

**MIXING DEVICE FOR A BIOLOGICAL LIQUID, MIXING SYSTEM FOR A
BIOLOGICAL LIQUID, AND METHOD FOR OPERATING A MIXING DEVICE
FOR A BIOLOGICAL LIQUID**

FIELD

5 The invention relates to a mixing device for a biological liquid.

Moreover, the invention is directed to a mixing system for a biological liquid comprising such a mixing device.

Furthermore, the invention relates to a method for operating a mixing device for a biological liquid.

10 BACKGROUND

Mixing devices are frequently used when treating or processing a biological liquid, i.e. a liquid containing biological material such as cells, parts of cells and/or biopharmaceuticals. Biopharmaceuticals or biopharmaceutical drugs are generally obtained by culturing a host cell in a bioreactor to produce the drug substance of interest. This is followed by a number of liquid
15 treatment steps such as clarification of the cell culture, filtration and chromatography steps. All or some of these steps may require mixing of the biological liquid in order to enhance homogeneity. To this end, magnetic stirrers or magnetic mixers may be used, i.e. devices that generate a rotating magnetic field in order to cause a so-called stir bar or flea immersed in the biological liquid to spin. In order to transfer the biological liquid into the magnetic stirrer and
20 to withdraw the biological liquid from the magnetic stirrer, pumps and associated piping may be used.

A problem to be solved by the present invention is thus to simplify equipment used for mixing a biological liquid. It is understood that the simplified equipment still needs to be suitable for processing the biological liquid.

25 SUMMARY

This problem is addressed by a mixing device for a biological liquid. The mixing device comprises a mixing chamber delimited by a first flexible wall segment and by a second flexible

5 wall segment. The first flexible wall segment and the second flexible wall segment are arranged on different sides of the mixing chamber. The first flexible wall segment comprises a first actuator interface configured to couple a first actuator to the first flexible wall segment such that the first flexible wall segment is displaceable by operating the first actuator. The second flexible wall segment comprises a second actuator interface configured to couple a second actuator to the second flexible wall segment such that the second flexible wall segment is displaceable by operating the second actuator. In this context, the first flexible wall segment and/or the second flexible wall segment may be called a membrane. The fact that the first flexible wall segment and the second flexible are flexible means that the first flexible wall segment and the second flexible wall segment are capable of being flexed, e.g. bent, especially in a repeated manner. Optionally, the first flexible wall segment and/or the second flexible wall segment are elastically deformable. Such a mixing device may draw or suck a biological liquid into the mixing chamber in that the first flexible wall segment and the second flexible wall segment are moved away from each other using the respective first actuator interface and second actuator interface. To this end, the mixing device may comprise an inlet port fluidically connected to the mixing chamber. In doing so, a volume of the mixing chamber is increased thereby creating a local underpressure that may draw or suck the biological liquid into the mixing chamber. Additionally, such a mixing device may expel the biological liquid from the mixing chamber, i.e. may empty the mixing chamber, in that the first flexible wall segment and the second flexible wall segment are moved towards each other using the respective first actuator interface and second actuator interface. To this end, the mixing device may comprise an outlet port fluidically connected to the mixing chamber. In doing so, a volume of the mixing chamber is decreased, thereby subjecting a biological liquid in the mixing chamber to a pressure that pushes out the biological liquid from the mixing chamber.

25 Furthermore, the mixing device may mix, i.e. homogenize, a biological liquid inside the mixing chamber. To this end, the first flexible wall segment and the second flexible wall segment are moved into the same direction, especially in an alternating manner, using the respective first actuator interface and second actuator interface. This means that the first flexible wall segment is moved towards the second flexible wall segment and the second flexible wall segment is moved away from the first flexible wall segment or vice versa. Consequently, the mixing device may provide the functionality of a pump for transferring biological liquid into the

mixing chamber, the functionality of a pump for expelling biological liquid from the mixing chamber and the functionality of a mixing device for homogenizing the biological liquid. All these functionalities are provided by a single device, i.e. the mixing device according to the invention. Thus, given the provided functionalities, such a mixing device is structurally simple
5 and compact.

The fact that the mixing device according to the invention offers the functionality of a pump for transferring biological liquid into the mixing chamber and for expelling biological liquid from the mixing chamber has the additional advantage that, by moving the first flexible wall segment and/or the second flexible wall segment, a volume of biological liquid in the mixing
10 chamber may be accurately controlled. This means that a precise amount of biological liquid may be treated using the mixing device.

A further advantage of the mixing device according to the present invention relates to the fact that emptying the mixing chamber using the first flexible wall segment and the second flexible wall segment which are moved towards one another, allows to empty the mixing chamber
15 completely or at least to a large extent. In order to achieve this, a volume of the mixing chamber extending between the first flexible wall segment and the second flexible wall segment has to be minimized. Thus, the first flexible wall segment needs to extend maximally towards the second flexible wall segment and the second flexible wall segment needs to extend maximally towards the first flexible wall segment. This means that the first flexible wall segment and the
20 second flexible segment need to be moved towards each other as closely as possible. In a special case, the first flexible wall segment and the second flexible wall segment contact each other or nearly contact each other. Thus, the mixing chamber may be easily and reliably emptied.

A further advantage of the mixing device according to the present invention relates to the fact
25 that the first actuator interface and the second actuator interface are provided. This allows to move the first flexible wall segment and the second flexible wall segment independent from one another. This applies both in respect of the timing of the movement and in respect of the amplitude of the movement. Consequently, a mixing action may be flexibly adapted to the mixing needs of a specific application.

In an embodiment, the mixing device may be configured such that a biological liquid located in the mixing chamber only contacts the first flexible wall segment and the second flexible wall segment. This is advantageous from a sanitary point of view since this allows aseptic handling of the biological liquid. Moreover, the first flexible segment and the second flexible wall segment may be sterilized in a simple and reliable manner.

Due to these properties, the mixing device of the present invention is well suitable for processing a biological liquid, e.g. in processing steps relating to clarification of cell cultures, filtration and chromatography. In particular, the mixing device may be used for tangential flow filtration (TFF) and/or in vitro translation/transcription (IVT).

According to an example, the mixing device further comprises a passive swirling element arranged inside the mixing chamber and arranged between the first flexible wall segment and the second flexible wall segment. In this context, a passive swirling element or mixing element is an element that provides a certain resistance to a flow of the biological liquid. The resistance is configured to at least locally create turbulence in the biological liquid. The swirling element is passive since it does not comprise movable or moving parts. Arranging the passive swirling element between the first flexible wall segment and the second flexible wall segment ensures that a comparatively large portion of a biological liquid located in the mixing chamber interacts with the passive swirling element. Consequently, the biological liquid is mixed, i.e. homogenized, in an effective and efficient manner.

