APPARATUS AND METHOD FOR PRODUCING A FILTER ELEMENT

TECHNICAL FIELD

The present disclosure relates to an apparatus and method for producing a filter element. The filter element may be suitable for use as a filter element in a tobacco product or non-tobacco product.

BACKGROUND

The following discussion of the background is intended to facilitate understanding of the present disclosure. However, it should be appreciated that the discussion is not an acknowledgment or admission that any of the material referred to was published, known or a part of the common general knowledge in any jurisdiction as at the priority date of the application.

In recent years, heatable tobacco products (also known as heat-not-burn products, or heated tobacco products) have been developed as an alternative to traditional cigarette, which provides smokers a healthier option. For heatable tobacco products, a nicotine-containing aerosol/vapour is produced by heating the tobacco products at temperature below a combustion temperature of tobacco materials.

For some heatable tobacco products, traditional cigarette filters, such as filter plugs formed from bundles of cellulose acetate fibres or from convoluted paper, may be used. The cellulose acetate and paper modify the particulate smoke phase by particle retention or filtration, and the activated charcoal content may be added in the filter to modify the gaseous phase through adsorption. At the same time, filters formed from other suitable materials may also be used in heatable tobacco products. For examples, filters with a net structure formed from plastic netting and/or knitted yarns, may be relatively more suitable filter type to be used in heatable tobacco products compared to the traditional cigarette filters, as the net structure of the filters may bring about may bring about an enhanced mouthfeel for the user.

Due to the different materials used for forming the filters and the difference specifications desired for the filters, existing filter forming machines and filter forming processes used for producing traditional cigarette filters may not be suitable for producing the filters for use in heatable tobacco products.

There exists a need to develop an apparatus and process for producing a filter element, which are suitable, but not limited for use in tobacco products.

SUMMARY

According to one aspect of the disclosure, there is provided an apparatus for producing a filter element having a filter forming module. The apparatus comprises a first forming guide configured to receive a primary filter material; a forming element positioned downstream of the first forming guide unit, and configured to compress the primary filter material to form a filter body of a pre-determined shape and/or a pre-determined dimension; and a heating unit placed along a pathway of the primary filter material and at an inlet side of the filter forming module, wherein the heating unit is configured to switch between two or more operational modes based on a property of the primary filter material.

In some embodiments, the two or more operational modes of the heating unit comprise at least one heating mode whereby the heating unit is operable to heat the primary filter material at a pre-determined heating temperature or a pre-determined heating profile according to a property of the primary filter material, and a non-heating mode whereby the heating unit is powered off.

In some embodiments, the pre-determined heating temperature used for the at least one heating mode is a glass transition temperature of the primary filter material.

In some embodiments, the apparatus further comprises a frontend cutting unit arranged at downstream of the first forming guide unit, the frontend cutting unit operable to cut the primary filter material exiting from the first forming guide unit into a plurality of filter strand segments, each segment having a pre-determined length.

In some embodiments, the apparatus further comprises a conveyor device and a positioning device, wherein the conveyor device is configured to move the plurality of filter strand segments to the forming unit, and the positioning device is configured to separate two adjacent filter strand segments by a gap of a pre-determined length along a pathway of the plurality of filter strand segments.

In some embodiments, the apparatus further comprises a wrapping unit configured to provide a wrapping material around at least a portion of the primary filter material exiting from the first forming guide unit, and direct the primary filter material and the wrapping material to the filter element.

In some embodiments, the wrapping unit comprises a wrapping material source arranged to provide the wrapping material to an infeed forming area at an inlet side of the forming unit; and a sealing device arranged to secure edges of the wrapping material around the primary filter material, such that an overwrap is formed circumscribing the surface of the filter body.

In some embodiments, the apparatus further comprises a backend cutting unit arranged at an outlet side of the filter forming module, and configured to cut the filter body into a pre-determined length and/or at pre-determined locations.

In some embodiments, the filter forming module comprises a second forming guide positioned downstream of the first forming guide and at an inlet side of the first forming element, wherein the second forming guide unit is configured to receive and gather a secondary filter material and the primary filter material from the first forming guide unit.

In some embodiments, the apparatus further comprises a steam chamber positioned adjacent the second forming guide unit for containing at least a portion of the secondary filter material and at least a portion of the primary filter material, wherein a steam generator is arranged to provide a desired humidity inside the steam chamber, and a

sprayer is configured to direct a mist of a chemical solution for forming a hardened layer of the second filter material on the surface of the primary filter material.

In some embodiments, the secondary filter material comprises a fibrous tow material.

In some embodiments, the primary filter material is formed from at least one of a net material, a filler material, and a combination of a net material and a filler material.

In some embodiments, the net material comprises a plastic netting formed using an extrusion process, or an open-mesh fabric material formed using a weaving, knitting, and/or braiding process.

In some embodiments, the primary filter material comprises a natural material obtained from one or more of the following plant parts: - leaf, bark, trunk, fruit, seed, stem, flower, pollen, branch, root, sap, pulp, resin bagasse, calyx of the respective flora.

In some embodiments, the filter forming module is connected to a filter material supply module, the filter material supply module comprises at least one material bobbin loaded with the primary filter material; and an unwinder operable to unwind and transfer the primary filter material from the material bobbin towards the filter forming module at a pre-determined speed.

In some embodiments, the filter material supply module further comprises at least one stock bobbin configured to supply the primary filter material to at least one of the following: the at least one material bobbin, the filter forming module.

In some embodiments, the filter forming module is connected to an inner channel formation module, the inner channel formation module is configured to receive the filter material and to form a filter body with an internal profile.

In some embodiments, the filter forming module is connected to an inner filter component supply module, the inner filter component supply module is configured to

contain one or more pre-formed inner filter components and to supply the one or more pre-formed inner filter components to the filter forming module at a pre-determined speed.

In some embodiments, the inner filter component supply module is further configured to separate each two adjacent pre-formed inner filter components by a gap of a pre-determined length.

According to another aspect of the disclosure, there is provided a method of forming a filter element, comprising the steps of: receiving a primary filter material at an inlet side of a filter forming module; passing the primary filter material through a heating unit, whereby the heating unit is configured to switch between two or more operational modes based on a property of the primary filter material; and compressing the primary filter material to form a filter body of a pre-determined shape and/or a pre-determined dimension.

In some embodiments, the two or more operational modes of the heating unit comprise at least one heating mode whereby the heating unit is operable to heat the primary filter material at a pre-determined heating temperature or a pre-determined heating profile according to a property of the primary filter material, and a non-heating mode whereby the heating unit is powered off.

In some embodiments, the method further comprises the steps of cutting the primary filter material into a plurality of filter strand segments of a pre-determined length; and separating each two adjacent filter strand segments by a gap of a pre-determined length.

