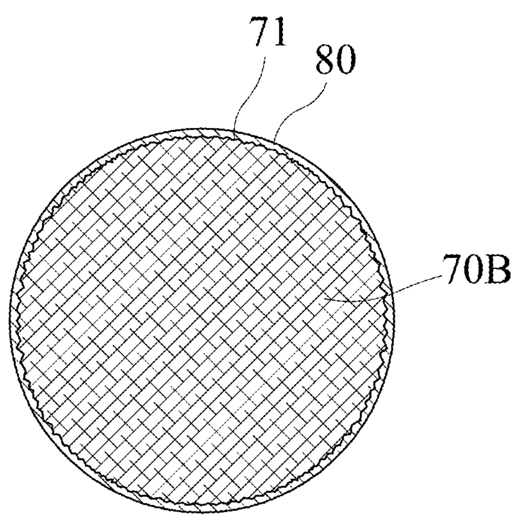


FIG.4

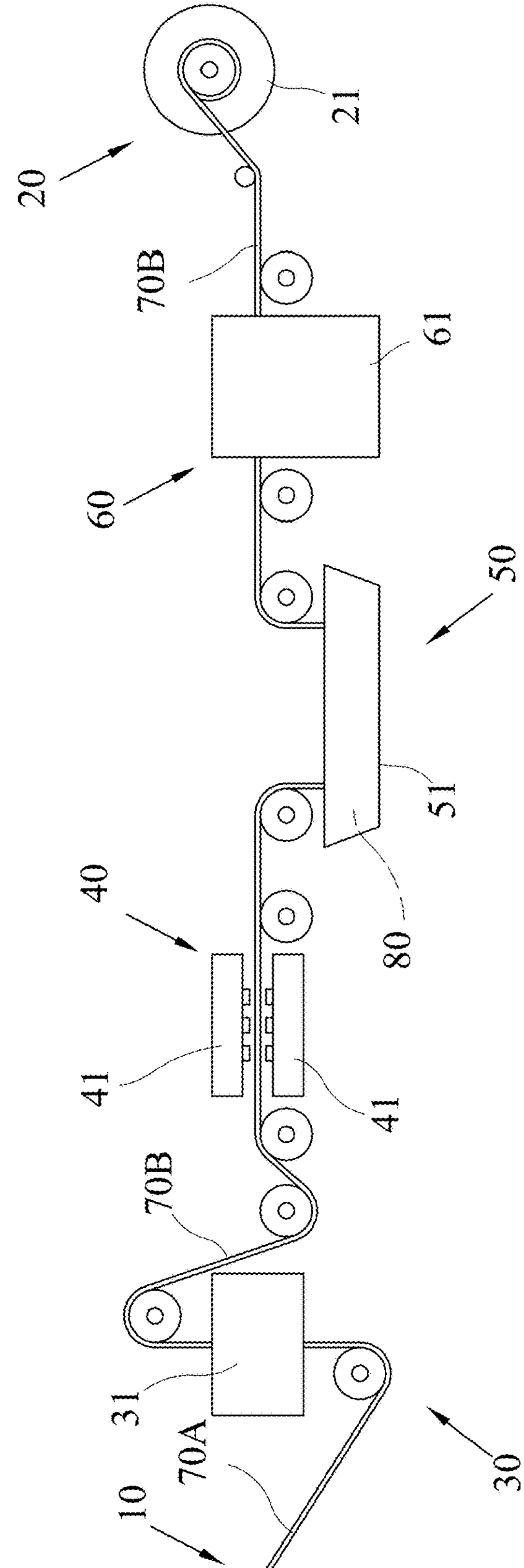


FIG.5

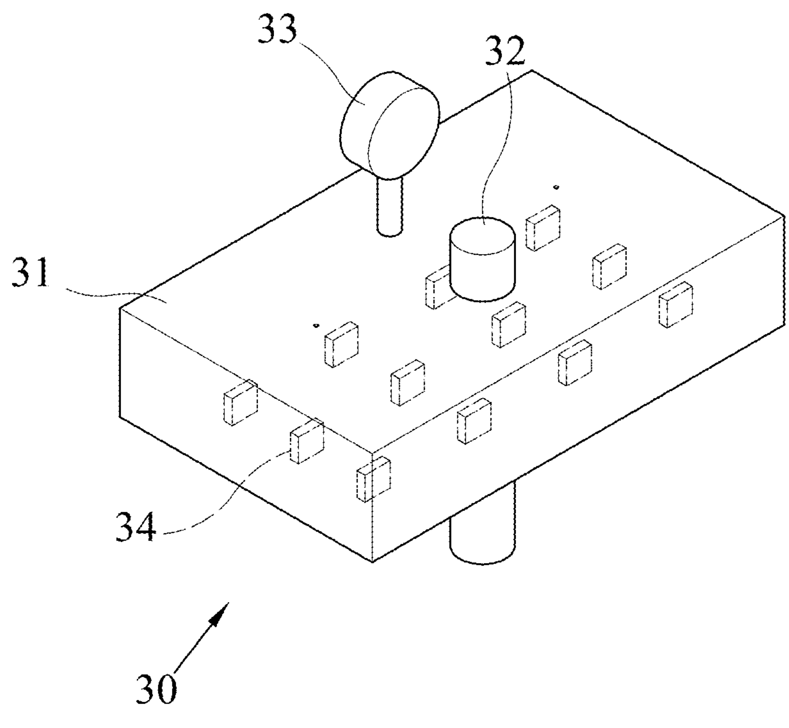


FIG.6

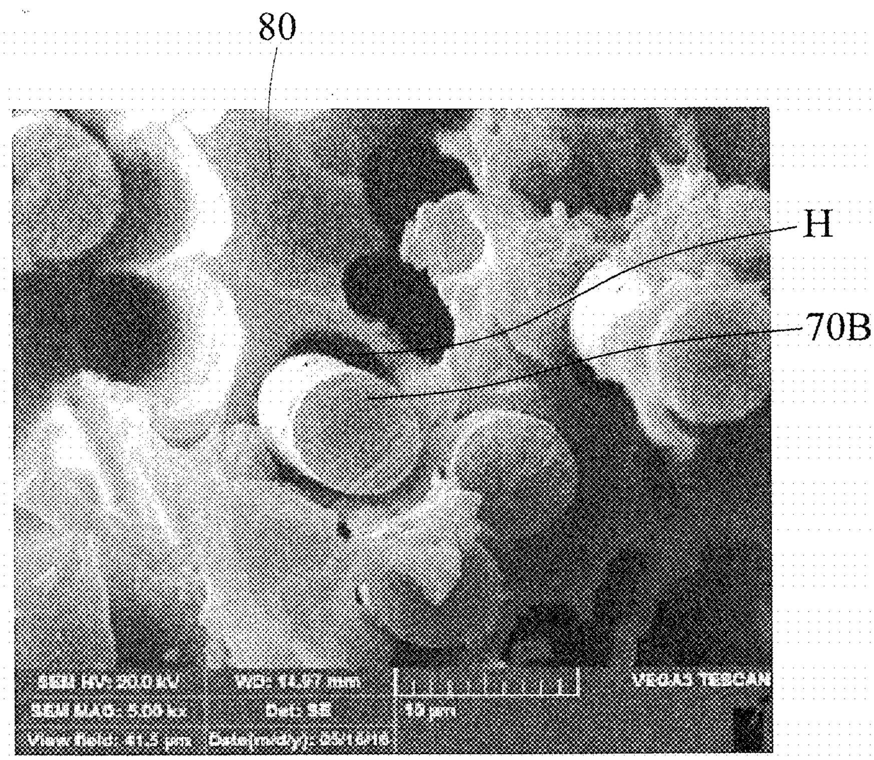


FIG.7a

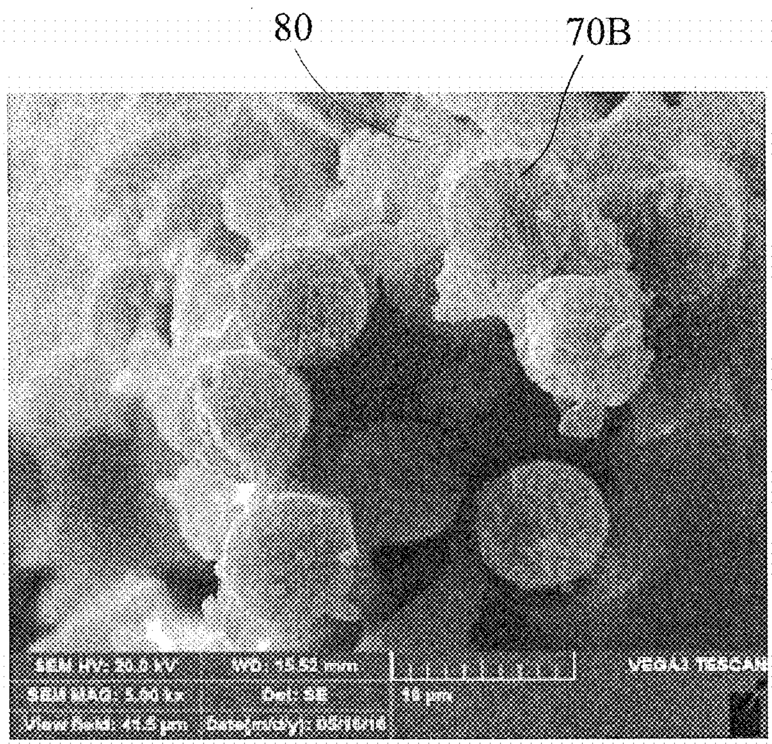


FIG.7b

CARBON FIBER MANUFACTURING APPARATUS

FIELD OF THE INVENTION

[0001] The present invention relates to a carbon fiber manufacturing apparatus, and more particularly to a carbon fiber manufacturing apparatus which can greatly improve the sizing quality of a carbon fiber and effectively reduce the cost of the carbon fiber production equipment and the working time.

BACKGROUND OF THE INVENTION

[0002] Carbon fibers are classified into carbon fibers or graphite fibers according to their carbon contents, which have excellent mechanical properties and electrical properties and can be widely used in various applications. A conventional carbon fiber is achieved by bundling precursor fibers, such as polyacrylonitrile fibers, to form a carbon fiber precursor fiber bundle, and then the carbon fiber precursor fiber bundle is calcined (high-temperature carbonization) to form the carbon fiber.

[0003] There are various precursor fibers of carbon fibers on the market, such as rayon, poly vinyl alcohol, vinylidene chloride, polyacrylonitrile (PAN), pitch, and the like. In general, polyacrylonitrile (PAN) is used as the raw material of carbon fibers. The manufacturing steps are generally as follows: PAN raw material (precursor fiber)->pre-oxidation->high-temperature carbonization->surface treatment->sizing.