It is noted that in a configuration in which the passive swirling element is arranged between the first flexible wall segment and the second flexible wall segment, both the first flexible wall segment and the second flexible wall segment may be moved towards the passive swirling element in order to expel biological liquid from the mixing chamber. The mixing chamber has a minimal volume in a situation in which both the first flexible wall segment and the second flexible wall segment abut against the passive swirling element.

The swirling element may comprise a plate having a plurality of through holes. Such a passive swirling element is structurally simple and compact. The compactness especially allows to have a comparatively small minimal volume of the mixing chamber in a condition in which both the first flexible wall segment and the second flexible wall segment abut against the passive

- swirling element. This volume may as well be called a hold-up volume. At the same time, the plurality of through holes create a plurality of local turbulences inside the mixing chamber. Thus, the biological liquid may be homogenized efficiently and effectively. Moreover, the number, size and position of the through holes may easily be adapted to a specific application
- 5 of the mixing device. In this context, a diameter of the through holes may be adapted to the biological liquid to be mixed. Moreover, a density of through holes in a first portion of the plate may be larger than a density of through holes in a second portion of the plate. In a special case, all the through holes may be provided in the first portion of the plate. Depending on the biological liquid, this may lead to enhanced mixing effects.
- 10 In an embodiment, the mixing device further comprises a heating element. Thus, the mixing device offers the additional functionality of either keeping the biological liquid at a desired temperature or increasing a temperature of the biological liquid inside the mixing chamber. This enhances the suitability of the mixing device for a biological liquid since such a liquid often needs to be processed within a predefined temperature range.
- 15 According to an example, the heating element is integrated into the swirling element. Consequently, the heating element is provided in a space-saving manner. Additionally, since mixing of the biological liquid requires frequent contacts between the biological liquid and the swirling element, locating the heating element in the swirling element allows to efficiently and reliably heat the biological liquid or keep the biological liquid at a desired temperature.
- 20 According to a variant, the heating element comprises at least one heating wire. A heating wire is an electric wire having an electric resistance which leads to the generation of heat if the heating wire is subject to an electric current. This is a simple and precisely controllable way to provide heat. At the same time, a heating wire may be easily integrated into the swirling element.
- 25 According to a variant, the mixing device further comprises a first abutment feature delimiting a range of motion of the first flexible wall segment towards an outside of the mixing chamber. Additionally or alternatively, the mixing device further comprises a second abutment feature delimiting a range of motion of the second flexible wall segment towards an outside of the mixing chamber. Thus, the first abutment feature defines an end position of the first flexible

- wall segment remote, i.e. at a maximum distance, from the second flexible wall segment. In the same manner, the second abutment feature defines an end position of the second flexible wall segment remote, i.e. at a maximum distance, from the first flexible wall segment. In a case in which the first flexible wall segment abuts against the first abutment feature and the second flexible wall segment abuts against the second abutment feature, the mixing chamber has a maximum volume. Using the first abutment feature and/or the second abutment feature, the range of motion of the first flexible wall segment and/or the second flexible wall segment is well-defined such that the first flexible wall segment and/or the second flexible wall segment may be moved in a precise and reliable manner.
- 10 According to an example, the first abutment feature and/or the second abutment feature has a substantially smooth, concave shape. In this context, the first abutment feature and/or the second abutment feature may be realized by a substantially smooth cavity. The cavity may be provided in a housing part of the mixing device. The smooth concave shape of the first abutment feature and/or the second abutment feature allows to repeatedly abut the first flexible wall segment and the second flexible wall segment against the associated abutment feature in a substantially wear-free manner. Due to this fact, the reliability and service life of the mixing device is enhanced.

- In an example, the mixing device further comprises a first limitation feature delimiting a range of motion of the first flexible wall segment towards an inside of the mixing chamber.
- 20 Additionally or alternatively, the mixing device further comprises a second limitation feature delimiting a range of motion of the second flexible wall segment towards an inside of the mixing chamber. Thus, the first limitation feature defines an end position of the first flexible wall segment adjacent, i.e. at a minimum distance, from the second flexible wall segment. In the same manner, the second limitation feature defines an end position of the second flexible wall segment adjacent, i.e. at a minimum distance, from the first flexible wall segment. In a case in which the first flexible wall segment abuts against the first limitation feature and the second flexible wall segment abuts against the second limitation feature, the mixing chamber has a minimal volume. Using the first limitation feature and/or the second limitation feature, the range of motion of the first flexible wall segment and/or the second flexible wall segment
- 25

is well-defined such that the first flexible wall segment and/or the second flexible wall segment may be moved in a precise and reliable manner.

According to an example, the first limitation feature is formed by a first surface of the swirling element. Additionally or alternatively, the second limitation feature is formed by a second surface of the swirling element. The first surface and the second surface are arranged on opposite sides of the swirling element. This is especially the case if the swirling element is plate-shaped. This configuration allows designing the mixing device in a compact manner. Moreover, this configuration ensures a comparatively small hold-up volume, i.e. a comparatively small minimal volume of the mixing chamber.

- 10 In an embodiment, the mixing device further comprises a first pneumatic actuation chamber delimited by at least a portion of the first flexible wall segment and fluidically coupled to a first pneumatic port configured to connect the first pneumatic actuation chamber to a pneumatic source. Additionally or alternatively, the mixing device further comprises a second pneumatic actuation chamber delimited by at least a portion of the second flexible wall segment and fluidically coupled to a second pneumatic port configured to connect the second pneumatic actuation chamber to a pneumatic source. Consequently, the first flexible wall segment is movable by pressurizing or depressurizing the first pneumatic actuation chamber accordingly. In order to pressurize or depressurize the first pneumatic actuation chamber, a pneumatic fluid, such as air, may be filled into the first pneumatic actuation chamber via the first pneumatic port or a pneumatic fluid, such as air, may be eliminated from the first pneumatic actuation chamber via the first pneumatic port. Eliminating a pneumatic fluid from the first pneumatic actuation chamber may be done actively by sucking out the pneumatic fluid or passively simply by fluidically connecting the first pneumatic actuation chamber to an environment at ambient pressure. In this variant, the first actuator interface of the first flexible wall segment is formed by the portion of the first flexible wall segment delimiting the first pneumatic actuation chamber. It is possible that substantially the entire first flexible wall segment delimits the first pneumatic actuation chamber. In the same manner, the second flexible wall segment is movable by pressurizing or depressurizing the second pneumatic actuation chamber accordingly. In order to pressurize or depressurize the second pneumatic actuation chamber, a pneumatic fluid, such as air, may be filled into the second pneumatic

actuation chamber via the second pneumatic port or a pneumatic fluid, such as air, may be eliminated from the second pneumatic actuation chamber via the second pneumatic port. Eliminating a fluid from the second pneumatic actuation chamber may be done actively by sucking out the pneumatic fluid or passively simply by fluidically connecting the second pneumatic actuation chamber to an environment at ambient pressure. In this variant, the second actuator interface of the second flexible wall segment is formed by the portion of the second flexible wall segment delimiting the second pneumatic actuation chamber. It is possible that substantially the entire second flexible wall segment delimits the second pneumatic actuation chamber. This configuration offers the possibility to actuate the first flexible wall segment and/or the second flexible wall segment in a precise and reliable manner.

