

Tubular connecting member for a membrane filtration system

The present invention relates to a tubular connecting member arranged for interconnecting a plurality of tubular members in a fluid flow system and a fluid flow system, such as a membrane
5 filtration system, comprising such a tubular connecting member.

Membrane filtration systems typically comprise a plurality of parallel arranged tubular filtering units, wherein a membrane filter is arranged to filter liquid flowing through said filtering units. These filtering units are typically connected to a feed and/or discharge line using a T-shaped
10 tubular connecting piece (i.e., junction) made from a plastic material. However, due to the elevated pressures in the range of 3 - 10 bars, the T-shaped tubular connecting pieces need to have relatively thick outer walls in order to keep the material stresses, especially at the critical locations in the axil of the T-shape, below a certain material dependent stress-threshold, often below the fatigue stress limits, in order to ensure a sufficient lifetime of the T-shaped connecting piece. The relatively thick
15 walls lead to a relatively expensive manufacturing process for these connecting pieces.

Additionally, due to the flow characteristics of such a membrane filtration system, the flow of liquid is not distributed evenly over the different membrane filtering units, leading to a decrease in the overall performance of the system.

20 The current invention seeks to provide for a tubular connecting member arranged for interconnecting a plurality of tubular members in a fluid flow system, for instance in a membrane filtration system, that improves the flow characteristics of such a system and is easier and cheaper to manufacture.

25 In a first aspect, the invention relates to a tubular connecting member arranged for interconnecting a plurality of tubular members in a fluid flow system, the tubular connecting member comprising:
- at least one primary outlet having a primary in-/outflow direction, wherein the primary outlet is arranged for connecting, in particular to an outer end thereof, a primary tubular element having, at
30 least at its outer end, a cylindrical cross-section;
- at least one secondary outlet having a secondary in-/outflow direction, wherein the secondary outlet is arranged for connecting, in particular to an outer end thereof, a secondary tubular element having, at least at its outer end, a cylindrical cross-section;

wherein the secondary in-/outflow direction is arranged at a non-zero angle with respect to
35 the primary in-/outflow direction; and

wherein the secondary outlet further comprises an inner section having, as seen in a plane that is substantially perpendicular to the secondary in-/outflow direction, a non-round, in particular oval-shaped, cross-section.

- 5 Such a tubular connecting member enables, due to the non-round cross-section of the inner section, to reduce the stress concentration factor, and thereby the critical stresses, in the axil of the tubular connecting member where the primary and secondary outlet are joined. This allows to reduce the overall wall thickness of the tubular connecting member, allowing it to be made efficiently, and at a lower cost, using molding processes, such as injection molding or additive manufacturing
- 10 processes. The non-round cross-section further allows to thereby adjust the flow characteristics of the tubular connecting member, and thereby of a membrane filtration system, enabling a more uniform flow out of the secondary outlet of the tubular connecting member. Thereby, when the respective secondary outlets of such tubular connecting members are respectively connected to a plurality of parallel filtering units, the non-round cross-sections enable a more uniform flow
- 15 through the different filtering units. As the flow of liquid is distributed more evenly over the different filtering units, the overall performance of the system is improved.

- Said inner section extends, with respect to the outer end of the secondary outlet, inwardly. That is, the inner section is located, as seen along a flow path from the primary to the secondary outlet
- 20 through the tubular connecting member, between the primary outlet and the outer end of the secondary outlet. More specifically, in the case of, e.g., a T-shaped connecting piece, the inner section may be located in the axil of the T-shape.

- The tubular connecting member, in particular the primary part, may have a round cross-section,
- 25 such as circular, or a polygonal cross-section such as square or triangular. For instance, as seen in cross-section, the circumference of the connecting member may be shaped as a square, a truncated circle, a rounded square, a squircle or similar shape. As such, the term "tubular" does not limit the shape to a circular cylinder. Preferably, the flow channel through the tubular connecting member is, apart from the non-round inner section of the secondary outlet, substantially circular in cross-
- 30 section.