[0004] In the carbonization step, the carbon fiber precursor fiber bundles are heated to form carbon fibers or graphite fibers by different heating apparatuses according to the application of the carbon fibers. In principle, the carbon content of the fibers of graphite fibers is 90% or more, forming a two-dimensional carbocyclic planar net structure and a graphite layer structure having parallel layers. The results show that the crystalline region of a high-strength carbon fiber is composed of 5-6 graphite layers, and the crystalline region of a high-strength and high-modulus carbon fiber is composed of 10-20 graphite layers. Theoretically and practically, it is pointed out that the larger the crystalline thickness of the graphite layer is, the higher the tensile modulus of the carbon fiber is.

[0005] On the other hand, untreated carbon fibers have insufficient adhesion to a matrix resin and have poor transverse properties such as separation strength and shear strength. Therefore, they are less directly utilized. They are usually combined with the matrix resin to form carbon fiber composite materials in accordance with their applications. The surface of the carbon fiber after carbonization is coated with a layer of oiling agent (in the sizing step) before it leaves the factory. The layer of oiling agent is used to protect the fiber from breakage due to friction in the subsequent step to affect the overall quality of the carbon fiber.

[0006] Furthermore, in the high-temperature carbonization step, the surface of the carbon fiber is excessively finely formed due to high-temperature sintering, and there are few functional groups on the surface. As a result, the fiber and the resin oiling agent cannot be bonded fully. It is known that a heat treatment or electrolysis technique can be applied to the surface treatment of the fiber after the high-temperature carbonization step in order to improve the bonding of the fiber and the resin oiling agent.

[0007] However, when the surface treatment of the carbon fiber is performed by means of heat treatment, a relatively long period of time is required. Besides, the heat treatment is always performed with a large number of fibers at a time, so it is difficult to control the processing quality. When the surface treatment of the carbon fiber is performed by means of electrolysis, at least one drying process is required before the surface of the fiber is coated with the oiling agent. Moreover, a change of the electrolyte may affect the processing quality. Even the surface of the fiber may have depositions.

[0008] Accordingly, the inventor of the present invention has devoted himself based on his many years of practical experiences to solve these problems.

SUMMARY OF THE INVENTION

[0009] In view of the problems of the prior art, the primary object of the present invention is to provide a carbon fiber manufacturing apparatus which can greatly improve the sizing quality of a carbon fiber and effectively reduce the cost of the carbon fiber production equipment and the working time.