In some embodiments, the method further comprises the steps of providing a wrapping material before the step of compressing the primary filter material into the filter body; and sealing edges of the wrapping material such that the wrapping material circumscribes at least a portion of the primary filter material.

In some embodiments, the method comprises the steps of providing a secondary filter material before the step of compressing the primary filter material into a filter body; and forming a layer of the second filter material around the primary filter material.

In some embodiments, the method further comprises a step of treating the secondary filter material with a hardening solution.

In some embodiments, the method further comprises a step of cutting the filter body into a plurality of portions.

In some embodiments, the method comprises a step of heating the primary filter material at a glass transition temperature of the primary filter material, according to the at least one heating mode.

In some embodiments, the method further comprises a step of transferring a continuous strand of a net filter material from a material supply module to the inlet side of the filter forming module.

In some embodiments, the method further comprises the steps of forming a filter body with an internal profile; and transferring the filter body with the internal profile to the inlet side of the filter forming module.

In some embodiments, the method further comprises a step of transferring one or more pre-formed inner filter components to the inlet side of the filter forming module.

Other aspects of the disclosure will be apparent to those of ordinary skill in the art upon review of the following description of specific embodiments of the disclosure in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Various embodiments are described, by way of example only, with reference to the accompanying drawings, in which:

Figure 1 and Figure 2 illustrate an apparatus and a process for producing a filter element using the apparatus according to one embodiment;

Figure 3 illustrates an apparatus and a process for producing a filter element according to another embodiment;

Figure 4 illustrates an apparatus and a process for producing a filter element according to another embodiment;

Figure 5 illustrates an apparatus and a process for producing a filter element according to another embodiment;

Figure 6 illustrates an apparatus and a process for producing a filter element according to another embodiment; and

Figure 7 illustrates various embodiments of a filter body formed using the apparatus.

Other arrangements are possible and it is appreciable that the accompanying drawings are not to be understood as superseding the generality of the preceding description of the disclosure.

DETAILED DESCRIPTION

Particular embodiments are described with reference to the accompany drawings. The terminology used herein is for the purpose of describing particular embodiments only and is not intended to limit the scope of the present disclosure. Other definitions for selected terms used herein may be found within the detailed description of the disclosure and apply throughout the description. Additionally, unless defined otherwise, all technical and scientific terms used herein have the same meanings as commonly understood by one ordinary skilled in the art to which the present disclosure belongs. Where possible, the same reference numerals are used throughout the figures for clarity and consistency.

Throughout the specification, unless the context requires otherwise, the term "comprise" or variations such as "comprises" or "comprising", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Throughout the specification, unless the context requires otherwise, the term "include" or variations such as "includes" or "including", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Throughout the specification, unless the context requires otherwise, the term "have" or variations such as "has" or "having", will be understood to imply the inclusion of a stated integer or group of integers but not the exclusion of any other integer or group of integers.

Throughout the specification, unless the context requires otherwise, the term "tobacco" will be understood to include products prepared from a part of the tobacco plant, such as leaves, through the process of drying or curing, and further optional processes of aging, fermenting, flavouring etc., and to include any other products derived from any forms of tobacco leaves such as ground and reconstituted tobacco material.

Throughout the specification, unless the context requires otherwise, the term "tobacco product" includes, but not limited to smoked tobacco products such as traditional cigarette(s) and cigar(s), heated tobacco product(s), electronic smoking device(s) such as electronic cigarette(s) and vaporizer(s)/vaping device(s).

Throughout the specification, the term "strand" will be understood to depict a slender and substantially elongated shape.

Throughout the specification, the term "continuous" will be understood to depict an unbroken or uninterrupted extension of a material.

Throughout the specification, the term “layer” will be understood to depict a planner or a curved surface with a substantially higher length and/or width compared to thickness.

Throughout the specification, the terms “upstream” and “downstream”, when used in the context of a filter forming process, refer to an earlier and a later stage of a filter forming process respectively. When used in the context of a filter forming apparatus, the terms “upstream” and “downstream” may refer to the relative positions of the different units or modules arranged in the filter forming apparatus in relation to the direction of the movement of the filter materials and/or any intermediate parts formed from the filter materials during the filter forming process.

In accordance with one embodiment of the disclosure and with reference to Figure 1, there is provided an apparatus 100 for producing a filter element 10. The apparatus 100 comprises at least a filter forming module 104. As shown in Figure 1, an inlet side of the filter forming module 104 may be connected to a filter supply module 102.

The filter forming module 104 is placed at downstream of the filter supply module 102 and is arranged to receive at least one filter material 20 from the filter supply module 102. The at least one filter material 20 is the primary material used for forming the filter element 10, and may also be referred to as a primary filter material 20. As a non-limiting example, the filter forming module 104 may be placed at a position near an outlet side of the filter material supply module 102, so that the filter material 20 coming out from the filter material supply module 102 can be transferred and fed directly into the filter forming module 104.

In various embodiments, the filter material 20 may comprise or be formed from the following materials (which may be plastic or non-plastic): polylactic acid (PLA), VectranTM, polyethylene (PE), polypropylene (PP), polyvinylchloride (PVC), polyethylene terephthalate (PET), polyether ether ketone (PEEK), cellulose acetate (CA), Fluorinated ethylene propylene (FEP) plastic, Polyurethane (PUR) Plastic, Polytetrafluoroethylene (PTFE), Liquid Crystal Polymer (LCP), polyimide, polyacrylonitrile (PAN), polysiloxanes such as silicone, in the form of silicone oil,

silicone grease, silicone rubber, silicone resin or silicone caulk, silicone as coating, laminate or mixed with other materials in this list; other polymer resins, natural plant fibers such as jute, hemp and others, natural animal fibers such as silk, wool and others, carbonized natural plant fibers such as bamboo charcoal fiber and others, carbonized animal fibers, charcoal fibers, natural or synthetic rubber and its derivatives, carbon, graphite, liquid wood, starch made polymer, natural fibre, synthetic fibre, biodegradable fiber or non-biodegradable fiber, one or more composite or derivatives of the above mentioned materials, possible combinations of one or more of the above materials.

In some embodiments, the filter material 20 may comprise or may be formed from one or more natural materials obtained from various parts of different types of plants including, but not limited to, a leaf, bark, trunk, fruit, seed, stem, flower, pollen, branch, root, sap, pulp, resin bagasse, calyx of the respective plants.