- Preferably, the non-round cross-section of the inner section has a major axis and a minor axis, wherein a width of the non-round cross-section is larger, in particular largest, along the major axis, than along the minor axis and wherein the major axis of the non-round cross-section is arranged at
- 35 a non-zero angle with respect to the primary in-/outflow direction. Such a configuration leads to reducing swirl disturbances in the secondary outlet, that negatively affect the throughflow of said

outlet. Thereby, a more uniform flow through the different filtering units of a membrane filtering unit is obtained.

To optimize this effect, the non-round cross-section of the inner section is, more preferably, a substantially oval-shaped cross-section having, preferably, a major axis that is substantially perpendicular to the primary in-/outflow direction and a minor axis that is substantially parallel to the primary in-/outflow direction.

The primary outlet may be coupled to the tubular elements by means of an annular clamp mounted around the respective outer ends. As the width of said inner section of the secondary outlet is smaller along the axis parallel to the primary in-/outflow direction, the length of the primary outlet can be reduced such that a more compact connecting piece is obtained while sufficient space remains for mounting the clamp. This way, a fluid flow system that is more compact overall can be obtained.

In a preferred embodiment, a diameter of the circular cross-section of the outer section of the primary outlet is smaller than a diameter of the circular cross-section of the outer section of the secondary outlet. This allows to directly connect a membrane filtrating unit, which comprises a tubular housing having a diameter of generally no more than 12" or 10", usually approximately 8" (ca. 20 cm), to the secondary outlet, while a feedpipe having a smaller diameter of generally at least 4", usually approximately 6" (ca. 15cm), can be directly connected to the primary outlet. This reduces the need for further separate adapters in such a membrane filtering system. More in general, it is thus preferred that the outer outlet diameters of the connecting member correspond to the outer end diameters of the tubular elements to be connected to the connecting member such that the connecting member can be directly connected to the respective outer ends of the tubular elements. For instance, a connecting member with two or three equal outer outlet diameters can thus also be envisaged.

Herein, for instance "outer end" and "outer section" may be used interchangeably and generally relate or refer to a free end of the respective outlet, which free end extends outwardly, in particular for connecting to a tubular element.

The primary outlet preferably comprises an inner section that extends, with respect to the outer section, inwardly, wherein said inner section comprises a circumferential wall and wherein the inner section of the secondary outlet is formed as a through hole through the circumferential wall of the inner section of the primary outlet. By selecting the shape of said through hole, the non-round cross-section of the inner section can be formed.

It is further preferred that a width of the major axis of said non-round cross-section of the inner section of the secondary outlet is no larger than a maximum width of the inner section of the primary outlet through which the inner section of the secondary outlet extends, preferably wherein,
5 as seen in a plane perpendicular to the primary in-/outflow direction, the inner section of the primary outlet has a substantially circular cross-section. It is then further preferred that the major axis of the non-round cross-section of the inner section of the secondary outlet is no larger than a diameter of said circular cross-section of the inner section of said primary outlet. By forming said non-round cross-section in such a manner, the above noted swirl disturbances can be effectively
10 reduced.

In preferred embodiment, the tubular connecting element further comprises a tertiary outlet for connecting a tertiary tubular element to an outer section thereof. This allows to connect a further tubular element to the tubular connecting piece, enabling, for instance, to apply multiple, parallel
15 arranged, membrane filtration units. It is then further preferred that the tertiary outlet is a second primary outlet having a second primary in-/outflow direction, wherein the second primary outlet is arranged for connecting to a primary tubular element having, at least at its outer end, a cylindrical cross-section,

wherein said second primary in-/outflow direction is substantially parallel, or equal, to said
20 primary in-/outflow direction and/or wherein a central axis of the outer section of said primary outlet is substantially parallel to, in particular coaxial with, a central axis of the outer section of the second primary outlet.

This further allows to form a feed- or discharge pipe by coupling adjacent primary outlets of adjacent tubular connecting elements, whereby the overall flow characteristics of a system can be
25 further improved. Preferably, said tubular connection element is therefore formed to comprise an at least T-shaped junction.