[0010] In order to achieve the forgoing object, the carbon fiber manufacturing apparatus of the present invention comprises a feeding module, a receiving module, a high-temperature carbonization module, a plasma surface treatment module, and a sizing module. The receiving module is disposed in the vicinity of the feeding module. The feeding module and the receiving module constitute a carbon fiber drag route. The high-temperature carbonization module is disposed at the carbon fiber drag route and located between the feeding module and the receiving module for heating the carbon fiber drag route. The plasma surface treatment module is disposed at the carbon fiber drag route and located between the high-temperature carbonization module and the receiving module for supplying a plasma gas flow to the carbon fiber drag route. The sizing module is disposed at the carbon fiber drag route and located between the plasma surface treatment module and the receiving module for coating a resin oiling agent on the surface of a carbon fiber.

[0011] Thereby, the carbon fiber manufacturing apparatus of the present invention can be operated in the integrated operation of the feeding module, the high-temperature carbonization module, the plasma surface treatment module, the sizing module, and the receiving module. A carbon fiber precursor fiber bundle released from the feeding module is sequentially processed at a predetermined speed to perform the steps of high-temperature carbonization, plasma surface treatment, sizing, and so on, in a relatively more active and reliable manner. The carbon fiber precursor fiber bundle is heated to form the carbon fiber, and then the surface of the carbon fiber is formed with the resin oiling agent. Particularly, through the plasma surface treatment module, the surface of the carbon fiber is roughened and provided with functional groups, which is beneficial to enhance the interface bonding of the resin oiling agent and the carbon fiber in the subsequent sizing procedure so as to improve the sizing quality of the carbon fiber greatly. The structure of the carbon fiber is more stable and reliable. The plasma surface treatment belongs to a dry-type and fast surface treatment technique to effectively reduce the cost of the carbon fiber production equipment and the working time.

[0012] Preferably, the high-temperature carbonization module has a chamber for the carbon fiber drag route or the carbon fiber precursor fiber bundle to pass therethrough. The chamber is formed with at least one microwave field concentration area and supplies an inert gas and a high-frequency microwave. Under the protection of the inert gas atmosphere, the electric field of the high-frequency microwave produces a sensing current to heat up and produce a high temperature quickly with the carbon fiber precursor fiber bundle passing through the microwave field concentration area.

[0013] Preferably, the high-temperature carbonization module has a chamber for the carbon fiber drag route or the carbon fiber precursor fiber bundle to pass therethrough. The chamber is formed with at least one microwave field concentration area and provided with a gas supply module to supply an inert gas and a microwave generating module to supply a high-frequency microwave. Under the protection of the inert gas atmosphere, the electric field of the high-frequency microwave produces a sensing current to heat up and produce a high temperature quickly with the carbon fiber precursor fiber bundle passing through the microwave field concentration area. The plasma surface treatment module is provided with at least one plasma generator.

[0014] Preferably, the plasma surface treatment module is provided with at least one plasma generator located at upper and lower positions of the carbon fiber drag route, respectively.

[0015] Preferably, the chamber is an elliptic chamber.

[0016] Preferably, the chamber is provided with at least one pair of microwave-sensitive materials.

[0017] Alternatively, the chamber is a flat plate chamber.

[0018] Alternatively, the chamber is a flat plate chamber, and the chamber is provided with at least one pair of microwave-sensitive materials.

[0019] Preferably, the plasma generator is able to generate the plasma gas flow having a power in the range of 100-10000 Watts.

[0020] Alternatively, the plasma generator is able to generate an atmospheric plasma gas flow having a power in a range of 100-10000 Watts.

[0021] Alternatively, the plasma generator is able to generate a low-pressure plasma gas flow having a power in the range of 100-10000 Watts.

[0022] Alternatively, the plasma generator is able to generate a microwave plasma gas flow having a power in the range of 100-10000 Watts.

[0023] Alternatively, the plasma generator is able to generate a glow plasma gas flow having a power in the range of 100-10000 Watts.

[0024] Preferably, the sizing module is provided with at least one reservoir.

[0025] Preferably, the carbon fiber manufacturing apparatus further comprises a drying module. The drying module is disposed at the carbon fiber drag route between the sizing module and the receiving module for the resin oiling agent to be adhered to the surface of the carbon fiber firmly.

