

Swivel stack for transfer of fluid across a rotary interface and method for manufacturing such a swivel stack.

Technical field

5 The present invention relates to a swivel stack for transfer of fluid across a rotary interface around a rotation axis between an incoming flow-line and an outgoing flow-line.

Moreover, the invention relates to a turret mooring system comprising such a swivel stack. Also, the invention relates to a floating offshore construction provided with such a swivel stack and to a method for manufacturing such a swivel stack

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Background art

Toroidal fluid swivels are known in the art for transfer of high-pressure fluids across a rotary interface between an incoming fluid line and an outgoing product piping. Applications for such a swivel include for example offshore oil and gas explorations where high-pressure
15 flows of oil and/or gas are transferred from a (deep-sea) offshore well to a floating vessel such as a Floating Production Storage and Offloading (FPSO) vessel. Typically, such a floating vessel is equipped with a turret mooring system that can couple a mooring buoy or a "mooring structure" and that holds one or more riser lines from the well, to product piping ducts on the vessel. Since the turret mooring system should allow some rotation between the
20 vessel and the buoy, the swivel is likewise adapted to provide rotation between the incoming fluid line and the product piping.

In swivel designs, the rotary interface is provided with seals to prevent leakage. Within the rotary interface the seals are subjected to high pressure differences between the high-pressure fluids running through the swivel and ambient.

25 Also, the seals are subjected to mechanical wear due to rotation of the interface. In the prior art, swivels (swivel stacks) thus face several issues affecting their performance and reliability; the main issue being the practical inability to change-out the dynamic seals in-situ, due to the relatively large size of the swivel parts.

Another major issue is the difficulty to meet seal design criteria, especially when seal
30 diameter, temperature range, or fluid pressure increases. It is an object of the invention to overcome or mitigate the disadvantages of the prior art.

Summary of the invention

The object is achieved by a swivel stack in accordance with appended claim 1. The
35 structure of the swivel stack allows a relatively uncomplicated manner of assembly or

disassembly, which also enhances the procedure to change-out any seals in the swivel stack.

Further, the invention relates to a turret mooring system equipped with a swivel stack as defined above, to a floating offshore construction provided with a swivel stack as defined
5 above and to a method for manufacturing a swivel stack as defined above.

Brief description of drawings

The invention will be explained in more detail below with reference to drawings in which illustrative embodiments thereof are shown. The drawings are intended exclusively for
10 illustrative purposes and not as a restriction of the inventive concept. The scope of the invention is defined in the appended claims.

Figure 1 shows a cross-section in perspective view of a swivel stack according to an embodiment of the invention;

Figure 2 shows a detailed cross-section of the rotary interface of a swivel stack according to
15 an embodiment of the invention;

Figure 3 shows a detailed cross-section of the rotary interface of a swivel stack according to an embodiment of the invention;

Figure 4A and 4B shows detailed cross-sections of a stab-in pipe for use in a swivel stack according to an embodiment of the invention;

20 Figure 5 shows a perspective view of a swivel stack according to an embodiment of the invention;

Figure 6 shows a perspective view of a portion of a manifold block in accordance with an embodiment of the invention, and

Figure 7 shows schematically a floating offshore construction equipped with a swivel stack in
25 accordance with an embodiment of the invention.

In the following description of embodiments, items indicated by an identical reference sign refer to the same or a similar item.

Detailed description of embodiments

30 Figure 1 shows a cross-section in perspective view of a swivel stack according to an embodiment of the invention.

A rotary interface 72 of a swivel stack 10 in accordance with the invention is constructed from a plurality of annular elements comprising a group of inner annular elements and an outer annular element that are all centered around a common rotation axis
35 A.

In this rotary interface, the outer annular element is configured for rotation around the rotation axis A relative to the group of inner annular elements.

The rotary interface comprises a group of inner annular elements 12, 14, 16 and an outer annular element 18. The group of inner annular elements comprises a lower annular element 12, a central annular element 14 and an upper annular element 16.

Each of inner annular elements 12, 14, 16 has a cylindrical inner surface at an inner
5 radius R11. The lower and upper annular elements 12, 16 each have a cylindrical outer surface at a first outer radius RO1. The central annular element 14 has a cylindrical outer surface at a second outer radius RO2. The second outer radius RO2 is smaller than the first outer radius RO1.