Said tubular connecting element may have a plurality of secondary outlets, wherein each secondary outlet having a respective secondary in-/outflow direction, wherein each secondary outlet is
30 arranged for connecting to a respective secondary tubular element having, at least at its outer end, a cylindrical cross-section;

wherein each respective secondary in-/outflow direction is arranged at a non-zero angle with respect to the primary in-/outflow direction; and

wherein each secondary outlet further comprises a respective inner section having, as seen
35 in a plane that is substantially perpendicular to the secondary in-/outflow direction, a non-round, in particular oval-shaped, cross-section.

This enables connecting multiple membrane filtration units to a single tubular connection element, while benefitting from the improved flow characteristics, as described above.

- Preferably, said primary outlet(s) are formed from a substantially cylindrical tubular element, wherein said outer section(s) is/are arranged at the respective end(s) of said substantially cylindrical tubular element, such that the primary in/outflow direction is substantially parallel to a central axis of said cylindrical tubular element. A substantially straight and unobstructed primary flow path can be obtained, such that the overall flow characteristics are further improved.
- 10 In a preferred embodiment, the respective outlets comprise fixation means for fixedly connecting a respective cylindrical tubular element thereto, wherein said fixation means preferably comprise engaging means, such as a circumferential protrusion, or recession, arranged on, or in, the outer circumferential surface of the respective outlet, wherein said fixation means preferably comprise a connecting bracket that is arranged to be
- 15 mounted on the outer circumferential surface of the respective outlet, and wherein said engaging means are, preferably, arranged for receiving the connecting bracket thereon for interconnecting said outlet to a respective primary or secondary tubular element that is arranged with similar, cooperating, engaging means. By arranging the fixation means on the external surfaces of the tubular coupling element, the substantially straight and unobstructed primary flow
- 20 path can be obtained through a series of coupled tubular elements and/or tubular connecting elements, such that the overall flow characteristics of the membrane filtration unit are further improved.

- Preferably, said tubular connecting member is monolithic. To economically obtain the monolithically shaped tubular connecting element having the preferred characteristics, it is, preferably made, in particular by a casting process, from a plastic material, in particular a reinforced plastic material, or from metal such as steel. For example, the connecting member may be made by an overmolding technique. Alternatively, the monolithic tubular connecting member may be made by welding. For instance, the secondary outlet may be connected to the primary
- 25 outlet by welding.
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- The tubular connection member is, preferably, an elbow shaped connecting member having only one primary outlet and only one secondary outlet, wherein, preferably, said primary and secondary in/outflow directions are arranged at an angle of 45° or 90° with respect to each other.
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Alternatively, the tubular connection member is, preferably, a T-shaped connecting member having only two primary outlets and only one secondary outlet, wherein, preferably, said primary and secondary in/outflow directions are arranged at an angle of 45° or 90° with respect to each other. Such a tubular connecting member allows to enable overall improved flow characteristics of the membrane filtration system.

The fluid flow system can be any system in which fluid can flow. The term “fluid” is not limited to liquid such as water but may also refer to gas. The fluid flow system may thus be any system in which a fluid pressure drop can occur, such as a membrane filtration system or a carbon capture system. As such, a fluid flow system is provided which comprises a plurality of tubular elements for a fluid to flow therethrough, wherein the system further comprises at least one tubular connecting member according to any of the above embodiments, wherein said tubular connecting member interconnects tubular elements of the plurality of tubular elements, wherein the primary outlet of the tubular connecting member connects, to its outer end, a primary tubular element of the plurality of tubular elements, the primary tubular element having, at least at its outer end, a cylindrical cross-section, wherein the secondary outlet of the tubular connecting member connects, to its outer end, a secondary tubular element of the plurality of tubular elements, the secondary tubular element having, at least at its outer end, a cylindrical cross-section.

In a second aspect, the invention relates to a method of manufacturing a tubular connecting member according to any of the preceding embodiments in a single piece by a casting process.

In a third aspect, the invention relates to a fluid flow system comprising a supply line for supplying a fluid to be processed and a discharge line for discharging the fluid after it is processed, further comprising at least one fluid processing unit that is arranged in between the supply line and the discharge line and that comprises an inlet and an outlet, wherein the fluid processing unit is arranged such that, when in use, fluid flows from said supply line to said discharge line, thereby passing through the fluid processing unit, and wherein at least one of the inlet and the outlet has a cylindrical cross-section;

the system further comprising at least one tubular connecting member according to any of the preceding embodiments, wherein said tubular connecting member interconnects the at least one of the inlet and outlet to, respectively, the supply line or the discharge line.