In various embodiments, the filter material 20 may be formed from one or more of the following natural materials including, but not limited to, oak, maple, *Pandanus amaryllifolius* or screwpine, Daun Asam or tamarind, Roselle, sugarcane, lotus, Yucca, bamboo, reed, nypa fruticans, canna, mesquite, hickory, alder, *Tetrapanax papyrifer or* rice-paper plant or, Broussonetia papyrifera or paper mulberry, and any other plants, grasses, or flora; vegetables and fruits such as lemon, banana, grape, grapefruit, melon, pineapple, pomegranate, cucumber, durian, orange, cherry, apple, pear, mango, apricot, peach, any edible berry, fig, pumpkin, and nectarine; edible mushroom; lichen; coconut; coir; corn; corn husk; rice; glutinous rice; hazelnut; walnut; almond; peanut; pecan; any derivatives from the above natural resources. *Pandanus amaryllifolius* or screwpine is also referred to as Rampe. It is appreciable that the natural materials may be obtained from other suitable natural resources.

The natural materials may undergo a preparatory treatment such as drying, steaming, curing, expanding, flattening, pre-cutting, heating, and carding. The pre-treated natural materials may then undergo further processes to be formed into an intermediate material (for example, a thread, a fabric material and etc.) for forming the net material 22 with the interlaced/net structure.

In various embodiments, the filter material 20 used for forming the filter element 10 may comprise a net material with an interlaced structure of fibers, threads, wires, yarns and/or filaments with a plurality of mesh openings. In various embodiments, the net material may have various mesh shapes, mesh sizes, diameters, widths, and lengths according to desired specifications of filter element 10 to be formed.

In some embodiments, the net material used as the filter material 20 may be a plastic netting formed using a plastic extrusion process. The plastic extrusion process may be adapted to form plastic nettings having a wide range of apertures/mesh sizes, weights, and thicknesses. For example, plastic resin (in pellets or in other suitable forms) may be melted and pushed through a die in “meat-grinder" fashion, through two counter-rotating dies, or through a circular oscillating die plate to produce a continuous plastic mesh netting in different configurations.

In various embodiments, the plastic resin may be pushed through the die at a melt flow rate of about 1g (grams) to 10g per 10 mins. In some embodiments, the plastic resin may be pushed through the die of the extruder at a melt flow rate of 3g to 5g per 10mins.

In various embodiments, the plastic resin used for forming the extruded plastic netting may have a glass transition temperature in the range between 120^{o}C to 200^{o}C.

In some embodiments, the net material used as the filter material 20 may comprise an open-meshed fabric material twisted, knotted, or woven together at pre-determined intervals. Different materials in the form of fibers, threads, filaments and yarns, may be used for forming the net material. Different weaving, knitting, braiding processes may be used to form the net material of a desirable shape and/or dimension and with a desirable mesh size and pattern.

In various embodiments, the net material may have a filament/thread size of about 0.5mm. The filament/thread size refers to the diameter of the fibers or filaments in the

resultant extruded plastic netting, or the diameter of the threads or yarns used in the knitted/woven open-mesh fabric material.

In various embodiments, the net material may be configured in the form of a tubular net or a flat net. The net material may be in a substantially elongated shape and may have a width of about 20mm to 100mm. In some embodiments, the filter material 20 may have a width of about 35mm. In some embodiments, the net filter materials 20 may have a width of about 22mm.

In some embodiments, the mesh openings of the net material may be formed with a particular shape. Non-limiting examples of such shapes include a square shape, a triangular shape, a hexagonal shape or a diamond shape.

In various embodiments, the filter material 20 may be packaged in the form of a roll, a bobbin, or coiled inside a drum to facilitate easy handling. The dimension of the roll or bobbin or drum may be adapted such that it may be mounted on a filter material supply module 102 of the apparatus directly. In some embodiments, the filter material 20 may be packaged in the form of a bobbin having an internal diameter in the range of 100mm to 1000mm. In some embodiments, the filter material 20 may be packaged in the form of a bobbin having an internal diameter of 120mm and a width of 600mm. The internal diameter of the bobbin corresponds to the diameter of a cylindrical body of the bobbin for winding the filter material. The width of the bobbin can correspond to the length of the cylindrical body.

In various embodiments, the filter material 20 may include a filler material. Such filler material may be formed from natural material, synthetic material or a combination of the same. It is appreciable that the list of natural material or synthetic material may include those which has been described for the net material above.

In various embodiments, the filler material 20 may be configured in any suitable forms for filling the volume and structure of the filter element 10. For example, the filler

material may be in a granule or pellet form, filament form, strip form, fibers or hardened fibers of any shape, and/or flakes.

In various embodiments, the filter material 20 may comprise one or more pre-formed inner filter components. The one or more pre-formed inner filter components may be loaded on a tray or on a container. It is appreciable that the pre-formed inner filter components may be formed from or comprise any suitable natural or synthetic filter material as described above. In some embodiments, the one or more pre-formed inner filter components may comprise one or more air channels 73 extending along the longitudinal axis of each of the pre-formed filter rods.

In various embodiments, the filter forming module 104 may be operatively connected to the filter material supply module 102. It is appreciable that the filter material supply module 102 may be movably mounted onto the filter forming module 104, placed inside the filter forming module 104, or integrated with the filter forming module 104.

In various embodiments, the filter material supply module 102 may comprise at least one bobbin 109 loaded with the filter material 20, and an unwinder 107 operable to unwind the filter material 20 from at least one bobbin 109. The bobbin 109 loaded with the filter material 20 and operatively mounted onto the unwinder 107 is also referred to as a material bobbin 109. The unwinder 107 is further operable to transfer and feed the unwounded filter material 20 to an inlet 116 of the downstream filter forming module 104 at a pre-determined speed.

It is appreciable that the transfer of the filter material 20 to the filter forming module 104 may be achieved via any suitable means, which allows a running strand of the filter material 20 to be continuously supplied to the filter forming module 104. For example, a core-to-core transfer may be used whereby the running strand of the filter material 20 is transferred from the material bobbin 109 to a new core on the fly, and towards the inlet 116 of the filter forming module 104. One or more rollers (not shown) may be used to assist in advancing the filter material 20, particularly if there is a relatively long

distance between the filter material supply module 10 and the inlet 116 of the downstream filter forming module 104.

In some embodiments, the filter material supply module 102 may further comprise one or more stock bobbins 109b, as shown in Figures 1, 3 and 4. The stock bobbin 109b is also referred to as a spare bobbin 109b, and may be loaded with the same filter material 20 as used for the material bobbin 109. The stock bobbin 109b may be configured to supply the filter material 20 to the material bobbin 109 when the material bobbin 109 is depleted during the filter forming process. For example, a starting portion of the filter material 20 wound on the stock bobbin 109b may be joined with an end portion of the filter material 20 loaded on the material bobbin 109. The joining of the filter materials 20 from the different bobbins 109, 109b may be done prior to the activation of the apparatus 100, or during the operation of the apparatus 100 and upon a material depletion or near depletion trigger from apparatus 100.

