CONTINUOUS FLOW REACTOR FOR VIRAL INACTIVATION

FIELD OF THE INVENTION

[0001] The present disclosure generally relates to an apparatus and a process for a continuous flow reactor. More particularly, the present disclosure relates to an apparatus and a process for a continuous flow reactor having at least two turns on a single longitudinal axis, each turn disposed in a different, non-parallel plane.

BACKGROUND OF THE INVENTION

[0002] The invention lies on the field of production of biological products like proteins which usually takes place in a bioreactor (fermenter) where e.g. eukaryotic cells are cultivated to produce a protein of interest. Different technologies are established therefore, e.g. fed-batch or continuous or perfusion fermentation. Before use the product needs to be purified. Among the purification steps inactivation of virusses is mandatory, esp. when the product is intended for use in humans.

[0003] Presently, virus inactivation at a low pH is performed in a batch reactor. The material to be inactivated (*i.e.*, a liquid which potentially contains the active viruses) is introduced into a batch reactor. The material to be inactivated is brought to a pH of ≤ 4 by an acidic solution and allowed to stand for the required time. The inactivation of the viruses is effected by contact of the viruses with the acidic solution for a particular product- and process-dependent time. The entire content of the batch reactor experiences inactivation with a virtually identical residence time. Additionally, the virus reduction achieved in each batch is virtually identical.

SUMMARY

[0004] In the disclosure, a continuous flow reactor is provided. The continuous flow reactor

includes a plurality of interwoven flow paths in fluid communication to form a single continuous flow reactor tube having a single flow path. In an aspect, the present disclosure provides a continuous flow reactor comprising: a plurality of interwoven flow paths in fluid communication to form a single continuous flow reactor tube having a single flow path.

[0005] In another example, each of the plurality of interwoven flow paths comprises a plurality of turns that are in different, non-parallel planes.

[0006] In a further example, the plurality of turns includes at least a first pattern and a second pattern different from the first pattern, wherein the first pattern includes a predetermined number of turns, and the second pattern includes a predetermined number of turns, and wherein the predetermined number of turns in the first pattern is same or different from the predetermined number of turns in the second pattern.

[0007] In an example, the plurality of turns includes a repeated pattern of turns.

[0008] In another example, the pattern of turns is repeated after 8 bends.

[0009] In a further example, each of the plurality of turns includes an angle of from about 100° to about 200°.

[0010] In an example, each of the plurality of turns includes an angle of from about 135° to about 140°.

[0011] In another example, the plurality of turns follows a three-dimensional path that includes flow direction changes at approximately 45°, at a turn center.

[0012] In a further example, the plurality of interwoven flow paths is made of at least one of flexible and memory alloy.

[0013] In an example, the plurality of interwoven flow paths includes from about 19.6 to

about 39.2 turns per 1 m^3.

[0014] In another example, the plurality of interwoven flow paths includes internals.

[0015] In a further example, the plurality of interwoven flow paths comprises a weft-like pattern and a wrap-like pattern.

[0016] In an example, the plurality of interwoven flow paths comprises a plural bends each bend being rotated, with respect to one another, at an angle around a longitudinal axis of the plurality of interwoven flow paths.

[0017] In another example, the angle around the longitudinal axis of the interwoven flow path is from about 25 degrees to about 60 degrees.

[0018] In the disclosure, a continuous flow reactor is provided. The continuous flow reactor at least one flow path on a single longitudinal axis and comprising a plurality of turns, wherein at least two of the plurality of turns are in different, non-parallel planes. In another aspect, the present disclosure provides a continuous flow reactor comprising: at least one flow path on a single longitudinal axis and comprising a plurality of turns, wherein at least two of the plurality of turns are in different, non-parallel planes.

[0019] In another example, the plurality of turns includes a first pattern that is repeated a predetermined number of times.

[0020] In a further example, the plurality of turns includes at least a first pattern and a second pattern different from the first pattern, wherein the first pattern includes a predetermined number of turns, and the second pattern includes a predetermined number of turns, and wherein the predetermined number of turns in the first pattern is same or different from the predetermined number of turns in the second pattern.

[0021] In an example, each of the plurality of turns is separated from one another by a bend having an angle smaller than an angle of the plurality of turns.

[0022] In another example, each of the bends includes an angle of less than about 135° and wherein each of the plurality of turns includes an angle of from about 135° to about 140°.

[0023] In a further example, the at least one flow path comprises four flow paths interwoven with one another.