According to an example, a wall of the first pneumatic actuation chamber arranged substantially opposite the portion of the first flexible wall segment delimiting the first pneumatic actuation chamber forms the first abutment feature delimiting the range of motion of the first flexible wall segment towards an outside of the mixing chamber. Additionally or alternatively, a wall of the second pneumatic actuation chamber arranged substantially opposite the portion of the second flexible wall segment delimiting the second pneumatic actuation chamber forms the second abutment feature delimiting the range of motion of the second flexible wall segment towards an outside of the mixing chamber. This configuration allows designing the mixing device in a space-saving manner.

According to an example, the mixing chamber, the first flexible wall segment, the second flexible wall segment, and at least one of the first pneumatic actuation chamber fluidically coupled to the first pneumatic port and the second pneumatic actuation chamber fluidically coupled to the second pneumatic port may be formed as a contiguous assembly unit. In this context, a contiguous assembly unit may be formed by a group of parts being connected to one another, such that the group of parts forms one single contiguous entity. This contiguous entity may be mounted in an apparatus in which it may be applied, without further assembly steps acting on the connection between the parts forming the entity. Alternatively, the contiguous assembly unit may be called a cassette or module. Forming the said parts as an assembly unit has the advantage that this contiguous assembly unit may be mounted in an apparatus in a quick and reliable manner. Such an assembly unit is particularly useful in applications that need to

comply with high sanitary standards. In such applications, the contiguous assembly unit, i.e. the mixing chamber, the first flexible wall segment, the second flexible wall segment, and at least one of the first pneumatic actuation chamber fluidically coupled to the first pneumatic port and the second pneumatic actuation chamber fluidically coupled to the second pneumatic port may be a single-use component. This means that for the treatment of one biological liquid, one contiguous assembly unit is used. Thereafter, the contiguous assembly unit is discarded. Another biological liquid is treated using another contiguous assembly unit. Thus, in such applications, the contiguous assembly unit needs to be changed frequently. Consequently, the above-mentioned advantages are of particular relevance. Beyond that, single-use components or single-use flow path components are advantageous since cleaning activities may be eliminated and a risk of cross-contamination is reduced or eliminated.

The mixing device may further comprise an inlet line having a first end fluidically coupled to the mixing chamber and a second end fluidically coupled to a first valve configured to selectively open and close the inlet line. The first end and the second end are opposite ends of the inlet line. Using the first valve, the inlet line may be selectively opened and closed, i.e. a flow of biological liquid through the inlet line may be precisely controlled. In particular, the actuation of the first valve is coordinated with the actuation of the first flexible wall segment and the second flexible wall segment. This means that the first valve is especially open if the first flexible wall segment and/or the second flexible wall segment are actuated in order to draw biological liquid into the mixing chamber.

The first valve may be a diaphragm valve. Additionally or alternatively, the first valve may be fluidically actuatable. Using a diaphragm valve is advantageous from a sanitary point of view since this allows aseptic handling of the biological liquid. Moreover, a diaphragm valve may be easily kept clean and/or sterile. Actuating the first valve fluidically allows to precisely control a flow of biological liquid into the mixing chamber.

In an example, the mixing device further comprises an outlet line having a first end fluidically coupled to the mixing chamber and a second end fluidically coupled to a second valve configured to selectively open and close the outlet line. The first end and the second end are opposite ends of the outlet line. Using the second valve, the outlet line may be selectively opened and closed, i.e. a flow of biological liquid through the outlet line may be precisely

controlled. In particular, the actuation of the second valve is coordinated with the actuation of the first flexible wall segment and the second flexible wall segment. This means that the second valve is especially open if the first flexible wall segment and/or the second flexible wall segment are actuated in order expel biological liquid from the mixing chamber.

- 5 The second valve may be a diaphragm valve. Additionally or alternatively, the second valve may be fluidically actuatable. Also in this case, using a diaphragm valve is advantageous from a sanitary point of view since this allows aseptic handling of the biological liquid. Moreover, a diaphragm valve may be easily kept clean and/or sterile. Actuating the second valve fluidically allows to precisely control a flow of biological liquid out of the mixing chamber.
- 10 Moreover, the problem is solved by a mixing system for a biological liquid. The mixing system comprises a mixing device according to the invention. Furthermore, the mixing system comprises a first actuator and a second actuator. The first actuator is coupled to the first actuator interface of the first flexible wall such that the first flexible wall segment is displaceable by operating the first actuator. The second actuator is coupled to the second actuator interface of
- 15 the second flexible wall segment such that the second flexible wall segment is displaceable by operating the second actuator. As has been mentioned before, the first flexible wall segment and/or the second flexible wall segment may be called a membrane. The fact that the first flexible wall segment and the second flexible wall segment are flexible means that the first flexible wall segment and the second flexible wall segment are capable of being flexed, e.g.
- 20 bent, especially in a repeated manner. Optionally, the first flexible wall segment and/or the second flexible wall segment are elastically deformable. Such a mixing system may draw or suck a biological liquid into the mixing chamber in that the first flexible wall segment and the second flexible wall segment are moved away from each other using the respective first actuator and second actuator. To this end, the mixing device may comprise an inlet port
- 25 fluidically connected to the mixing chamber. In doing so, a volume of the mixing chamber is increased thereby creating a local underpressure that may draw or suck in the biological liquid. Additionally, such a mixing system may expel the biological liquid from the mixing chamber, i.e. may empty the mixing chamber, in that the first flexible wall segment and the second flexible wall segment are moved towards each other using the respective first actuator and
- 30 second actuator. To this end, the mixing device may comprise an outlet port fluidically

connected to the mixing chamber. In doing so, a volume of the mixing chamber is decreased, thereby subjecting a biological liquid in the mixing chamber to a pressure that pushes out the biological liquid from the mixing chamber. Furthermore, the mixing system may mix, i.e. homogenize, a biological liquid inside the mixing chamber. To this end, the first flexible wall segment and the second flexible wall segment are moved into the same direction, especially in an alternating manner, using the respective first actuator and second actuator. This means that the first flexible wall segment is moved towards the second flexible wall segment and the second flexible wall segment is moved away from the first flexible wall segment or vice versa. Consequently, the mixing system may provide the functionality of a pump for transferring biological liquid into the mixing chamber, the functionality of a pump for withdrawing biological liquid from the mixing chamber and the functionality of a mixing device for homogenizing the biological liquid. All these functionalities may be performed by a single device. Thus, given these functionalities, such a mixing system is structurally simple and compact.