In some embodiments, the stock bobbin 109b may be configured to supply the filter material 20 directly to the inlet of the filter forming module 104 at the downstream, after the material bobbin 109 is depleted. In other words, the stock bobbin 109b may be converted into and/or replace the material bobbin 109 if required.

The use of stock bobbin 109b in the filter material supply module 102 provides the benefits of minimizing disruption of production cause by depletion or shortage of the filter material 20. Production downtime required for changing the material bobbin 109 is reduced and production efficiency is improved. It is appreciable that more than one stock bobbins 109b may be used to meet the requirement of continuous production.

In various embodiments, the filter forming module 104 comprises a first forming guide 116 at the inlet side of the filter forming module 104, a forming element 125 placed at the downstream of the first forming guide 116, and a heating unit 120 placed along a pathway of the running strand of filter material 20. As shown in Figures 1, 3 and 4, the heating unit 120 may be placed at a position between the inlet side of the filter forming module 104 and the outlet side of filter material supply module 102, such that the strand

of filter material 20 coming from the material supply module 102 will pass through the heating unit 120 prior to entering the first forming guide 116 or prior to entering the forming element 125.

It is appreciable that the heating unit 120 may be arranged in any suitable configurations. In some embodiments, the heating unit 120 may be movably mounted onto the filter forming module 104. In some embodiments, the heating unit 120 may be placed inside or integrated with the filter forming module 104 at the inlet side.

In various embodiments, the heating unit 120 may comprise one or more heat sources which are configured to heat the running strand of filter material 20 from the material bobbin 109 at a pre-determined temperature. Different types of heat sources may be used, for example, hot air blower, heating element (or electrical resistance based heating device), infrared heater, and steam heater. The one or more heat sources may be used in combination, and may be arranged to heat the continuous strand of filter material 20 at different positions.

In some embodiments, the heating unit 120 may be a heating tunnel connected to the outlet side of the filter material supply module 102 at one end of the heating tunnel and connected to the first forming guide 116 of the filter forming module 104 at the other end of the heating tunnel. The heating tunnel may be configured to cover a relatively longer portion of the strand of filter material 20, thus allowing the filter material 20 to be heated more homogeneously and more efficiently.

In some embodiments, the heating unit 120 may comprise one or more blowers or fans to improve convection within the heating unit 120 for more uniform heating.

In various embodiments, the heating unit 120 is configured to switch between two or more operational modes based on a property of the primary filter material. For example, the heating unit 120 may switch between two or more operational modes based on a material type or a material composition of the filter material 20, based on the form and

structure of the filter material 20 (for example, a net material or a filler material), and/or based on a phase transition temperature of the filter material 20.

In various embodiments, the two or more operational modes of the heating unit 120 may comprise at least one heating mode and a non-heating mode.

When the heating unit 120 is set to operate at the at least one heating mode, the heating unit 120 may operate to heat the primary filter material 20 at a pre-determined heating temperature or with a pre-determined heating profile. In various embodiments, a suitable heating temperature or a suitable heating profile may be selected according to the primary filter material, such that the filter material 20 may be transformed from a relatively hard and brittle state into a relatively viscous and rubbery state. For example, when the filter material 20 is a net material 20 comprising a plastic extrusion netting, a knitted open-mesh fabric material formed from plastic filaments/threads/fibers, and/or other types of filter material comprising polymeric materials, the heating unit 120 may be set to operate at or switch to the at least one heating mode.

In some embodiments, the heating unit 120, operating under the at least one heating mode, may be configured to heat the filter material at temperatures in the range of about 50 ºC to 400ºC.

In some embodiments, the heating temperatures used in the at least one heating mode of the heating unit 120 may be in the range of about 100 ºC to 300ºC.

In some embodiments, the heating unit 120 may be configured to heat the strand of filter material 20 with a pre-determined heating profile. In other words, the heating temperature may not be a constant and fixed heating temperature, and may be varied during the operation of the heating unit 120.

In some embodiments, the pre-determined heating profile may comprise a plurality of heating cycles. In some embodiments, each heating cycle comprises alternating heating and non-heating/off periods. In some embodiments, each heating cycle comprises two

or more heating periods with two or more heating temperatures. For example, the heating unit 120 may be configured or controlled to heat the filter material 20 at a first heating temperature during a first heating period and at a second heating temperature during a second heating period. The first and second heating periods, and optionally a non-heating/off period, may constitute one heating cycle of the pre-determined heating profile. The same heating cycle may then repeated to heat the filter material.

In some embodiments, the pre-determined heating profile may comprise two or more heating temperatures applied by two or more heat sources positioned at different parts of the heating unit 120. For example, the heating unit 120 may comprise two or more heating zones arranged sequentially along the pathway of the strand of filter material 20. The two or more heating zones may each comprise one or more heat sources set to heat the filter material 20 at different desired temperatures.

In some embodiments whereby the filter material 20 is formed from an amorphous materials or semi-crystalline materials (for example, hard plastics, covalent network glasses such as silicates), the pre-determined heating temperature and the pre-determined heating profile used in the at least one heating mode of the heating unit 120 may be or may comprise a temperature at or close to a glass transition temperature of the filter material 20.

Advantageously, the flexibility and compressibility of the filter material 20 may be improved after passing through the heating unit 120 operating at the at least one heating mode. The improved flexibility and compressibility of the filter material 20 allows easy processing at the downstream filter forming stage. The filter material 20 may be shaped by the forming guide 116 and the forming element 125 in a relatively easier manner due to the pre-heating process. Further, when a net material is used as a filter material 20, the net structure of the net material and of the resultant filter element 10 may be a relatively less ordered and more randomized structure, because the filter material 20 is at a relatively viscous and rubbery state while undergoing the filter forming process at the forming guide 116 and/or forming element 125.

Depending on the property of the filter material 20, the heating-unit 120 may be powered-off or may not activated. More specifically, the heating unit 120 may be set at or switch to a non-heating mode, when pre-heating of the filter material 20 does not result in any noticeable effect on improving the flexibility or compressibility of the filter material. The non-heating mode of the heating unit 120 may also be used when the heating temperature required to transform the filter material 20 into a more flexible and more compressible state is too high, and/or may cause the emission of volatile substances from the filter material 20 which may be harmful to human body.

In relation to embodiments using filter materials 20 formed from non-plastic materials, the heating unit 120 may be set at the non-heating mode, because such non-plastic based filter materials 20 may not undergo any changes in physical properties (e.g. a glass-fluid phase transition) when being heated. For example, when net materials formed from paper yarn or other non-plastic materials, or filler materials formed from natural plant parts are used as the filter material 20, the heating unit 120 may be configured to operate at or switch to the non-heating mode.