[0026] Through the carbon fiber manufacturing apparatus of the present invention, the carbon fiber precursor fiber bundle is heated to form the carbon fiber in a relatively more active and reliable means, and the surface of the carbon fiber has the resin oiling agent thereon. In particular, the surface of the carbon fiber can be roughened by the plasma surface treatment module, and the surface of the carbon fiber is provided with the functional groups. The sizing quality of the carbon fiber can be greatly improved. By the microwave focusing heating way of the high-temperature carbonization module, the same apparatus can be applied to a carbon fiber precursor fiber bundle whose surface has not been processed with a pre-oxidation treatment or a carbon fiber precursor fiber bundle whose surface has been processed with a pre-oxidation treatment in advance. By simply adjusting the microwave power, the apparatus can be used to produce general carbon fibers or high modulus carbon fibers (graphite fibers) so as reduce the cost of the carbon fiber production equipment and the working time effectively.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] FIG. **1** is a structural schematic view of a carbon fiber manufacturing apparatus in accordance with a first embodiment of the present invention;

[0028] FIG. **2** is a structural schematic view of a high-temperature carbonization module in accordance with an embodiment of the present invention;

[0029] FIG. **3** is a sectional schematic view of a carbon fiber after finishing a plasma surface treatment through a plasma surface treatment module of the present invention;

[0030] FIG. **4** is a sectional schematic view of a carbon fiber after finishing a sizing process through a sizing module of the present invention;

[0031] FIG. **5** is a structural schematic view of a carbon fiber manufacturing apparatus in accordance with a second embodiment of the present invention;

[0032] FIG. **6** is a structural schematic view of a high-temperature carbonization module in accordance with another embodiment of the present invention;

[0033] FIG. **7***a* illustrates a SEM image of an object to be tested without plasma treatment; and

[0034] FIG. **7***b* illustrates a SEM image of an object to be tested with the plasma treatment.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0035] Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings.

[0036] The present invention discloses a carbon fiber manufacturing apparatus which can greatly improve the sizing quality of carbon fibers and effectively reduce the cost of the carbon fiber production equipment and the working time. As shown in FIG. **1**, the carbon fiber manufacturing apparatus of the present invention comprises a feeding module **10**, a receiving module **20**, a high-temperature carbonization module **30**, a plasma surface treatment module **40**, and a sizing module **50**.

[0037] Referring to FIG. **1** to FIG. **4**, the feeding module **10** is used to supply a carbon fiber precursor fiber bundle **70**A to be processed into a carbon fiber **70**B. In practice, the carbon fiber precursor fiber bundle **70**A may be formed of rayon, poly vinyl alcohol, vinylidene chloride, polyacrylonitrile (PAN), pitch, and the like. The surface of the carbon fiber precursor fiber bundle **70**A may have not been processed with a pre-oxidation treatment or have been processed with a pre-oxidation treatment in advance.

[0038] The receiving module **20** is disposed in the vicinity of the feeding module **10**, and corresponds to the feeding module **10** to constitute a carbon fiber drag route. The receiving module **20** includes a yarn winding assembly **21** to receive the carbon fiber **70**B. The yarn winding assembly **21** performs a drag action on the carbon fiber **70**B to be received.

[0039] The high-temperature carbonization module **30** is disposed at the carbon fiber drag route between the feeding module **10** and the receiving module **20** for heating the carbon fiber precursor fiber bundle **70**A, enabling the carbon fiber precursor fiber bundle **70**A to become the carbon fiber **70**B having a predetermined carbon content. In practice, as shown in FIG. **2**, the high-temperature carbonization module **30** has a chamber **31** for the carbon fiber precursor fiber bundle **70**A to pass therethrough. The chamber **31** is formed with at least one microwave field concentration area **311** therein, and is provided with a gas supply module **32** to supply an inert gas and a microwave generating module **33** to supply a high-frequency microwave. Under the protection of the inert gas atmosphere, the electric field of the high-frequency microwave produces a sensing current to heat up and produce a high temperature quickly with the carbon fiber precursor fiber bundle **70**A passing through the microwave field concentration area **311**, enabling the carbon fiber precursor fiber bundle **70**A to form the carbon fiber **70**B having a predetermined carbon content.

[0040] The plasma surface treatment module **40** is disposed at the carbon fiber drag route between the high-temperature carbonization module **30** and the receiving module **20** to provide a plasma gas flow with a predetermined power to act on the carbon fiber **70**B, such that the surface of the carbon fiber **70**B is formed with a plasma-modified configuration **71** (shown in FIG. **3**) which is rougher or has more functional groups relative to the carbon fiber precursor fiber bundle **70**A.