According to an example, the first actuator is a pneumatic actuator and/or the second actuator is a pneumatic actuator. The mixing device may comprise a first pneumatic actuation chamber and/or a second pneumatic actuation chamber as has been mentioned above.

According to an example, the mixing system further comprises a weighing unit configured to provide an indicator of a weight of a liquid inside the mixing chamber. Consequently, using the weighing unit, a weight of a biological liquid inside the mixing chamber may be considered when controlling the mixing system. For example, this allows drawing a desired mass of biological liquid into the mixing chamber. In another example, emptying of the mixing chamber may be controlled using the weighing unit. Altogether, the mixing system may be controlled in a particularly precise and reliable manner.

The problem is additionally solved by a method for operating a mixing device for a biological liquid. The mixing device comprises a mixing chamber delimited by a first flexible wall segment and by a second flexible wall segment. The first flexible wall segment and the second flexible wall segment are arranged on different sides of the mixing chamber. The method comprises:

- displacing the first flexible wall segment and the second flexible wall segment away from one another in order to draw liquid into the mixing chamber, and/or
- displacing the first flexible wall segment and the second flexible wall segment into the same direction in order to mix the liquid inside the mixing chamber, and/or
- displacing the first flexible wall segment and the second flexible wall segment towards one another in order to expel liquid from the mixing chamber.

As before, the first flexible wall segment and/or the second flexible wall segment may be called a membrane. The fact that the first flexible wall segment and the second flexible wall segment are flexible means that the first flexible wall segment and the second flexible wall segment are capable of being flexed, e.g. bent, especially in a repeated manner. Optionally, the first flexible wall segment and/or the second flexible wall segment are elastically deformable. Using the present method, the mixing device may provide the functionality of a pump for transferring biological liquid into the mixing chamber, the functionality of a pump for withdrawing biological liquid from the mixing chamber and/or the functionality of a mixing device for homogenizing the biological liquid. All these functionalities may be performed by a single device. Thus, using the above method simplifies the provision of the mentioned functionalities.

It is noted that the method according to the present invention may be used in combination with a mixing device according to the present invention and/or in combination with a mixing system according to the present invention.

According to an example, the method further comprises opening or keeping open a first valve provided at an inlet line fluidically coupled to the mixing chamber. This step is in particular executed at the same time as displacing the first flexible wall segment and the second flexible wall segment away from one another in order to draw liquid into the mixing chamber. Consequently, biological liquid may be drawn into the mixing chamber in a precise and reliable manner.

According to another example, the method further comprises opening or keeping open a second valve provided at an outlet line fluidically coupled to the mixing chamber. This step is in particular executed at the same time as displacing the first flexible wall segment and the second

flexible wall segment towards one another in order to expel liquid from the mixing chamber. Consequently, biological liquid may be expelled from the mixing chamber in a precise and reliable manner.

5 In a further example, the method comprises closing or keeping closed the first valve and closing or keeping closed the second valve. That is in particular executed at the same time as displacing the first flexible wall segment and the second flexible wall segment into the same direction in order to mix the liquid. Thus, the biological liquid is efficiently and effectively mixed.

10 Additionally or alternatively, the method may comprise assessing the weight of the biological liquid in the mixing chamber. This allows to precisely control an amount of biological liquid treated by the mixing device.

15 It is noted that features, effects and advantages that have been mentioned in connection with one of the mixing devices according to the invention, the mixing system according to the invention and the method according to the invention apply *mutatis mutandis* to the respective others of the mixing device according to the invention, the mixing system according to the invention and the method according to the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other aspects of the present invention will become apparent from examples described hereinafter with reference to the following drawings.

20 Figure 1 shows an apparatus for processing a biological liquid comprising a system for mixing a biological liquid according to the present invention with a mixing device according to the present invention, wherein the mixing device may be operated using a method according to the present invention,

Figures 2 shows the mixing device of Figure 1 in a schematic, sectional view,

Figures 3 to 4 illustrate the working principle of the mixing device of Figure 2,

25 Figure 5 shows a mixing device according to another example of the present invention,

Figure 6 shows the mixing device of Figure 5 in a sectional view along plane VI in Figure 5,

Figures 7 to 9 illustrate an operation of the mixing device of Figures 5 and 6.

DETAILED DESCRIPTION

- 5 Figure 1 shows an apparatus 10 for treating a biological liquid. In particular, the apparatus 10 is an apparatus for tangential flow filtration (TFF) or an apparatus for in vitro translation/transcription (IVT).

The apparatus 10 comprises a mixing system 12 for the biological liquid.

The mixing system 12 comprises a mixing device 14 which is shown in Figure 2 in more detail.

- 10 In the present example, the mixing device 14 comprises a housing 16. This housing 16 is essentially composed of two housing halves 16a, 16b which are connected in order to form the housing 16.

The first housing half 16a comprises a first cavity 18 and a first flexible wall segment 20 which may as well be called a membrane.

- 15 The first flexible wall segment 20 is connected to a circumference of the first cavity 18 such that, depending on a position of the first flexible wall segment 20 within the first cavity 18, the first flexible wall segment 20 may separate the first cavity 18 into two cavity portions 18a, 18b.

- The cavity portion 18a which is arranged on a side of the first flexible wall segment 20 which is located opposite to the housing half 16b, forms a first pneumatic actuation chamber 22. Thus,
20 the first pneumatic actuation chamber 22 is delimited by the first flexible wall segment 20 and by a portion of the first cavity 18.

The first pneumatic actuation chamber 22 is fluidically connected to a first pneumatic port 24. Consequently, the first flexible wall segment 20 may be moved by pressurizing or depressurizing the first pneumatic actuation chamber 22 via the first pneumatic port 24.

Due to this, the portion of the first flexible wall segment 20 delimiting the first pneumatic actuation chamber 22 may be considered a first actuator interface 26.

In a similar manner, the second housing half 16b comprises a second cavity 28 and a second flexible wall segment 30 which may as well be called a membrane. The material used to form the second flexible wall segment 30 may be substantially the same thickness as the material used to form the first flexible wall segment 20. This can help when manufacturing the mixing device 14 and also be used to help to ensure that consistent strong bonding can be provided for the membranes therein.

The second flexible wall segment 30 is connected to a circumference of the second cavity 28 such that, depending on a position of the second flexible wall segment 30 within the second cavity 28, the second flexible wall segment 30 may separate the second cavity 28 into two cavity portions 28a, 28b.

The cavity portion 28a which is arranged on a side of the second flexible wall segment 30 which is located opposite to the housing half 16a forms a second pneumatic actuation chamber 32. Thus, the second pneumatic actuation chamber 32 is delimited by the second flexible wall segment 30 and by a portion of the second cavity 28.