[0024] In the disclosure, a method of viral inactivation in a continuous flow reactor is provided. The method includes a process stream and at least one virus inactivating compound or solution into a continuous flow reactor at a flow rate having a Reynolds number of from about 187 to about 333 and a Dean Number of from about 105 to about 212; and contacting the process stream with the at least one virus inactivating compound or solution in the continuous flow reactor. In another aspect, the present disclosure provides a method of viral inactivation in a continuous flow reactor comprising: introducing a process stream and at least one virus inactivating compound or solution into a continuous flow reactor at a flow rate having a Reynolds number of from 187 to 333 and a Dean Number of from 105 to 212; contacting the process stream with the at least one virus inactivating compound or solution in the continuous flow reactor.

[0025] In the disclosure, a process for a continuous low pH of viral inactivation of a product stream is provided.

[0026] Additional features and advantages of various examples will be set forth, in part, in the description that follows, and will, in part, be apparent from the description, or may be learned by the practice of various examples. The objectives and other advantages of various examples will be realized and attained by means of the elements and combinations particularly pointed out in the description herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0027] The present disclosure in its several aspects and embodiments can be more fully understood from the detailed description and the accompanying drawings, wherein:

[0028] Fig. 1A is a perspective view of a continuous flow reactor showing its casing and exemplary reactor tube, according to an example of the present disclosure;

[0029] Fig. 1B is a partial perspective view of the continuous tubular reactor of Fig. 1A,

CLAIMS

We claim:

1. A continuous flow reactor comprising:

a plurality of interwoven flow paths in fluid communication to form a single continuous flow reactor tube having a single flow path.

2. The continuous flow reactor of claim 1, wherein each of the plurality of interwoven flow paths comprises a plurality of turns that are in different, non-parallel planes.

3. The continuous flow reactor of claim 2, wherein the plurality of turns includes at least a first pattern and a second pattern different from the first pattern, wherein the first pattern includes a predetermined number of turns, and the second pattern includes a predetermined number of turns, and wherein the predetermined number of turns in the first pattern is same or different from the predetermined number of turns in the second pattern.

4. The continuous flow reactor of claim 2, wherein the plurality of turns includes a repeated pattern of turns, preferably wherein the pattern of turns is repeated after 8 bends.

5. The continuous flow reactor of claim 2, wherein each of the plurality of turns includes an angle of from 100° to 200°, preferably wherein each of the plurality of turns includes an angle of from 135° to 140°.

6. The continuous flow reactor of claim 2, wherein the plurality of turns follows a three-dimensional path that includes flow direction changes at approximately 45°, at a turn center.

7. The continuous flow reactor of one or more of claims 1 to 6, wherein the plurality of interwoven flow paths is made of at least one of flexible and memory alloy.

8. The continuous flow reactor of one or more of claims 1 to 7, wherein the plurality of interwoven flow paths includes from 19.6 to 39.2 turns per 1 m^3.

9. The continuous flow reactor of one or more of claims 1 to 8, wherein the plurality of interwoven flow paths includes internals.

10. The continuous flow reactor of one or more of claims 1 to 9, wherein the plurality of interwoven flow paths comprises a weft-like pattern and a wrap-like pattern.

11. The continuous flow reactor of one or more of claims 1 to 10, wherein the plurality of interwoven flow paths comprises a plural bends each bend being rotated, with respect to one another, at an angle around a longitudinal axis of the plurality of interwoven flow paths, preferably wherein the angle around the longitudinal axis of the interwoven flow path is from 25 degrees to 60 degrees.

12. A continuous flow reactor comprising:

at least one flow path on a single longitudinal axis and comprising a plurality of turns, wherein at least two of the plurality of turns are in different, non-parallel planes.

13. The continuous flow reactor of claim 12, wherein the plurality of turns includes a first pattern that is repeated a predetermined number of times.

14. The continuous flow reactor of claim 12, wherein the plurality of turns includes at least a first pattern and a second pattern different from the first pattern, wherein the first pattern includes a predetermined number of turns, and the second pattern includes a predetermined number of turns, and wherein the predetermined number of turns in the first pattern is same or different from the predetermined number of turns in the second pattern.

15. The continuous flow reactor of claim 12, wherein each of the plurality of turns is separated from one another by a bend having an angle smaller than an angle of the plurality of turns, preferably wherein each of the bends includes an angle of less than 135° and wherein each of the plurality of turns includes an angle of from 135° to 140°.

16. The continuous flow reactor of claim 12, wherein the at least one flow path comprises four flow paths interwoven with one another.

17. A method of viral inactivation in a continuous flow reactor comprising:

introducing a process stream and at least one virus inactivating compound or solution into a continuous flow reactor at a flow rate having a Reynolds number of from 187 to 333 and a Dean Number of from 105 to 212;

contacting the process stream with the at least one virus inactivating compound or solution in the continuous flow reactor.