[0041] The sizing module **50** is disposed at the carbon fiber drag route between the plasma surface treatment module **40** and the receiving module **20** for the plasma-modified configuration **71** on the surface of the carbon fiber **70**B to be coated with a resin oiling agent **80** (as shown in FIG. **4**). The sizing module **50** is provided with at least one reservoir **51** for storing the resin oiling agent **80**. The resin oiling agent **80** may be a thermosetting resin oiling agent or a thermoplastic resin oiling agent.

[0042] Thereby, the carbon fiber manufacturing apparatus of the present invention can be operated in the integrated operation of the feeding module **10**, the high-temperature carbonization module **30**, the plasma surface treatment module **40**, the sizing module **50**, and the receiving module **20**. The carbon fiber precursor fiber bundle **70**A released from the feeding module **10** is sequentially processed at a predetermined speed to perform the steps of high-temperature carbonization, plasma surface treatment, sizing, and so on, in a relatively more active and reliable manner. The carbon fiber precursor fiber bundle **70**A is heated to form the carbon fiber **70**B, and then the surface of the carbon fiber **70**B is formed with the resin oiling agent **80**.

[0043] The plasma surface treatment module **40** is provided with at least one plasma generator **41** for generating a plasma gas flow. In this embodiment, the plasma surface treatment module **40** is provided with at least one plasma generator **41** disposed at the upper and lower positions of the carbon fiber drag route respectively for generating a plasma gas flow to act on the surface of the carbon fiber **70**B.

[0044] Since the plasma gas flow contains particles having energy, the impurities that originally adhere to the surface of the carbon fiber **70**B can be broken to form small molecules by the impact of the plasma gas flow through the physical reaction (collision) of the plasma gas flow, and then the small molecules are blown away from the surface of the carbon fiber **70**B by the air flow, so that the surface of the carbon fiber **70**B is clean. In the subsequent procedure of the sizing module **50**, the resin oiling agent **80** can be completely in contact with the carbon fiber **70**B to increase the bonding effect. In addition, the impact of the plasma gas flow will also form the plasma-modified configuration **71** on the surface of the carbon fiber **70**B. The plasma-modified configuration **71** is rougher relative to the carbon fiber precursor fiber bundle **70**A, and is further formed with pores. The surface of the carbon fiber **70**B is roughened or formed with the pores, which is beneficial to increase the contact area between the resin oiling agent **80** and the carbon fiber **70**B in the subsequent procedure of the sizing module **50**. The resin oiling agent **80** penetrates into the pores, and the resin oiling agent **80** is anchored between the pores to form an anchor effect to enhance the bonding effect of the resin oiling agent **80** and the carbon fiber **70**B.

[0045] The plasma gas flow also makes the surface of the carbon fiber **70**B generate a chemical reaction at the same time, so that at least one functional group (such as —OH, —N, etc.) is added to the surface of the carbon fiber **70**B. In the procedure of the sizing module **50**, the surface tension of the surface of the carbon fiber **70**B is increased due to the presence of the functional group, which is beneficial to improve the wetting effect for the resin oiling agent to be coated on the carbon fiber **70**B. That is, the contact angle of the resin oiling agent **80** to the carbon fiber **70**B becomes small, so that the resin oiling agent **80** can be quickly or instantaneously coated on the carbon fiber **70**B, and the speed of the procedure of the sizing module **50** is increased, thereby accelerating the overall production speed of the carbon fiber **70**B. The presence of the functional group such as the OH group reacts with the resin oiling agent **80**, such as epoxy resin (Epoxy), to generate hydrogen bonding, thereby increasing the bonding effect.

[0046] In practice, the plasma generator **41** is able to generate a plasma gas flow having a power in the range of 100-10000 Watts, or an atmospheric plasma gas flow having a power in a range of 100-10000 Watts, or a low-pressure plasma gas flow having a power in the range of 100-10000 Watts, or a microwave plasma gas flow having a power in the range of 100-10000 Watts, or a glow plasma gas flow having a power in the range of 100-10000 Watts.

[0047] The plasma surface treatment module of the present invention provides a dry-type surface treatment for the carbon fiber. This not only prevents the carbon fiber from generating additional impurities or sediment but also reduces the working time and working procedure of drying after the completion of the plasma surface treatment.

[0048] As shown in FIG. **5**, the carbon fiber manufacturing apparatus of the present invention may further comprise a drying module **60**. The drying module **60** is disposed at the carbon fiber drag route between the sizing module **50** and the receiving module **20** for the resin oiling agent **80** to be firmly adhered to the surface of the carbon fiber **70**B. In practice, the drying module **60** is provided with at least one blast furnace **61** to generate hot blast.