The second pneumatic actuation chamber 32 is fluidically connected to a second pneumatic port 34. Consequently, the second flexible wall segment 30 may be moved by pressurizing or depressurizing the second pneumatic actuation chamber 32 via the second pneumatic port 34.

Due to this, the portion of the second flexible wall segment 30 delimiting the second pneumatic actuation chamber 32 may be considered a second actuator interface 36.

The second portion 18b of the first cavity 18 and the second portion 28b of the second cavity 28 are arranged adjacent to one another and form a mixing chamber 38.

Consequently, the mixing chamber 38 is delimited by the first flexible wall segment 20, a portion of the wall of the first cavity 18, the second flexible wall segment 30 and a portion of the wall of the second cavity 28.

The first flexible wall segment 20 and the second flexible wall segment 30 are arranged on different sides of the mixing chamber 38.

The mixing device 14 additionally comprises an inlet line 40 having a first end fluidically coupled to the mixing chamber 38 and a second end fluidically coupled to a first valve 42. The
5 first valve 42 is configured to selectively open and closed the inlet line 40.

The first valve 42 may be a diaphragm valve which is fluidically actuatable.

In the present example, the inlet line 40 is provided on the housing 16.

Moreover, the mixing device 14 comprises an outlet line 44 having a first end fluidically coupled to the mixing chamber 38 and a second end fluidically coupled to a second valve 46.
10 The second valve 46 is configured to selectively open and closed the outlet line 44.

The second valve 46 may be a diaphragm valve which is fluidically actuatable.

In the present example, the outlet line 44 is provided on the housing 16.

More precisely, the inlet line 40 and the outlet line 44 are arranged on opposite sides of the mixing chamber 38.

15 Additionally, a passive swirling element 48 is arranged inside the mixing chamber 38. More precisely, the passive swirling element 48 is arranged at an interface of the first housing half 16a and the second housing half 16b. In other words, the passive swirling element 48 separates the mixing chamber 38 in two halves of substantially equal size.

In this position, the passive swirling element 48 is also arranged between the first flexible wall
20 segment 20 and the second flexible wall segment 30.

In the present example, the passive swirling element 48 is formed as a plate 50 having a plurality of through holes 52. It is noted that for reasons of better visibility only some of the through holes are provided with a reference sign in the Figures.

Furthermore, a heating element 54 is integrated into the passive swirling element 48. The heating element 54 comprises a heating wire 56 which extends in an interior of the passive swirling element 48.

5 In the present example, the passive swirling element 48 is made from a plastics material using a molding process and the heating wire 56 is molded in.

In the present example, the passive swirling element 48 limits a range of motion of both the first flexible wall segment 20 and the second flexible wall segment 30.

10 Consequently, a side of the passive swirling element 48 oriented towards the first flexible wall segment 20 may be considered as a first limitation feature 58 delimiting a range of motion of the first flexible wall segment 20 towards an inside of the mixing chamber 38.

In the same manner, a side of the passive swirling element 48 oriented towards the second flexible wall segment 30 may be considered as a second limitation feature 60 delimiting a range of motion of the second flexible wall segment 30 towards an inside of the mixing chamber 38.

15 A movement of the first flexible wall segment 20 towards an outside of the mixing chamber 38 is delimited by a wall of the first cavity 18, more precisely by a wall of the first portion 18a of the first cavity 18.

Consequently, this wall of the first portion 18a of the first cavity 18 forms a first abutment feature 62 delimiting a range of motion of the first flexible wall segment 20 towards an outside of the mixing chamber 38.

20 A movement of the second flexible wall segment 30 towards an outside of the mixing chamber 38 is delimited by a wall of the second cavity 28, more precisely by a wall of the first portion 28a of the second cavity 28.

25 Consequently, this wall of the first portion 28a of the second cavity 28 forms a second abutment feature 64 delimiting a range of motion of the second flexible wall segment 30 towards an outside of the mixing chamber 38.

It is noted that in the present example, the housing 16 comprising the mixing chamber 38, the first flexible wall segment 20, the second flexible wall segment 30, the first pneumatic actuation chamber 22 coupled to the first pneumatic port 24 and the second pneumatic actuation chamber 32 coupled to the second pneumatic port 34 are formed as a contiguous assembly unit 66.

Such an assembly unit 66 may be quickly and easily mounted in the apparatus 10 and dismounted from the apparatus 10. This is especially advantageous in applications in which the assembly unit 66 is a single-use unit which is discarded after use.

In the example of Figure 1, the contiguous assembly unit 66, i.e. the mixing device 14, is inserted into the apparatus 10 in an upright position. This means that in an installed state, the mixing device 14 is turned by 90° as compared to the representation of Figures 2 to 4. In this state, the plate 50 forming the passive swirling element 48 is in a vertical or upright position.

When installed in the apparatus 10, first valve 42 may be fluidically coupled to a first valve actuation unit 68.

The second valve 46 may be fluidically coupled to a second valve actuation unit 70.

In the present example, both the first valve actuation unit 68 and the second valve actuation unit 70 are configured to fluidically actuate the associated first valve 42 and second valve 46 respectively. To this end, both the first valve actuation unit 68 and the second valve actuation unit 70 may comprise a pressure generator and/or a vacuum generator. The first valve actuation unit 68 and the second valve actuation unit 70 may use a shared or common pressure generator and/or vacuum generator. Consequently, both the first valve 42 and the second valve 46 may be precisely opened or closed by applying pressure or vacuum to the associated diaphragms.

Moreover, the first pneumatic port 24 may be fluidically connected to a first actuator 72 being formed as a first pneumatic source.

Consequently, the first flexible wall segment 20 is displaceable by operating the first actuator 72.

The second pneumatic port 34 may be fluidically connected to a second actuator 74 being formed as a second pneumatic source.

Consequently, the second flexible wall segment 30 is displaceable by operating the second actuator 74.

- 5 In the present example, the first valve actuation unit 68, the second valve actuation unit 70, the first actuator 72 and the second actuator 74 form part of the mixing system 12 but are external to the mixing device 14. Consequently, the first valve actuation unit 68, the second valve actuation unit 70, the first actuator 72 and the second actuator 74 are also external to the contiguous assembly unit 66.
- 10 In practical terms, this means that the first valve actuation unit 68, the second valve actuation unit 70, the first actuator 72 and the second actuator 74 do not need to be discarded if the contiguous assembly unit 66 is discarded.

- One or more of the first housing half 16a and/or the second housing half 16b may be formed of a plastics material, such as cyclic olefin copolymer (COC). The first flexible wall segment
- 15 20 and/or the second flexible wall segment 30 may comprise a thermoplastic elastomer (TPE) material (with at least one thermoplastic and at least one elastomeric component) that is bonded within a respective of the first housing half 16a and/or the second housing half 16b. Bonding between such components may be provided by temperature induced heat/diffusion bonding, for example.