The flexibility of the heating unit 120 to switch between the two or more operational modes, and/or to set or select the heating temperature or the heating profile according to the filter material allows the filter forming module 104 to be used with a broad range of different types of filter materials 20. Further, it provides the benefits of energy saving. It is appreciable that the switch between the at least one heating mode and the non-heating mode, and the selection or setting of the heating temperature or heating profile may be performed either by a human operator or by a built-in controller module. When the heating unit 120 comprises a built-in controller module, the heating unit 120 may operate according to digital commands or a software algorithm pre-programmed in the built-in controller module, and the switch between the different operational modes of the heating unit 120 may be automated or semi-automated. The built-in controller module may include an application specific integrated circuit (ASIC) or can include a general-purpose processor.

In various embodiments, the first forming guide 116 is configured to receive the filter material 20 from the filter material supply module 102, and to advance the filter material 20 towards the direction of the forming element 125. As shown in Figure 1, the first forming guide 116 may be configured in a truncated pyramid shape, a cone shape or a funnel shape, which comprises two openings 116a, 116b of different sizes. The first forming guide 116 is arranged such that the filter material 20 is received from the filter material supply module 102 at a first opening 116a of a relatively larger size, and is advanced towards a second opening 116b of a relatively smaller size. Due to the different sizes of the two openings 116a, 116b, the filter material 20 may be compressed or converged to a relatively more compact form as it passes through the first forming guide 116.

In some embodiments, the second opening 116b of the forming guide 116 may be shaped and dimensioned as an oval, or a circle. In relation to embodiments including a forming guide 116 with a circular-shaped second opening 116b, the second opening 116b may have a diameter in a range between 4mm to 15mm. In relation to embodiments including a forming guide 116 with an oval-shaped second opening 116b, the second opening 116b may have a width (i.e. a distance measured along a minor axis of the oval shape) and/or a length (i.e. a distance measured along a major axis of the oval shape) in the range between 4mm to 15mm.

In various embodiments, the filter material 20 exited from the second opening 116b of the first forming guide 116 may follow the same or a substantially similar shape and dimension of the second opening 116.

The filter material 20 compressed or converged by the forming guide 116 may then be moved towards the downstream forming element 125, and may be shaped by the forming element 125 in a relatively easier manner.

In various embodiments, the forming element 125 may comprise an internal channel (not shown) with an internal profile corresponding to the shape and/or dimension of the filter element 10 to be formed. As the filter material 20 passes through the forming

element 125, the filter material 20 is further compressed to form into a continuous filter body with a desired shape and/or dimension. For example, as shown in Figure 1, a continuous filter body 27 in a tube or rod-like shape may be formed from the filter material 20. The flexibility of the filter material 20 allows it to better conform to the shape of the inner channel of the forming element 125. Manufacturing variation is minimized. Thereafter, the continuous filter body 27 formed is moved to and exited from an outlet side 114 of the filter forming module 104.

In various embodiments, the apparatus 100 may further comprise a backend cutting unit 132. The backend cutting unit 132 may be positioned at the outlet side 114 of the filter forming module 104, and is configured to cut or otherwise break the continuous filter body 27 into multiple segments of a pre-determined length. Each segment of the continuous filter body 27 is also referred to as a filter body segment 33. The filter body segment 33 may already constitute a filter element 10 for incorporation into or for use with a tobacco product. Alternatively and additionally, the multiple filter body segments 33 may undergo one or more further trimming and/or shaping processes before being incorporated into or used with the tobacco product.

In various embodiments, the apparatus 100 may further comprise a frontend cutting unit 139. The frontend cutting unit 139 is positioned at or near the inlet side of the filter forming module 104, and at the downstream of the first forming guide 116, as shown in Figure 3 and 4. The frontend cutting unit 139 is configured to cut or otherwise break the converging strand of filter material 20 coming out from the second end 116b of the forming guide 116 into a plurality of segments, as the filter material 20 moves past the frontend cutting unit. A portion of the converging strand of filter materials 20 is also referred to as a filter strand segment (not shown). Each filter strand segment is cut into a pre-determined length, which may correspond substantially to or may be relatively shorter as compared to, the desired length of the final filter element 10 to be formed.

In various embodiments, the second cutting unit 139 may comprise or may be connected to a conveyor device 145, which is configured to move the plurality of filter strand segments from the second cutting unit 139 towards the direction of the forming element 125. Non-limiting examples of the conveyor device includes a belt conveyor and a roller

conveyor. The plurality of filter strand segments are arranged substantially in axial alignment with each other on the conveyor device 145 while being transferred to the forming element 125.

In various embodiments, the conveyor device 145 may be coupled to a positioning device 148. For example, the conveyor device 145 may be directly connected to the positioning device 148. The positioning device 148 is adapted to introduce a gap or a space between each two adjacent filter strand segments on the conveying means. As a non-limiting example, the positioning device may be a gapping wheel 148. The plurality of filter strand segments passing through the gapping wheel 48 are shifted axially and away from each other, such that any two adjacent filter strand segments are separated by a gap of a pre-determined length. It is appreciable that that positioning device 145 may be configured in other suitable configurations, for example, comprising a stop and release mechanism to release each of the plurality of filter strand segments to the conveyor device at pre-determined time-intervals.

In various embodiments, the apparatus 100 may comprise a wrapping unit 137 located downstream of the first forming guide 116 and upstream of the forming element 125.

In some embodiments whereby the apparatus 100 does not comprise a frontend cutting unit 139, or whereby the frontend cutting unit 139 of the apparatus 100 is not activated to cut the strand of filter material 20, the wrapping unit 137 may be configured to provide a wrapping material circumscribing or encasing the strand of filter material 20. The strand of filter material 20 with the wrapping material is subsequently fed into the downstream filter element 125, and is compressed into a continuous filter body in a desired shape and/or dimension. During the filter forming stage, an overwrap is simultaneously formed on surface of the continuous filter body 27. The wrapped continuous filter body may then be cut into a plurality of wrapped filter elements 10 of a pre-determined length at the backend cutting unit 132.

In some embodiments whereby the apparatus 100 comprises a frontend cutting unit 139 in operation to produce the plurality of filter strand segments, the wrapping unit is set

to provide an wrapping material circumscribing or encasing the plurality of filter strand segments, and move the plurality of filter strand segments 25 circumscribed by the wrapping material to the downstream filter forming element 125.