This allows to obtain a fluid flow system having an improved flow characteristic, having the improved connecting member, as was described above, therein.

Preferably, the secondary outlet of the tubular connecting member is connected to the at least one of the inlet and outlet of the fluid processing unit and said primary outlet of the tubular connecting member is connected to, respectively, the supply or discharge line. In a preferred embodiment, the housing of the fluid processing unit is substantially tubular having a cylindrical cross-section,
5 wherein the inlet and outlet are arranged at opposite ends of the respective tubular shaped housing, wherein a first tubular connection member interconnects the inlet to the supply line and a second tubular connection member interconnects the outlet to the discharge line. An improved system with the above-described advantages is hereby obtained.

10 It is preferred that the fluid flow system comprises a plurality of fluid processing units that are arranged substantially parallel with respect to each other and a plurality of tubular connection members for interconnecting the plurality of fluid processing units to the supply line and discharge line. It is then further preferable that each inlet of each fluid processing unit is connected to a secondary outlet of a respective first tubular connection member and wherein each outlet of each
15 fluid processing unit is connected to a secondary outlet of a respective first tubular connection member and wherein adjacent first tubular connection members are coupled through the primary outlets for forming the supply line and wherein adjacent second tubular connection members are coupled through the primary outlets for forming the discharge line.

Hereby, a more uniform flow distribution over the fluid processing units is obtained, as was
20 described above.

The fluid flow system may be a membrane filtration system, wherein the supply line is for supplying a liquid to be filtered, wherein each fluid processing unit is a membrane filtration unit that comprises a housing having the inlet, the outlet and a filtration membrane therebetween,
25 wherein the membrane filtration unit is arranged such that, when in use, liquid flows from said inlet to said outlet, thereby passing through the filtration membrane.

Alternatively, the fluid flow system may be a carbon capture system for capturing carbon dioxide from a gas mixture from a source, such as an industrial source, wherein the supply line is for
30 supplying the gas mixture from which the carbon dioxide is to be captured, wherein each fluid processing unit is a carbon capture unit for removing carbon dioxide from the mixture. The carbon capture unit is, e.g., a sorption unit or a membrane gas separation unit that comprises a housing having the inlet, the outlet and a gas separation membrane therebetween. The discharge line is then for discharging the captured carbon dioxide or for discharging the gas mixture after the carbon
35 dioxide is captured therefrom. As the flow of liquid is distributed more evenly over the different

sorption or membrane gas separation units due to the non-round cross-section of the tubular connecting members, the overall performance of the carbon capture system is improved.

The present invention is further illustrated by the following figures, which show preferred
5 embodiments of the invention and are not intended to limit the scope of the invention in any way, wherein:

- Figure 1 shows a schematic representation of a membrane filtration system, where the feed solution can be pumped through eight parallel connected membrane filtrating units and the flow and pressure can be adjusted by a valve.

10 - Figure 2 schematically shows a three-dimensional perspective view of a T-shaped tubular connecting element according to an embodiment of the invention.

- Figure 3 schematically shows a top view of the T-shaped tubular connecting element

- Figure 4 schematically shows a three-dimensional cross-sectional view of a T-shaped tubular connecting element taken along the longitudinal axis.

15 - Figure 5 schematically shows, in a frontal view along the longitudinal axis, a cross-sectional view of a T-shaped tubular connecting element taken perpendicular to the longitudinal axis.

- Figures 6A-B schematically show a comparison of results from a computational fluid dynamics (CFD) simulation of the flow in a membrane filtration system employing respectively a T-shaped connecting element according to the state of art and, similar to the one shown in figure 1, a T-

20 shaped connecting element according to the invention.

- Figure 7 shows, in a bar graph, a comparison between the flow in a membrane filtration system employing respectively a T-shaped connecting element according to the state of art and a T-shaped connecting element according to the invention.