- 20 Where both of the first housing half 16a and the second housing half 16b comprise a TPE or other flexible wall segment membrane material, these may be either the same material or different materials (e.g. of the same thickness). The use of different materials (e.g. two different TPE materials) may be used to provide different expansion rates within the respective first pneumatic actuation chamber 22 and the second pneumatic actuation chamber 32 for a
- 25 same applied pressure. One advantage that can be achieved with such an arrangement is that the first actuator 72 and the second actuator 74 might then be driven by the same source, with any required pressure difference being provided by the differential elasticity provided by different membrane materials.

In various embodiments, the elastomeric component of a TPE membrane may comprise a SEBS (Styrene-Ethylene-Butadiene-Styrene) matrix, which can then be used as a base material to provide appropriate glass transition temperatures (T_g) for bonding and provide the elastomeric component with further desired properties. For example, there may also be included therein soft segments such as polyethylene and polybutadiene, and stiff segments such as polystyrene provided in quantities tailored to give an appropriate elasticity.

The membrane may also comprise at least one material component that has a glass transition temperature (T_g) that is matched to the glass transition temperature (T_g) of the housing half materials 16a, 16b (e.g. COC). This material component may be a thermoplastic used to at least partially replace the polypropylene that would otherwise generally be used in a conventional TPE based membranes. For example, COC8007 may be used with $T_g = 65-95\text{ }^{\circ}\text{C}$. One or more thermoplastic component (with a lower T_g or melting temperature than polypropylene) added into the TPE based membrane may then be used to provide a T_g that is substantially matched thereto. Matching of the T_g properties in this way enables improved diffusion bonding to occur by way of molecular movement between the components and provides a strong bond therebetween.

Various embodiments may thus use a thermoplastic elastomer (TPE) as a diaphragm material. The TPE may comprise at least one elastomeric material and at least one thermoplastic material having a glass transition temperature (T_g) from about 65 to about 95 $^{\circ}\text{C}$ (e.g. from about 70 $^{\circ}\text{C}$ to about 85 $^{\circ}\text{C}$ or about 75 $^{\circ}\text{C}$ to about 80 $^{\circ}\text{C}$). The at least one elastomeric material may comprise a SEBS (Styrene-Ethylene-Butadiene-Styrene) matrix and/or the at least one elastomeric material may comprise soft and/or stiff segments therein. Such soft segments may comprise polyethylene and/or polybutadiene and/or the stiff segments may comprise polystyrene.

Moreover, the mixing system 12 comprises a weighing unit 76 which is also external to the mixing device 14. The weighing unit 76 is configured to provide an indicator of a weight of the biological liquid inside the mixing chamber 38. In the configuration of Figure 1, the weighing unit 76 is arranged below the mixing device 14. Since the weight of each of the components of the mixing device 14 is known, a weight of the biological liquid inside the

mixing chamber 38 may be determined by weighing the mixing device 14 together with the biological liquid.

The mixing device 14 or mixing system 12 may be operated using a method for operating a mixing device for a biological liquid. The operation is illustrated in Figures 2 to 4.

- 5 In a first step S1 of the method, the first flexible wall segment 20 and the second flexible wall segment 30 are displaced in a direction away from one another. This may for example be done with the first flexible wall segment 20 and the second flexible wall segment 30 in a starting position as illustrated in Figure 2. At the same time, the inlet line 40 is opened by opening the first valve 42 using the first valve actuation unit 68. The outlet line 44 is closed by closing the
10 second valve 46 using the second valve actuation unit 70.

Consequently, biological liquid is drawn into the mixing chamber 38 via the inlet line 40.

The amount of biological liquid may be controlled using the weighing unit 76.

- Once the desired amount of biological liquid is determined to be located in the mixing chamber 38, the displacement of the first flexible wall segment 20 and the second flexible wall segment
15 30 may be stopped and the first valve 42 may be closed using the first valve actuation unit 68.

- It is noted that in an alternative, in which a maximum amount of biological liquid shall be drawn into the mixing chamber 38, the starting position of the first flexible wall segment 20 and the second flexible wall segment 30 may be altered such that both the first flexible wall segment 20 and the second flexible wall segment 30 abut against the passive swirling element
20 48 on opposite sides.

The biological liquid located in the mixing chamber 38 may now be mixed, i.e. homogenized. This may be done in a second step S2 of the method.

- To this end, the first flexible wall segment 20 and the second flexible wall segment 30 may be displaced into the same direction. This is done by pressurizing and depressurizing the first
25 pneumatic actuation chamber 22 and the second pneumatic actuation chamber 32 in a coordinated manner using the first actuator 72 and the second actuator 74. This is illustrated in Figures 3 and 4.

In Figure 3, both the first flexible wall segment 20 and the second flexible wall segment 30 are moved downwards, i.e. towards the second pneumatic port 34.

In Figure 4, both the first flexible wall segment 20 and the second flexible wall segment 30 are moved upwards, i.e. towards the first pneumatic port 24.

- 5 These movements of the first flexible wall segment 20 and the second flexible wall segment 30 are executed repeatedly. Consequently, the biological liquid located in the mixing chamber 38 is repeatedly pushed through the through holes 52 of the passive swirling element 48. Thereby, the biological liquid is mixed, i.e. homogenized.

- 10 Optionally, the heating element 54 may be operated such that the biological liquid in the mixing chamber 38 may be kept at the desired temperature or may be heated.

The biological liquid may for example be mixed for a predefined time span. Thereafter, a third step of the method may be executed.

In this step, the second valve 46 may be opened using the second valve actuation unit 70.

- 15 At the same time, the first flexible wall segment 20 and the second flexible wall segment 30 may be displaced towards one another. This has the effect that the biological liquid is expelled from the mixing chamber 38 via the outlet line 44.

The amount of biological liquid which has been expelled from the mixing chamber 38 may be controlled by the weighing unit 76.

- 20 It is noted that the full amount of biological liquid or just a portion thereof may be expelled from the mixing chamber 38.

In a case in which a maximum amount of biological liquid shall be expelled from the mixing chamber 38, both the first flexible wall segment 20 and the second flexible wall segment 30 need to be displaced until both abut against an associated side of the passive swirling element 48.

- 25 Another example of the mixing device 14 is illustrated in Figures 5 to 9.

In the following, only the differences with respect to the previous example will be explained. Beyond that, the previous explanations apply *mutatis mutandis*.

In the example of Figures 5 to 9, the housing 16 has a substantially cylindrical form with the housing halves 16a, 16b being shaped as half-shells.

- 5 Furthermore, in the example of Figures 5 to 9, a supply line 78 is fluidically connected to the first valve 42. The supply line 78 is configured to supply biological liquid to the mixing device 14. Consequently, by actuating the first valve 42, the supply line 78 and the inlet line 40 may be selectively fluidically connected or separated.