A non-limiting example of the wrapping unit is shown in Figure 3. In operation, the wrapping unit 137 receives the wrapping material from a wrapping material source 150. The wrapping material source 150 may be an external module to the apparatus 100, or may be integrated with the filter forming module 102 of the apparatus 100. The wrapping material may be a paper, plastic or fabric material, or any other suitable material which is substantially flexible. The wrapping material may be aligned substantially along the strand of filter material 20 or along the pathway of the plurality of filter strand segments, and may be wrapped around the same. In other words, the strand of filter material 20 or the filter strand segments 25 are at least partially enclosed or encased by the wrapping material. At this stage, the wrapping material may not be in contact with the strand of filter material or the filter strand segments 25.

The strand of filter material 20 or the plurality of filter strand segments encased by the wrapping material may continue downstream past an infeed forming area 169 at an inlet side of the forming element 125. At the infeed forming area 169, the filter material 20 and the wrapping material 50 are further converged into a relatively smaller diameter and a relatively more compact form. For example, another cone-shaped member similar to the first forming guide 116 may be used to converge and guide the filter material 20 and the wrapping material 50 to move further downstream towards the forming element 125.

In some embodiments, prior to entering into the filter element 125, a sealing device 172 may be used to secure edges of the wrapping material, for example, using an adhesive bonding method. After passing through the forming element 125, the filter material 20 and the wrapping material 50 is formed into a filter body in a desired shape and/or dimension, and an overwrap is integrally formed on the surface of the filter body. The filter body covered by the overwrap is also referred to as a wrapped filter body 36.

In some embodiments wherein the strand of filter material 20 is not cut into segments at any upstream processes, the wrapped filter body 36 may be a continuous filter body 27 with an overwrap.

Alternatively, in other embodiments where the filter material strand has been cut into the plurality of filter strand segments by the frontend cutting unit 139, the resultant filter body exiting the forming element 125 may correspondingly comprise a plurality of filter body segments 33 spaced apart by a pre-determined distance. Each of the plurality of filter body segments 33 is covered by the overwrap. At the same time, the plurality of filter body segments are connected by the wrapping material, and a plurality of hollow portions 37 are formed therebetween. The hollow portions 37 formed by the wrapping material are akin to air pockets due to the absence of filter materials therein, as shown in Figure 3 and Figure 7. The filter body having a plurality of filter body segments 33 and a plurality of hollow portions 37 is also referred to as a segmented filter body 39.

In various embodiments, the backend cutting unit 132 is operable to cut the segmented filter body 39 at pre-determined locations to form a plurality of filter elements 10 of a desired length.

In various embodiments, the filter forming module 104 of the apparatus 100 may further comprise a second forming guide 177, which is configured to receive a secondary filter material 54, and the filter material 20 from the first forming guide 116. A non-limiting example of the secondary filter material 54 may be a fibrous tow material from a tow bale 180, as shown in Figure 3. It is appreciable that the filter material be in the form of a continuous filter material strand or a segmented filter material strand, depending on whether the filter material 20 has been cut or segmented by the frontend cutting unit 139.

In operation, the filter material 20 (as a primary filter material) is first converged at the first forming guide 116 and then further along the process the secondary filter material 54 is introduced at the second forming guide 177 as an outer layer surrounding the strand of primary filter material 20. The primary filter material 20 and the secondary

filter material are both received at the second forming guide 177, and are gathered and/or combined together to continue downstream past the forming element 125 for shaping into the filter body.

In various embodiments, the filter forming module 104 further comprises a steam chamber 188 wherein the secondary filter material 54 is treated with a chemical solution before entering the forming element 125. The chemical solution is also referred to as a hardening solution. The treated secondary filter material may form a hardened outer layer or a shell around the primary filter material 20, which provides for better structural integrity for the resultant filter body. It is appreciable that suitable chemical solutions may be selected based on the composition of the secondary filter material. For example, a 10-35% Triacetin solution may be used for treating and hardening a secondary filter material comprising cellulose acetate tow fibers. It is further appreciable that the chemical solution may be directed to or applied onto the secondary filter material 54 using any suitable devices including, but not limited to, a sprayer, a syringe dispenser, a brush or a wide bar applicator.

In various embodiments, the steam chamber 188 may be positioned adjacent the second forming guide 177, as illustrated in Figures 4, 5 and 6. The steam chamber may contain at least a portion of the filter material 20 coming from and converged by the upstream first forming guide 116, and at least a portion of the secondary filter material 54.

In various embodiments, the steam chamber 188 may further comprise a sprayer 190 configured to introducing a mist of the chemical solution in the steam chamber, and a steam generator (not shown) for providing a desired humidity inside the steam chamber 188. The sprayer 190 may be adapted such that the chemical mist is directed to the infeed forming area 169 near the second forming guide 177, where the primary filter material 20 and the secondary filter material 54 are gathered and combined together. The humidity inside the steam chamber 188 provides the benefits of improving the chemical reaction between the secondary filter material 54 and the chemical solution. It is appreciable that other environmental parameters, such as a temperature in the steam

chamber 188, may also be controlled to provide a desired condition for improving or for facilitating the chemical reaction inside the steam chamber 188.

As illustrated in Figure 4 and Figure 7, the resultant filter body exited from the forming element 125 has a hybrid and integral structure, which comprising an inner core of the primary filter material 20 with a net structure, and an outer layer of the secondary filter material 54. It is appreciable that the apparatus 100 may be modified further for producing a multi-layer structure from various other filter materials.

In some embodiments wherein the strand of filter material 20 is not cut into segments at the upstream processes, the hybrid filter body produced from the forming element 125 may be a continuous hybrid filter body 61. The continuous hybrid filter body 61 has a relatively uniform structure, whereby the primary filter material 20 at the core and the secondary filter material 54 at the outer layer are co-extending without any gaps formed in between.

In some embodiments whereby the strand of filter material 20 has been cut into the plurality of filter strand segments by the front-end cutting unit 139, the resultant hybrid filter body produced from the forming element would correspondingly comprise alternating segments of a layered filter body segment and a hollow filter body segment. The hybrid filter body having alternating filter segments with different structures is also referred to as a segmented hybrid filter body 68, as shown in Figure 4. The alternating segments may each have a pre-determined length. The length of the hollow filter body segment may correspond substantially with the space or gap between the filter strand segments introduced by the positioning device 148 at the upstream processes.

In various embodiments, the backend cutting unit 132 may be configured to cut the hybrid filter body at pre-determined locations. For the segmented hybrid filter body 68, two different filter types including a hollow filter and a layered filter may be produced therefrom, when the backend cutting unit 132 is set to cut at the joining portions of the alternating segments. Alternatively, a multi-segment filter element may be formed

which may comprise at least one layered filter segment and at least one hollow filter segment.