25 Figure 1 shows a membrane filtration system 1000, where the feed solution can be pumped through eight parallel connected membrane filtrating units 1001 – 1008 by pump 1009 and the flow and pressure can be adjusted by a valve 1010. Pressures and temperatures can be measured by pressure sensors 1011, 1012 and temperature sensor 1013. The system is seen to comprise a feed line 1100 for feeding the feed solution (i.e. liquid to be filtered) to the membrane filtrating units 1001 – 1008,
30 a filtered liquid discharge line 1200 for collecting the liquid that is filtered by the membrane filtrating units 1001 – 1008, and a reject line 1300 for discharging the waste mixture filtered out from the feed solution, also referred to as the “reject” or “concentrate”. In the current system 1000, the membrane filtrating units 1001 – 1007 are connected to the feed line by means of a T-shaped tubular connecting element 1, as shown in detail in figures 2 – 5, whereas the final membrane
35 filtrating unit 1008 is connected by means of an elbow-shaped tubular connecting element according to the invention (not shown in detail).

Figures 2 - 5 shows the T-shaped tubular connecting element 1 in more details, wherein the T-shaped tubular connecting element 1 is seen to comprise two primary outlets 10 that can be coupled to the feed- or discharge line and a single secondary outlet 20 that can be coupled to the cylindrically shaped housing of the membrane filtration units 1001 – 1008 shown in Figure 1. The T-shaped tubular connecting element 1 is further provided with a bracket 50 for connecting the T-shaped tubular connecting element 1 to a frame and/or similar supporting member. T-shaped tubular connecting element 1 is formed monolithically by injection molding preferably metal or plastic, such as polybutylene terephthalate (PBT), polyamide (PA), polyethylene (PE), polypropylene (PP), polyethersulfone (PES), polysulfone (PSU), polyvinyl chloride (PVC) or polylactic acid (PLA), in particular high-performance plastics such as styrenic resins (e.g., acrylonitrile butadiene styrene (ABS)) or amorphous blends of polyphenylene ether and polystyrene (PPE/PS) or polyamide (PPE/PA). The tubular connecting element 1 may be made from a fiber-reinforced composition such as fiberglass, preferably including at least one of the aforementioned materials.

The T-shaped tubular connecting element 1 comprises two primary outlets 10 having a primary in-/outflow direction I, wherein the primary outlet 10 is arranged for connecting to a primary tubular element having, at least at its outer end, a cylindrical cross-section. The outer section 13 is hereto arranged with a circular cross-section. In between the respective (tubular shaped) outer sections 13 of the two primary outlets 10, a (tubular shaped) inner section 14 is comprised that interconnects the respective outer sections 13. Said outer sections 13 and inner section 14 thereby effectively form a substantially straight, tubular member having a primary central axis AI that extends parallel to the primary in-/outflow direction I.

The secondary outlet 20, that effectively extends from the inner section 14 of the primary outlets, has a secondary in-/outflow direction II, wherein the secondary outlet 20 is arranged for connecting, to an outer end 21 thereof, a secondary tubular element having, at least at its outer end, a cylindrical cross-section. The outer section 23 is hereto arranged with a circular cross-section. The inner section 24 of the secondary outlet 20, that is arranged in between the inner section 14 of the primary outlets 10 and the outer section 21 of the secondary outlet 20, comprises a substantially non-round (inner) cross-section, as is best seen in figure 3. The secondary outlet 20 thus extends, by means of a non-round, in particular oval shaped, through hole 25 through the inner section 14, in particular through the circumferential wall thereof, of the primary outlet 10. The cross-section of the outer end 21 of the secondary outlet 20 is seen to have a larger diameter than the cross-section of the outer end 11 of the primary outlet 10, as was described earlier.

The primary and secondary outlets 10, 20 thereby form a T-shaped tubular connection member (or T-shaped junction member), whereby a flow of liquid entering one of said primary outlets 10, may be directed to the other of said primary outlets 10 and the secondary outlet, whereas a flow of liquid entering through the secondary outlet 20 may be directed to the respective primary outlets 10. The secondary outlet 20 is seen to comprise an intermediate section 26, arranged in between the inner and outer sections 23, 24, formed as, effectively, a shape transition piece for accommodating the difference in cross-sectional shapes of the respective inner and outer sections 23, 24.