- Also in the present example, the first valve 42 is a diaphragm valve which is fluidically
10 actuatable. To this end, a fluidic actuation line 80 is connected to the first valve 42. The fluidic actuation line 80 may be considered to form part of the first valve actuation unit 68.

- Moreover, a discharge line 82 is fluidically connected to the second valve 46. The discharge line 82 is configured to withdraw biological liquid from the mixing device 14. Consequently, by actuating the second valve 46, the discharge line 82 and the outlet line 44 may be selectively
15 fluidically connected or separated.

Also in the present example, the second valve 46 is a diaphragm valve which is fluidically actuatable. To this end, a fluidic actuation line 84 is connected to the second valve 46. The fluidic actuation line 84 may be considered to form part of the second valve actuation unit 70.

- Moreover, a first actuator line 86 is fluidically connected to the first pneumatic port 24 such
20 that the first actuator line 86 fluidically connects the first actuator 72 and the first pneumatic port 24.

In the same manner, a second actuator line 88 is fluidically connected to the second port 34 such that the second actuator line 88 fluidically connects the second actuator 74 and the second pneumatic port 34.

- 25 The example of Figures 5 to 9 further differs from the example of Figures 2 to 4 in that a first venting valve 90 is provided. The first venting valve 90 is fluidically connected to the first

pneumatic actuation chamber 22 and to an environment. The connection to the environment is realized using a first venting line 92.

Also the first venting valve 90 is a diaphragmatic valve which is fluidically actuatable. To this end, a fluidic actuation line 94 is connected to the first venting valve 90.

- 5 Consequently, by actuating the first venting valve 90 via the fluidic actuation line 94, the first pneumatic actuation chamber 22 may be selectively vented or selectively fluidically separated from the environment.

Thus, in the example of Figures 5 to 9, the first pneumatic port 24 is only configured to provide pressurized pneumatic fluid, e.g. air, to the first pneumatic actuation chamber 22.

- 10 In other words, the first flexible wall segment 20 may be displaced by pressurizing the first pneumatic actuation chamber 22 using the first pneumatic port 24 and by depressurizing the first pneumatic actuation chamber 22 using the first venting valve 78.

- Moreover, a second venting valve 96 is provided. The second venting valve 96 is fluidically connected to the second pneumatic actuation chamber 32 and to the environment. The
15 connection to the environment is realized using a second venting line 98.

Also the second venting valve 96 is a diaphragm valve which is fluidically actuatable. To this end, a fluidic actuation line 100 is connected to the second venting valve 96.

- Consequently, by actuating the second venting valve 96 via the fluidic actuation line 100, the second pneumatic actuation chamber 32 may be selectively vented or selectively fluidically
20 separated from the environment.

Thus, in the example of Figures 5 to 9, the second pneumatic port 34 is only configured to provide pressurized pneumatic fluid, e.g. air, to the second pneumatic actuation chamber 32.

- In other words, the second flexible wall segment 30 may be displaced by pressurizing the second pneumatic actuation chamber 32 using the second pneumatic port 34 and by
25 depressurizing the second pneumatic actuation chamber 32 using the second venting valve 96.

Moreover, in the example of Figures 5 to 9, the passive swirling element 48 is clamped between the two housing halves 16a, 16b.

The first flexible wall segment 20 and the second flexible wall segment 30, i.e. the membranes, are heated-bonded to the associated sides of the passive swirling element 48.

- 5 Furthermore, in the example of Figures 5 to 9, the flexible wall segment 20 additionally forms the diaphragms of the first valve 42, the second valve 46, the first venting valve 90 and the second venting valve 96.

It is noted that the heat-bonding of the first flexible wall segment 20 and the second flexible wall segment 30 is optional. In another example, the first flexible wall segment 20 and the
10 second flexible wall segment 30 may be simply clamped between one of the housing halves 16a, 16b and the passive swirling element 48.

It is noted that despite the fact of the supply line 78, the discharge line 82, the actuation lines 80, 84, 94, 100, the first actuator line 86, the second actuator line 88 and the venting lines 92, 98 being fixedly connected to the housing 16, also in the example of Figures 5 to 9, the mixing
15 device may be formed as a contiguous assembly unit 66. To this end, the fixed connections of the said lines need to be replaced by suitable couplings that allow for fluidically coupling in a state in which the mixing device 14 is mounted in the apparatus 10. In simplified words, the said lines then form lines internal to the apparatus 10 but external to the mixing device 14.

The mixing device 14 of Figures 5 to 9 may be operated in the same manner as has been
20 explained in connection with the example of Figures 2 to 4, the only difference relating to the venting of the first pneumatic actuation chamber 22 and the second pneumatic actuation chamber 32.

Figure 7 illustrates the first step S1 in which the first valve 42 is open and the second valve 46 is closed. At the same time, the first flexible wall segment 20 and the second flexible wall
25 segment 30 are displaced away from one another such that biological liquid is drawn into the mixing chamber 38. In the representation of Figure 7, the first flexible wall segment 20 abuts against the abutment feature 62 and the second flexible wall segment 30 abuts against the abutment feature 64.

Figure 8 illustrates the second step S2 in which both the first valve 42 and the second valve 46 are closed. The first flexible wall segment 20 and the second flexible wall segment 30 are displaced into the same direction. In the representation of Figure 8, the first flexible wall segment 20 abuts against the limitation feature 58 and the second flexible wall segment 30 abuts against the abutment feature 64.

Figure 9 illustrates the third step S3 in which the first valve 42 is closed and the second valve 46 is open. The first flexible wall segment 20 and the second flexible wall segment 30 are displaced towards each other such that the biological liquid is expelled from the mixing chamber 38 via the outlet line 44. In the representation of Figure 9, the first flexible wall segment 20 abuts against the limitation feature 58 and the second flexible wall segment 30 abuts against the limitation feature 60.

In this context, both the mixing device 14 of Figures 2 to 4 and the mixing device of Figures 5 to 9 may be operated according to a first mode of operation in which the mixing chamber 38 is always completely or quasi-completely emptied after completion of the mixing process in the second step S2. After emptying, new biological fluid may be provided in the mixing chamber 38. In other words, the first step S1, the second step S2 and the third step S3 may be executed periodically.

In case these steps are executed within a comparatively small time span, i.e. with sufficient speed, the mixing of the biological fluid using the mixing device 14 may be done in a quasi-continuous manner.

Alternatively, both the mixing device 14 of Figures 2 to 4 and the mixing device of Figures 5 to 9 may be operated according to a second mode of operation. In this mode of operation, the mixing chamber 38 is never completely emptied. Rather, a comparatively small volume of biological fluid is expelled from the mixing chamber 38 in the second step S2 and a corresponding, small volume of biological fluid is drawn into the mixing chamber 38 in the first step S1. Also in this mode of operation, the first step S1, the second step S2 and the third step S3 may be executed periodically, wherein at each iteration the comparatively small volume of mixed biological fluid is provided.