The filter element 10 form with the apparatus 100 and using the above-described processes may be or may comprise a net structure with randomized and interconnected internal channels, which may form a plurality of aerosol paths. The randomized and interconnected internal channels of the filter element provides for an enhanced particle retention and filtration effect on the tobacco-flavoured smoke or aerosol. As the smoke or aerosol stream is drawn through the filter element 10, particulate elements in the aerosol which may give rise to undesirable taste can be filtered or blocked by the randomized internal channels therein. At the same time, water vapour molecules with a relatively smaller molecule size are allowed to pass through the filter element 10. This is different from the conventional cigarette filters, for example acetate tow filters, where the particulate elements in the aerosol can pass through relatively unhindered. Although the filter element 10 may be arranged to block or filter particulate elements, the net structure of the filter element 10 does not filter vapor associated with or containing the tobacco flavour. The filter element 10 therefore provides the additional benefits of reducing the amount of particulate elements in the tobacco smoke or aerosol without affecting the tobacco taste of the smoke or aerosol. In this manner, the level of harmful substances in the aerosol can be effectively controlled and the tobacco-flavoured aerosol delivered to the user for consumption is improved.

Further, the filter element 10 with the net structure provides a better aerosol delivery, in particular with a relatively lower pressure drop across the tobacco product 100. While aerosol is directed to flow through the filter element 10, the filter element 10 with the randomly disposed internal channels also helps redirect or distribute heat from the aerosol across the filter element 10. A tobacco product, when incorporated with or used with the filter element 10, may provide for a desirable mouthfeel and improved user experience.

In some embodiments, the apparatus 100 may comprise an inner channel formation module 197 operatively connected to the filter forming module 104. The inner channel

formation module 197 may be placed at an inlet side of the filter forming module 104, as shown in Figure 5. The inner channel formation module 197 may be a separate module placed outside the filter forming module 104, or may be integrated with the filter forming module 104.

The inner channel formation module 197 is configured to receive the filter material 20, and to form a filter body with an internal profile. As shown in Figures 5 and 7, the filter body with an internal profile may comprise one or more air channels 73 extending along the longitudinal axis of the filter body. The filter body with such an internal profile may also be referred to as a channelled filter body 72. When incorporated into the tobacco product, the inner air channels 73 allow the aerosol to flow through the filter element 10 at a desired rate as the user draws on a mouth end of the tobacco product. It is appreciable that the air channels 73 may be in various shapes and dimensions, corresponding to the internal profile of the channelled filter body 72. Figure 7 illustrates two non-limiting examples of the channelled filter body 72, wherein it is shown that the cross-section of the longitudinally extending air channels 16 in different channelled filter bodies 72 may be in a circular shape, a near semi-circular shape, a triangular shape, and/or a rectangular shape.

In accordance with another embodiment of the disclosure and with reference to Figure 6, the apparatus 100 may comprise an inner filter component supply module 220 for containing a plurality of pre-formed inner filter components 75 and supplying the plurality of pre-formed inner filter components 75 to the filter forming module 104. operatively connected to the filter forming module 104. The inner filter component supply module 220 may be placed at an inlet side of the filter forming module 104, as shown in Figure 6. The inner filter component supply module 220 may be a separate module placed outside the filter forming module 104, or may be integrated with the filter forming module 104.

As a non-limiting example, the inner filter component supply module 220 may comprise one or more trays 223 containing the plurality of pre-formed inner filter components, and one or conveyor devices 224 for transferring the pre-formed inner

filter components to the filter forming module 104. The conveyor devices 224 may be configured to deliver the different inner filter components to the downstream filter forming module 104 at controlled timings so as to introduce a gap of a pre-determined length between adjacent inner filter components 75. In the resultant filter element 10, the pre-formed inner filter components 75 constitute an inner part of the filter element 10, which may be located substantially at the centre of the filter element 10, as shown in Figure 6 and 7.

It is appreciable that the per-formed inner filter component 75 may be formed from any suitable filter materials using any suitable forming process. For example, the pre-formed inner filter components 75 may be pre-cut wrapped rods containing natural and/or synthetic filler materials, pre-cut wrapped rods containing or loaded with a carbon material, or filter rods with or without an internal profile formed using a plastic extrusion process.

In some embodiments, a secondary filter material 180', for example a fibrous tow material, may be introduced as an outer layer surrounding the plurality of pre-formed filter body segments. The process of forming the outer layer of the secondary filter material 180' is the same as described above, which may comprise the use of a mist of a chemical solution 190' for forming a hardened layer of the secondary filter material 180' on the surface of the pre-formed inner filter components 75, and the use of a steam generator 188' to provide a desired humidity for facilitating the formation of the outer layer of the secondary filter material 180', as illustrated in Figure 6. The pre-formed filter body segments surrounded by the secondary filter material 180'is then fed into the first forming guide 116 of the filter forming module 104. It is appreciable that one or more additional layers of the secondary filter material may be introduced along the process of forming the filter element 10.

In various embodiments, it is appreciable that different parts of the apparatus 100 can be integrally formed with other parts of the apparatus 100, or can be otherwise connected thereto using any suitable joining techniques. Some parts may be mounted onto the apparatus 10 using brackets, nuts and screws, clamps, and other suitable

attaching means. Some parts may also be movably and adjustably mounted onto the apparatus 10 relative to other parts of the apparatus 10.

The above is description of an apparatus for forming a filter element and method of using the same. It will be apparent that various other modifications and adaptations of the disclosure will be apparent to the person skilled in the art after reading the foregoing disclosure without departing from the spirit and scope of the disclosure. It is intended that all such modifications and adaptations come within the scope of the appended claims.

Further, it is to be appreciated that features from various embodiment(s), may be combined to form one or more additional embodiments.

Reference

10	filter element
20	filter material/primary filter material
22	net material
24	filler material
27	continuous filter body
33	filter body segment
36	wrapped filter body
37	hollow portion
39	segmented filter body
50	wrapping material
54	secondary filter material
61	continuous hybrid filter body
68	segmented hybrid filter body
72	channelled filter body
73	air channel
75	pre-formed inner filter component
100	apparatus
102	filter material supply module
104	filter forming module
107	unwinder
109	material bobbin
109a	stock bobbin
111	outlet side of the filter material supply module
113	inlet side of the filter forming module
114	outlet side of the filter forming module
116	first forming guide
116a	first opening
116b	second opening
120	heating unit

125	forming element
132	backend cutting unit
137	wrapping unit
139	frontend cutting unit
145	conveyor device
148	positioning device
150	wrapping material source
169	infeed forming area
172	sealing device
177	second forming guide
180	tow bale
188	steam chamber
190	sprayer
197	inner channel formation module
200	pre-formed filter body supply module
223	tray
224	conveyor device

CLAIMS

1. An apparatus for producing a filter element having a filter forming module, comprising: -

- a first forming guide configured to receive a primary filter material;
- a forming element positioned downstream of the first forming guide unit, and configured to compress the primary filter material to form a filter body of a pre-determined shape and/or a pre-determined dimension; and
- a heating unit placed along a pathway of the primary filter material and at an inlet side of the filter forming module, wherein the heating unit is configured to switch between two or more operational modes based on a property of the primary filter material.