[0049] The foregoing inert gas may be nitrogen, argon, helium, or a combination thereof. The frequency of the high-frequency microwave may be in the range of 300-30,000 MHz, and its microwave power density may be in the range of 1-1000 kW/m^3.

[0050] In the embodiment as shown in FIG. **2**, the chamber **31** may be an elliptic chamber, or the chamber **31** may be a flat plate chamber (as shown in FIG. **6**). As shown in FIG. **6**, whatever the chamber **31** is, the chamber **31** is provided with a pair of microwave-sensitive materials **34** therein, thereby enhancing the focusing effect on the microwave field in order to further accelerate the high-temperature carbonization process. In practice, the microwave-sensitive materials **34** may be one of graphite, carbide, magnetic compound, nitride, and ionic compound or a combination thereof.

[0051] Due to the resonant effect of microwave heating, the carbonization of the carbon fiber is enhanced rapidly and more crystalline carbons are formed and stacked, which leads to the formation of larger graphite crystalline molecules, namely, larger graphite crystalline thickness, while deriving a higher microwave induction heating effect is derived. Such a cycle generates an autocatalytic reaction, enabling the carbon fiber to be rapidly heated to the graphitization temperature (1500-3000° C.), and carbon atoms are reconstructed and rearranged more rapidly to form a graphite layer.

[0052] In other words, the same apparatus can be applied to a carbon fiber precursor fiber bundle whose surface has not been processed with a pre-oxidation treatment or a carbon fiber precursor fiber bundle whose surface has been processed with a pre-oxidation treatment in advance. It is only necessary to adjust the microwave power for the production, the apparatus can be used to produce general carbon fibers (1000-1500° C.) or high modulus carbon fibers (graphite fibers).

[0053] In a preferred embodiment, an article to be tested that the resin oiling agent **80** after the drying module **60** is firmly adhered to the surface of the carbon fiber **70**B, and the treatment conditions of the plasma surface treatment module **40** are shown in Table 1 below:

TABLE 1

the conditions of the plasma surface treatment

plasma gas consumption	N_2	200	L/min
	CDA	0.4	L/min
plasma gas amount	200.4		L/min
plasma power	0~1000		W
plasma surface treatment time	0.025~0.100		sec.
carbon fiber yarn width	7		mm
yarn per unit time receiving capacity	0.28		J/s
distance	1		mm

[0054] The ILSS strength (interlayer bonding force) was measured for an object to be tested in an environment of a temperature of 23° C. and a humidity of 50% RH by using an INSTRON measuring machine according to ASTM 2344, and the results are shown in Table 2 below:

TABLE 2

the relationship between the plasma surface treatment power (W), the processing time (sec.) and the interlayer bonding force (MPa) (epoxy resin used as the resin oiling agent) of PAN carbon fiber 12K

plasma power (W) of surface	interlayer bonding force (ILSS)(MPa)		
treatment	0.025 sec.	0.075 sec.	0.100 sec.
0(untreated)	70	70	70
250	71	73	75
500	73	76	81
750	75	81	85
900	79	86	88
1000	83	89	91

[0055] As can be seen from Table 2, the carbon fiber without the plasma surface treatment, the interlayer bonding force of the object to be tested is only 70 MPa. With an increase of the plasma power, for example, the processing time is 0.075 seconds and the plasma power is increased from the untreated (0 W, without plasma power) to 10000 W, the interlayer bonding force is increased from 70 MPa to 89 MPa. That is, the interlayer bonding force is increased to 127%.

[0056] In the procedure of the sizing module **50**, the epoxy resin is used as the resin oiling agent **80**, and the carbon fiber is used as the carbon fiber **70**B. FIG. **7**A shows a SEM image of the object to be tested without the plasma treatment. FIG. **7**B shows a SEM image of the object to be tested with the plasma treatment. As shown in FIG. **7**A, the SEM image of the object to be tested without the plasma surface treatment illustrates a void H between the resin oiling agent **80** and the carbon fiber **70**B because the surface of the carbon fiber **70**B is smooth and doesn't have functional groups. The void H causes a decrease in the strength of the object to be tested. That is to say, the bonding force between the carbon fiber and the resin oiling agent is insufficient for protecting the fiber.