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The non-round cross-section of the inner section 24 has a major axis III and a minor axis IV, wherein a width of the non-round cross-section is largest along the major axis III. The major axis III of the non-round cross-section is arranged at a non-zero angle with respect to the primary in-/outflow direction I. In the current embodiment, the major axis III is arranged substantially orthogonal to the primary in-/outflow direction I. A width w_2 of the major axis III of said oval cross-section of the inner section 24 of the secondary outlet 20 is no larger than a maximum width w_1 , corresponding to the inner diameter, of the inner section 14 of the primary outlet 10 through which the inner section 24 of the secondary outlet extends.

20 In figure 4 it can be seen that, in order to further reduce the stress concentration factors at the axil 30 where the primary and secondary outlets 10, 20 are joined, the wall thickness of at least the primary outlets 10 increases towards a center of the inner section 14, to be at a maximum thickness at, or near, the center of the inner section 14.

25 The outer surfaces 11, 21 of, respectively, the primary and secondary outlets 10, 20 are seen to comprise circumferential recessions 111, 211 that are arranged at end sections of the respective surfaces, close to the respective outer ends 12, 22 of the respective primary and secondary outlets 10, 20. These circumferential recessions 111, 211, that form engaging means, as part of the fixation means, for receiving one end of a connecting bracket (not shown) therein that is arranged to be mounted on the outer circumferential surface 11,21 of the respective outlet 10, 20 for interconnecting said outlet 10, 20 to a respective primary of secondary tubular element that is arranged with similar, cooperating, engaging means.

35 Figures 6A-B schematically show a comparison of results from a computational fluid dynamics (CFD) simulation of the flow in a part of membrane filtration system 1000 employing respectively a T-shaped connecting element 1' according to the state of art and, similar to the one shown in

- figure 1, a T-shaped connecting element according to the invention 1. The parallel arranged membrane filtration units 1002 – 1004, comprising each a cylindrical shaped housing 101, are connected to a feed line 1100 that is formed by interconnected tubular connecting members 1, 1', in particular by interconnecting adjacent primary outlets 10, 10' thereof. The cylindrical shaped housings 101 are connected to the respective secondary outlets 20, 20'. As can be seen in Figure 6B, compared to the secondary outlets 20' in Figure 6A, swirling in the secondary outlets 20 is reduced, whereby an improved flow-through and more uniform flow through the respective membrane filtration units 1002 – 1004 is obtained.
- 10 The improved flow characteristic, given by the flow through, is further confirmed by the results presented in figure 7, wherein the average axial flow velocity per membrane filtration unit, for a membrane filtration system comprising 25 parallel arranged membrane filtration units M1-M25, is determined for both a system 1000 comprising T-shaped connecting members 1' according the state of art, i.e. a simple T-shaped tubular connecting member having circular cross-sections for all
- 15 the respective outlets, and a system comprising T-shaped connecting members 1 as shown in figures 2 – 5. The normalized results are indicated per membrane filtration unit, wherein a respective left bar R1 indicates the average axial flow velocity for the system according to the state of art and a respective right bar R2 indicates the average axial flow velocity for the system according to the invention. Clearly, the use of the T-shaped tubular connecting member according
- 20 to the invention leads to a more uniform, and thus improved, flow through.

The present invention is not limited to the embodiment shown but extends also to other embodiments falling within the scope of the appended claims.

Claims

1. Tubular connecting member arranged for interconnecting a plurality of tubular members in a fluid flow system, the tubular connecting member comprising:

5 - at least one primary outlet having a primary in-/outflow direction, wherein the primary outlet is arranged for connecting, to an outer end thereof, a primary tubular element having, at least at its outer end, a cylindrical cross-section;

- at least one secondary outlet having a secondary in-/outflow direction, wherein the secondary outlet is arranged for connecting, to an outer end thereof, a secondary tubular element having, at least at its outer end, a cylindrical cross-section;

10 wherein the secondary in-/outflow direction is arranged at a non-zero angle with respect to the primary in-/outflow direction; and

wherein the secondary outlet further comprises an inner section having, as seen in a plane that is perpendicular to the secondary in-/outflow direction, a non-round cross-section.