When the inner, central and outer annular elements are stacked on each other, with the
10 central annular element 14 positioned between the lower annular element 12 and the upper annular element 16, a circular trench is present between facing surfaces 12a, 16a of the lower annular element and the upper annular element, which surfaces are substantially perpendicular to the rotating axis A.

The outer annular element 18 has a cylindrical inner surface at a second inner radius
15 R12 and a cylindrical outer surface at a third outer radius RO3, and is also centered around the rotation axis A. The second inner radius R12 of the outer annular element 18 is somewhat larger than the second outer radius RO2 of the central inner annular element 14 in such a way there is a radial gap G (see Figure 2 and Figure 3) of about 1 mm between the central inner annular element and the outer annular element. The outer annular element 18 is
20 arranged in the circular trench between the lower and the upper inner annular elements 12, 16 such that the cylindrical inner surface 22 of the outer annular element abuts the outer cylindrical surface 20 of the central inner annular element. Along the circumference of the cylindrical inner surface of the outer annular element a recess 24 is provided such that a toroidal chamber 24a is formed between the cylindrical outer surface 20 of the central inner
25 annular element and the cylindrical inner surface 22 of the outer annular element 18.

In the outer annular element 18, a conduit 26 in radial direction is provided between the recess 24 and the outer circumference to provide an outlet (or inlet) of the toroidal chamber 24a.

The upward surface 12a of the lower annular element 12 and the downward surface
30 16a of the upper annular element 16 that each extend outward beyond the cylindrical outer surface 20 of the central annular element 14 at the second outer radius RO2, are provided with a first stepped surface. The outer annular element 18 has upward and downward surfaces 18a, 18b with a second stepped surface that is complementary to the first stepped surface.

35 Between the downward facing surface 16a of the upper annular element 16 and the upward facing surface 18b of the outer annular element 18 and between the upward facing surface 12a of the lower annular element 12 and the downward facing surface 18a of the

outer annular element 18, annular cavities 28, 30, 32, 34 are formed in which face seal type seal rings are arranged (not shown here). The arrangement of the annular cavities and the seal rings will be described in more detail with reference to Figure 2.

Referring to Figure 1, the swivel stack can comprise a plurality of rotary interfaces. To
5 simplify stacking, the lower and upper annular elements 12, 16 are designed with a same shape of their upper and lower surfaces 12a, 16a (perpendicular to the rotation axis A). In this manner an upper annular element 16 of a first rotary interface can be used as a lower annular element 12 of a second rotary interface stacked on top of the first rotary interface.

In between each pair of stacked outer annular elements a coupling ring or drive ring 36
10 is placed. The coupling rings are configured to couple the outer annular element pairwise for joined rotation. One of coupling rings is fitted with a pair of lugs (not shown) designed to receive a pair of drive arms 38 for coupling to an external structure (not shown) on the floating structure (not shown).

The swivel stack 10 comprises a base annular element 40 on which a lower support
15 annular element 42 is arranged. The lower support annular element 42 has an upward facing surface 42a that has an identical shape as an upward facing surface 12a of the lower annular element 12 as described above. The lower support annular element 42 has a stepped upward facing surface on which an outer annular element 18 can be arranged in a manner that annular cavities are present in between the annular elements 42, 18.

20 The base annular element 40 is provided on its circumference with inlet ports 44 (and/or outlet ports) in radial direction that are each configured to be coupled with an incoming flow-line 46 or outgoing flow-line, respectively. Further, each inlet or outlet port 44 is coupled within the base annular element 40 with a conduit 48 extending upward and parallel to the rotation axis A.

25 Each of the inner annular elements 12, 14, 16 is provided with at least one through-hole 50 for transport of (hydrocarbon) fluids parallel to the rotation axis A. In each inner annular element 12, 14, 16 the at least one through-hole 50 is positioned at a location corresponding with the location of the conduit 48 in the base annular element 40.

On the top of the swivel stack 10, a closing annular element 52 can optionally be
30 arranged. The closing annular element 52 can also function as a support or (fluid) connector for an other swivel stack located above.

Within the swivel stack 10, the inner annular elements 12, 14, 16 are joined between
the base annular element 40 and the closing annular element 52 by a plurality of bolted rods 54 extending through holes arranged on a pitch diameter DP of the annular elements. A
35 more detailed illustration will be given below with reference to Figure 2.

Figure 2 shows a detailed cross-section of the rotary interface of a swivel stack according to an embodiment of the invention.