[0057] As shown in FIG. **7**B, the SEM image of the object to be tested with the plasma surface treatment illustrates that there is no void between the resin oiling agent **80** and the carbon fiber **70**B because the surface of the carbon fiber **70**B is rough and has functional groups (such as —OH, —N, etc.). The resin oiling agent **80** and the carbon fiber **70**B are bonded tightly, so that the strength of the object to be tested is enhanced. That is, the adhesion between the carbon fiber and the resin oiling agent is enhanced, so that the purpose of protecting the fiber can be achieved.

[0058] Specifically, through the carbon fiber manufacturing apparatus of the present invention, the carbon fiber precursor fiber bundle is heated to form the carbon fiber in a relatively more active and reliable means, and the surface of the carbon fiber has the resin oiling agent thereon. In particular, the surface of the carbon fiber can be roughened by the plasma surface treatment module, and the surface of the carbon fiber is provided with the functional groups. The sizing quality of the carbon fiber can be greatly improved. By the microwave focusing heating way of the high-temperature carbonization module, the same apparatus can be applied to a carbon fiber precursor fiber bundle whose surface has not been processed with a pre-oxidation treatment or a carbon fiber precursor fiber bundle whose surface has been processed with a pre-oxidation treatment in advance. By simply adjusting the microwave power, the apparatus can be used to produce general carbon fibers or high modulus carbon fibers (graphite fibers) so as reduce the cost of the carbon fiber production equipment and the working time effectively.

[0059] Although particular embodiments of the present invention have been described in detail for purposes of illustration, various modifications and enhancements may be made without departing from the spirit and scope of the present invention. Accordingly, the present invention is not to be limited except as by the appended claims.

What is claimed is:

1. A carbon fiber manufacturing apparatus, comprising:

a feeding module and a receiving module, the receiving module being disposed in the vicinity of the feeding module, the feeding module and the receiving module constituting a carbon fiber drag route;

a high-temperature carbonization module, disposed at the carbon fiber drag route and located between the feeding module and the receiving module for heating the carbon fiber drag route;

a plasma surface treatment module, disposed at the carbon fiber drag route and located between the high-temperature carbonization module and the receiving module for supplying a plasma gas flow to the carbon fiber drag route; and

a sizing module, disposed at the carbon fiber drag route and located between the plasma surface treatment module and the receiving module.

2. The carbon fiber manufacturing apparatus as claimed in claim **1**, wherein the high-temperature carbonization module has a chamber, a gas supply module, and a microwave generating module, the carbon fiber drag route passes through the chamber, the gas supply module is used to supply an inert gas, and the microwave generating module is used to supply a high-frequency microwave.

3. The carbon fiber manufacturing apparatus as claimed in claim **2**, wherein the plasma surface treatment module is provided with at least one plasma generator.

4. The carbon fiber manufacturing apparatus as claimed in claim **2**, wherein the plasma surface treatment module is provided with at least one plasma generator located at upper and lower positions of the carbon fiber drag route, respectively.

5. The carbon fiber manufacturing apparatus as claimed in claim **2**, wherein the chamber is an elliptic chamber.

6. The carbon fiber manufacturing apparatus as claimed in claim **5**, wherein the chamber is provided with at least one pair of microwave-sensitive materials.

7. The carbon fiber manufacturing apparatus as claimed in claim **2**, wherein the chamber is a flat plate chamber.

8. The carbon fiber manufacturing apparatus as claimed in claim **7**, wherein the chamber is provided with at least one pair of microwave-sensitive materials.

9. The carbon fiber manufacturing apparatus as claimed in claim **3**, wherein the plasma generator is able to generate the plasma gas flow having a power in the range of 100-10000 Watts.

10. The carbon fiber manufacturing apparatus as claimed in claim **3**, wherein the plasma generator is able to generate an atmospheric plasma gas flow having a power in a range of 100-10000 Watts.

11. The carbon fiber manufacturing apparatus as claimed in claim **3**, wherein the plasma generator is able to generate a low-pressure plasma gas flow having a power in the range of 100-10000 Watts.

12. The carbon fiber manufacturing apparatus as claimed in claim **3**, wherein the plasma generator is able to generate a microwave plasma gas flow having a power in the range of 100-10000 Watts.

13. The carbon fiber manufacturing apparatus as claimed in claim **3**, wherein the plasma generator is able to generate a glow plasma gas flow having a power in the range of 100-10000 Watts.

14. The carbon fiber manufacturing apparatus as claimed in claim **1**, wherein the sizing module is provided with at least one reservoir.

15. The carbon fiber manufacturing apparatus as claimed in claim **1**, further comprising a drying module, the drying module being disposed at the carbon fiber drag route between the sizing module and the receiving module.

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