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2. Tubular connecting member according to claim 1, wherein the non-round cross-section of the inner section has a major axis and a minor axis, wherein a width of the non-round cross-section is largest along the major axis, and wherein the major axis of the non-round cross-section is arranged at a non-zero angle with respect to the primary in-/outflow direction.

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3. Tubular connecting member according to claim 2, wherein the non-round cross-section of the inner section is a substantially oval-shaped cross-section having a major axis that is substantially perpendicular to the primary in-/outflow direction and a minor axis that is substantially parallel to the primary in-/outflow direction.

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4. Tubular connecting member according to claim 3, wherein said non-round cross-section of the inner section is an inner cross-section of the secondary outlet.

5. Tubular connecting member according to any of the preceding claims, wherein the secondary outlet comprises an outer section, wherein the inner section of the secondary outlet is located, as seen along a flow path from the primary outlet to the secondary outlet through the tubular connecting member, between the primary outlet and the outer section of the secondary outlet.

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6. Tubular connecting member according to claim 5, wherein the outer section of the secondary outlet has a circular cross-section, wherein the primary outlet comprises an outer section having a circular cross-section, wherein a diameter of the circular cross-section of the outer section of the

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primary outlet is smaller than a diameter of the circular cross-section of the outer section of the secondary outlet.

7. Tubular connecting member according to any of the preceding claims, wherein the primary
5 outlet comprises an inner section that extends, with respect to the outer section, inwardly, wherein said inner section comprises a circumferential wall and wherein the inner section of the secondary outlet is formed as a through hole through the circumferential wall of the inner section of the primary outlet.
- 10 8. Tubular connecting member according to claim 1 or 2 and claim 7, wherein a width of the major axis of said non-round cross-section of the inner section of the secondary outlet is no larger than an a maximum width of the inner section of the primary outlet through which the inner section of the secondary outlet extends, preferably wherein, as seen in a plane perpendicular to the primary in-/outflow direction, the inner section of the primary outlet has a substantially circular cross-section
15 and wherein the major axis of the non-round cross-section of the inner section of the secondary outlet is no larger than a diameter of said circular cross-section of the inner section of said primary outlet.
9. Tubular connecting member according to any of the preceding claims, further comprising a
20 tertiary outlet for connecting a tertiary tubular element to an outer section thereof.
10. Tubular connecting member according to claim 9, wherein the tertiary outlet is a second primary outlet having a second primary in-/outflow direction, wherein the second primary outlet is arranged for connecting to a primary tubular element having, at least at its outer end, a cylindrical
25 cross-section,
wherein said second primary in-/outflow direction is substantially parallel, or equal, to said primary in-/outflow direction and/or wherein a central axis of the outer section of said primary outlet is substantially parallel to, in particular coaxial with, a central axis of the outer section of the second primary outlet.
- 30 11. Tubular connecting member according to any of the preceding claims, having a plurality of secondary outlets, wherein each secondary outlet having a respective secondary in-/outflow direction, wherein each secondary outlet is arranged for connecting to a respective secondary tubular element having, at least at its outer end, a cylindrical cross-section;
35 wherein each respective secondary in-/outflow direction is arranged at a non-zero angle with respect to the primary in-/outflow direction; and

wherein each secondary outlet further comprises a respective inner section having, as seen in a plane that is perpendicular to the secondary in-/outflow direction, a non-round cross-section.