Also when using the second mode of operation, the mixing of the biological fluid using the mixing device 14 may be done in a quasi-continuous manner in case these steps are executed within a comparatively small time span, i.e. with sufficient speed.

Reference Signs

	10	apparatus for treating a biological liquid
	12	mixing system
	14	mixing device
5	16	housing
	16a	first housing half
	16b	second housing half
	18	first cavity
	18a	first portion of the first cavity
10	18b	second portion of the first cavity
	20	first flexible wall segment
	22	first pneumatic actuation chamber
	24	first pneumatic port
	26	first actuator interface
15	28	second cavity
	28a	first portion of the second cavity
	28b	second portion of the second cavity
	30	second flexible wall segment
	32	second pneumatic actuation chamber
20	34	second pneumatic port
	36	second actuator interface
	38	mixing chamber
	40	inlet line
	42	first valve
25	44	outlet line
	46	second valve
	48	passive swirling element
	50	plate
	52	through hole
30	54	heating element
	56	heating wire
	58	first limitation feature
	60	second limitation feature

	62	first abutment feature
	64	second abutment feature
	66	contiguous assembly unit
	68	first valve actuation unit
5	70	second valve actuation unit
	72	first actuator
	74	second actuator
	76	weighing unit
	78	supply line
10	80	actuation line
	82	discharge line
	84	actuation line
	86	first actuator line
	88	second actuator line
15	90	first venting valve
	92	first venting line
	94	actuation line
	96	second venting valve
	98	second venting line
20	100	actuation line
	S1	first step
	S2	second step
	S3	third step

CLAIMS:

1. A mixing device (14) for a biological liquid, the mixing device (14) comprising a mixing chamber (38) delimited by a first flexible wall segment (20) and by a second flexible wall segment (30), wherein the first flexible wall segment (20) and the second flexible wall segment (30) are arranged on different sides of the mixing chamber (38), wherein the first flexible wall segment (20) comprises a first actuator interface (26) configured to couple a first actuator (72) to the first flexible wall segment (20) such that the first flexible wall segment (20) is displaceable by operating the first actuator (72), and
- wherein the second flexible wall segment (30) comprises a second actuator interface (36) configured to couple a second actuator (74) to the second flexible wall segment (30) such that the second flexible wall segment (30) is displaceable by operating the second actuator (74).
2. The mixing device (14) of claim 1, further comprising a passive swirling element (48) arranged inside the mixing chamber (38) and arranged between the first flexible wall segment (20) and the second flexible wall segment (30).
3. The mixing device (14) of claim 2, wherein the passive swirling element (48) comprises a plate (50) having a plurality of through holes (52).
4. The mixing device (14) of any one of the preceding claims, further comprising a heating element (54).
5. The mixing device (14) of any one of the preceding claims, further comprising a first abutment feature (62) delimiting a range of motion of the first flexible wall segment (20) towards an outside of the mixing chamber (38) and/or comprising a second abutment feature (64) delimiting a range of motion of the second flexible wall segment (30) towards an outside of the mixing chamber (38).

6. The mixing device (14) of any one of the preceding claims, further comprising a first limitation feature (58) delimiting a range of motion of the first flexible wall segment (20) towards an inside of the mixing chamber (38) and/or comprising a second limitation feature (60) delimiting a range of motion of the second flexible wall segment (30) towards an inside of the mixing chamber (38).
7. The mixing device (14) of any one of the preceding claims, further comprising a first pneumatic actuation chamber (22) delimited by at least a portion of the first flexible wall segment (20) and fluidically coupled to a first pneumatic port (24) configured to connect the first pneumatic actuation chamber (22) to a pneumatic source and/or comprising a second pneumatic actuation chamber (32) delimited by at least a portion of the second flexible wall segment (30) and fluidically coupled to a second pneumatic port (36) configured to connect the second pneumatic actuation chamber (32) to a pneumatic source.
8. The mixing device (14) of claim 7 wherein the mixing chamber (38), the first flexible wall segment (20), the second flexible wall segment (30), and the first pneumatic actuation chamber (22) fluidically coupled to the first pneumatic port (24) and/or the second pneumatic actuation chamber (32) fluidically coupled to the second pneumatic port (34), are formed as a contiguous assembly unit (66).
9. The mixing device (14) of any one of the preceding claims, further comprising an inlet line (40) having a first end fluidically coupled to the mixing chamber (38) and a second end fluidically coupled to a first valve (42) configured to selectively open and close the inlet line (40).
10. The mixing device (14) of claim 9, wherein the first valve (42) is a diaphragm valve and/or wherein the first valve (42) is fluidically actuatable.

11. The mixing device (14) of any one of the preceding claims, further comprising an outlet line (44) having a first end fluidically coupled to the mixing chamber (38) and a second end fluidically coupled to a second valve (46) configured to selectively open and close the outlet line (44).
- 5
12. The mixing device (14) of claim 11, wherein the second valve (46) is a diaphragm valve and/or wherein the second valve (46) is fluidically actuatable.
13. The mixing device (14) of any preceding claim, wherein first flexible wall segment (20) and/or the second flexible wall segment (30) comprise a respective thermoplastic elastomer (TPE) material that is heat/diffusion bonded within a respective of a first housing half (16a) and/or a second housing half (16b) of the mixing device (14).
- 10
14. A mixing system (12) for a biological liquid, comprising a mixing device (14) according to any one of the preceding claims, a first actuator (72) and a second actuator (74), wherein the first actuator (72) is coupled to the first actuator interface (26) of the first flexible wall segment (20) such that the first flexible wall segment (20) is displaceable by operating the first actuator (72), and wherein the second actuator (74) is coupled to the second actuator interface (36) of the second flexible wall segment (30) such that the second flexible wall segment (30) is displaceable by operating the second actuator (74).
- 15
- 20
15. The mixing system (14) of claim 14, further comprising a weighing unit (76) configured to provide an indicator of a weight of a liquid inside the mixing chamber (38).
- 25
16. A method for operating a mixing device (14) for a biological liquid, the mixing device (14) comprising a mixing chamber (38) delimited by a first flexible wall segment (20) and by a second flexible wall segment (30), wherein the first flexible wall segment (20) and the second flexible wall segment (30) are arranged on different sides of the mixing chamber (38), the method comprising:
- 30

- displacing the first flexible wall segment (20) and the second flexible wall segment (30) away from one another in order to draw liquid into the mixing chamber (38) (S1), and/or
- 5 – displacing the first flexible wall segment (20) and the second flexible wall (30) segment into the same direction in order to mix the liquid inside the mixing chamber (38) (S2), and/or
- displacing the first flexible wall segment (20) and the second flexible wall segment (30) towards one another in order to expel liquid from the mixing chamber (38) (S3).

10