2. The apparatus according to claim 1, wherein the two or more operational modes of the heating unit comprise: at least one heating mode whereby the heating unit is operable to heat the primary filter material at a pre-determined heating temperature or a pre-determined heating profile according to a property of the primary filter material, and a non-heating mode whereby the heating unit is powered off.

3. The apparatus according to claim 2, wherein the pre-determined heating temperature used for the at least one heating mode is a glass transition temperature of the primary filter material.

4. The apparatus according to any one of the preceding claims, further comprising:

- a frontend cutting unit arranged at downstream of the first forming guide unit, the frontend cutting unit operable to cut the primary filter material exiting from the first forming guide unit into a plurality of filter strand segments, each segment having a pre-determined length.

5. The apparatus according to claim 4, further comprising a conveyor device and a positioning device, wherein the conveyor device is configured to move the plurality of filter strand segments to the forming unit, and the positioning device is configured to

separate two adjacent filter strand segments by a gap of a pre-determined length along a pathway of the plurality of filter strand segments.

6. The apparatus according to any one of the preceding claims, further comprising:

- a wrapping unit configured to provide a wrapping material around at least a portion of the primary filter material exiting from the first forming guide unit, and direct the primary filter material and the wrapping material to the filter element.

7. The apparatus according to claim 6, wherein the wrapping unit comprises:

- a wrapping material source arranged to provide the wrapping material to an infeed forming area at an inlet side of the forming unit; and
- a sealing device arranged to secure edges of the wrapping material around the primary filter material, such that an overwrap is formed circumscribing the surface of the filter body.

8. The apparatus according to any one of the preceding claims, further comprising:-

- a backend cutting unit arranged at an outlet side of the filter forming module, and configured to cut the filter body into a pre-determined length and/or at pre-determined locations.

9. The apparatus according to any one of the preceding claims, wherein the filter forming module comprises a second forming guide positioned downstream of the first forming guide and at an inlet side of the first forming element, wherein the second forming guide unit is configured to receive and gather a secondary filter material and the primary filter material from the first forming guide unit.

10. The apparatus according to claim 9, further comprising a steam chamber positioned adjacent the second forming guide unit for containing at least a portion of the secondary filter material and at least a portion of the primary filter material, wherein

- a steam generator is arranged to provide a desired humidity inside the steam chamber, and

- a sprayer is configured to direct a mist of a chemical solution for forming a hardened layer of the second filter material on the surface of the primary filter material.

11. The apparatus according to claim 9 or 10, wherein the secondary filter material comprises a fibrous tow material.

12. The apparatus according to any one of the preceding claims, wherein the primary filter material is formed from at least one of a net material, a filler material, and a combination of a net material and a filler material.

13. The apparatus according claim 12, wherein the net material comprises a plastic netting formed using an extrusion process, or an open-mesh fabric material formed using a weaving, knitting, and/or braiding process.

14. The apparatus according to any one of claims 1 to 13, wherein the primary filter material comprises a natural material obtained from one or more of the following plant parts: - leaf, bark, trunk, fruit, seed, stem, flower, pollen, branch, root, sap, pulp, resin bagasse, calyx of the respective flora.

15. The apparatus according to any one of the preceding claims, wherein the filter forming module is connected to a filter material supply module, the filter material supply module comprises:

- at least one material bobbin loaded with the primary filter material; and
- an unwinder operable to unwind and transfer the primary filter material from the material bobbin towards the filter forming module at a pre-determined speed.

16. The apparatus according to claim 15, wherein the filter material supply module further comprises at least one stock bobbin configured to supply the primary filter material to at least one of the following: the at least one material bobbin, the filter forming module.

17. The apparatus according to any one of the preceding claims, wherein the filter forming module is connected to an inner channel formation module, the inner channel formation module is configured to receive the filter material and to form a filter body with an internal profile.

18. The apparatus according to any one of the preceding claims, wherein the filter forming module is connected to an inner filter component supply module, the inner filter component supply module is configured to contain one or more pre-formed inner filter components and to supply the one or more pre-formed inner filter components to the filter forming module at a pre-determined speed.

19. The apparatus according to claim 18, wherein the inner filter component supply module is further configured to separate each two adjacent pre-formed inner filter components by a gap of a pre-determined length.

20. A method of forming a filter element, comprising the steps of:

- receiving a primary filter material at an inlet side of a filter forming module;
- passing the primary filter material through a heating unit, whereby the heating unit is configured to switch between two or more operational modes based on a property of the primary filter material; and
- compressing the primary filter material to form a filter body of a pre-determined shape and/or a pre-determined dimension.

21. The method according to claim 20, wherein the two or more operational modes of the heating unit comprise at least one heating mode whereby the heating unit is operable to heat the primary filter material at a pre-determined heating temperature or a pre-determined heating profile according to a property of the primary filter material, and a non-heating mode whereby the heating unit is powered off.

22. The method according to any one of claims 20 or 21, further comprising the steps of

- cutting the primary filter material into a plurality of filter strand segments of a pre-determined length; and
- separating each two adjacent filter strand segments by a gap of a pre-determined length.

23. The method according to any one of claims 20 to 22, further comprising the steps of

- providing a wrapping material before the step of compressing the primary filter material into the filter body; and
- sealing edges of the wrapping material such that the wrapping material circumscribes at least a portion of the primary filter material.

24. The method according to any one of claims 20 to 23, comprising the steps of

- providing a secondary filter material before the step of compressing the primary filter material into a filter body; and
- forming a layer of the second filter material around the primary filter material.

25. The method according to claim 24, further comprising a step of treating the secondary filter material with a hardening solution.

26. The method according to any one of claims 20 to 25, further comprising a step of cutting the filter body into a plurality of portions.

27. The method according to any one of claims 21 to 26, comprising a step of heating the primary filter material at a glass transition temperature of the primary filter material, according to the at least one heating mode.

28. The method according to any one of claims 20 to 27, further comprising a step of transferring a continuous strand of a net filter material from a material supply module to the inlet side of the filter forming module.

29. The method according to any one of claims 20 to 28, further comprising the steps of:

- forming a filter body with an internal profile; and
- transferring the filter body with the internal profile to the inlet side of the filter forming module.

30. The method according to any one of claims 20 to 29, further comprising a step of transferring one or more pre-formed inner filter components to the inlet side of the filter forming module.