12. Tubular connecting member according to any of the preceding claims, wherein said primary outlet(s) are formed from a substantially cylindrical tubular element, wherein said outer section(s) is/are arranged at the respective end(s) of said substantially cylindrical tubular element, such that the primary in-/outflow direction is substantially parallel to a central axis of said cylindrical tubular element.
13. Tubular connecting member according to any of the preceding claims, wherein the respective outlets comprise fixation means for fixedly connecting a respective cylindrical tubular element thereto, wherein said fixation means preferably comprise engaging means, such as a circumferential protrusion, or recession, arranged on, or in, the outer circumferential surface of the respective outlet,
- wherein said fixation means preferably comprise a connecting bracket that is arranged to be mounted on the outer circumferential surface of the respective outlet, and
- wherein said engaging means are, preferably, arranged for receiving the connecting bracket thereon for interconnecting said outlet to a respective primary or secondary tubular element that is arranged with similar, cooperating, engaging means.
14. Tubular connecting member according to any of the preceding claims, wherein said tubular connection member is made, in particular by a casting process, from a plastic material, in particular a reinforced plastic material.
15. Tubular connecting member according to any of the preceding claims, wherein said tubular connection member is an elbow shaped connecting member having only one primary outlet and only one secondary outlet, wherein, preferably, said primary and secondary in-/outflow directions are arranged at an angle of 45° or 90° with respect to each other.
16. Tubular connecting member according to any of the preceding claims 1 - 14, wherein said tubular connection member is a T-shaped connecting member having only two primary outlets and only one secondary outlet, wherein, preferably, said primary and secondary in-/outflow directions are arranged at an angle of 45° or 90° with respect to each other.
17. Tubular connecting member according to any of the preceding claims 1 - 16, wherein the tubular connecting member is monolithic.

18. Method of manufacturing a tubular connecting member according to any of the preceding claims in a single piece by a casting process.

- 5 19. Fluid flow system comprising a supply line for supplying a fluid to be processed and a discharge line for discharging the fluid after it is processed, further comprising at least one fluid processing unit that is arranged in between the supply line and the discharge line and that comprises an inlet and an outlet, wherein the fluid processing unit is arranged such that, when in use, fluid flows from said supply line to said discharge line, thereby passing through the fluid
- 10 processing unit, and wherein at least one of the inlet and the outlet has a cylindrical cross-section; the system further comprising at least one tubular connecting member according to any of the preceding claims 1 - 17, wherein said tubular connecting member interconnects the at least one of the inlet and outlet to, respectively, the supply line or the discharge line.

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20. Fluid flow system according to claim 19, wherein the secondary outlet of the tubular connecting member is connected to the at least one of the inlet and outlet of the fluid processing unit and said primary outlet of the tubular connecting member is connected to, respectively, the supply or discharge line.

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21. Fluid flow system according to any of the preceding claims 19 - 20, wherein the fluid processing unit is substantially tubular having a cylindrical cross-section, wherein the inlet and outlet are arranged at opposite ends of the respective tubular shaped fluid processing unit, wherein a first tubular connection member interconnects the inlet to the supply line and a second tubular
- 25 connection member interconnects the outlet to the discharge line.

22. Fluid flow system according to any of the preceding claims 19 - 21, comprising a plurality of fluid processing units that are arranged substantially parallel with respect to each other and a plurality of tubular connection members according to at least claim 9 or 10 for interconnecting the
- 30 plurality of fluid processing units to the supply line and discharge line.

23. Fluid flow system according to claim 22, wherein each inlet of each fluid processing unit is connected to a secondary outlet of a respective first tubular connection member and wherein each outlet of each fluid processing unit is connected to a secondary outlet of a respective first tubular
- 35 connection member and wherein adjacent first tubular connection members are coupled through

the primary outlets for forming the supply line and wherein adjacent second tubular connection members are coupled through the primary outlets for forming the discharge line.

24. Fluid flow system according to any of the preceding claims 19 - 23, wherein the fluid flow
5 system is a membrane filtration system, wherein the supply line is for supplying a liquid to be filtered, wherein each fluid processing unit is a membrane filtration unit that comprises a housing having the inlet, the outlet and a filtration membrane therebetween, wherein the membrane filtration unit is arranged such that, when in use, liquid flows from said inlet to said outlet, thereby passing through the filtration membrane.

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25. Fluid flow system according to any of the preceding claims 19 - 23, wherein the fluid flow system is a carbon capture system for capturing carbon dioxide from a gas mixture from a source, such as an industrial source, wherein the supply line is for supplying the gas mixture from which the carbon dioxide is to be captured, wherein each fluid processing unit is a carbon capture unit.