The first and second stepped surfaces have a layout in which four annular cavities 28, 30, 32, 34 are centered around the rotation axis A. The first and second stepped surfaces have a rectangular cross-section and are provided between the central outer annular element 18 and the lower and upper inner annular elements 12, 16. Two of the annular
5 cavities 28, 30 are arranged at a first interface A1 between the facing surfaces 16a, 18b of the upper annular element 16 and the outer annular element 18. The other two annular cavities 32, 34 are arranged at a second interface A2 between the facing surfaces 12a, 18a of the lower annular element 12 and the outer annular element 18. In each of the annular cavities 28, 30, 32, 34 a face seal type seal ring 56 is installed.

10 In Figure 2, a portion of an arrangement of the lower annular element 12, the central annular element 14, the upper annular element 16 in combination with the outer annular element 18 is shown. Also, a portion of a bolted rod 54 is shown, extending through the lower, central and upper annular elements.

Above and below the toroidal chamber 24a, the annular cavities 28, 30, 32, 34 are
15 arranged at a first and second interface A1, A2 between the outer annular element 18 and the upper annular element 16, and the central annular element 14 and the lower annular element 12, respectively.

At both first and second interfaces A1, A2 an hydraulic area H, i.e., a radial area H where the annular cavities and corresponding seal rings are located, is kept minimal. That is,
20 each of the annular cavities has a radial width W and each seal ring has a corresponding width when placed in the associated annular cavity. Between the two annular cavities 28, 30; 32, 34 in each of the first interface A1 and the second interface A2 a non-zero interspace X is arranged. Thus the radial area H has a width equal to the width W of the two annular cavities 28, 30; 32, 34 plus the interspace X in the same interface A1; A2.

25 In addition, to keep the hydraulic area H minimal, in each interface one of the two annular cavities 28; 32 is arranged directly adjacent to the cylindrical outer end surface 15 of the central annular element 14.

A radial width B of the toroidal chamber 24a is equal to or smaller than a height C of the toroidal chamber 24a. Additionally, the radial width B of the toroidal chamber is smaller
30 than the width of the hydraulic area H (i.e., the width W of the two annular cavities combined 28, 30; 32, 34 plus the interspace X in the same interface A1; A2). At the same time, the inner diameter of the radially inner seal ring is substantially equal to the inner diameter of the toroidal chamber. When the toroidal chamber is under operational pressure, these measures have the effect that the vertical force F2 on the seals in the first and second interfaces A1; A2
35 is smaller than the vertical force F1 on the upper and lower radial walls of the toroidal chamber 24a.

In addition, in each of the upward and downward facing surfaces 18a, 18b of the outer annular element 18, a bushing 58 (plain bearings) is positioned outside the hydraulic area H, thus at larger radius than the radius of the seal rings 56.

5 In an embodiment, the bolted rods 54 are positioned at a distance to the second outer radius RO2 so as to leave 5 to 10 mm gap between the bolt hole and an O-ring seal groove 60 holding an O-ring seal ensuring tightness between the central annular element 14 and the lower/upper inner annular element 12; 16. To achieve this, the centre of each rod is located towards the outer radius RO1 and away from the inner radius RI1 in the central annular element.

10 In this manner, the clamping force on each of the inner annular elements 12, 14, 16 is mainly acting on the O-ring seal groove 60 to limit opening and risk of extrusion of the O-ring seal out of the O-ring seal groove 60 when associated flow lines and toroidal chamber in the swivel stack 10 are under high operating pressure. This technique translates the attempt to minimize the prying effect on the bolted rods (see below).

15 It is recognized that a pressure induced end cap force is acting on the hydraulic area H – from the inner diameter of the O-ring seal groove 60 to an outer diameter of the outer annular cavity groove (holding the face seal). This force tends to open both the interface between the central annular element and lower annular element and the interface between the central annular element and upper annular element. The pressure induced end cap force
20 is amplified by the ratio of the distance of the hydraulic area H to the inner radius RI1 to the distance of the bolt 54 to the same inner radius RI1 (prying effect): obviously the larger the distance of the bolt 54 to inner radius RI1, the smaller the tensile load on the bolt 54. This property is vital for this type of design.

According to an embodiment, the first and second stepped surfaces have a layout in
25 which at least two annular cavities 28, 30, 32, 34 are centered around the rotation axis A with half of the at least two of the annular cavities located at a first interface between the downward facing surface of the upper annular element and the upward facing surface of the outer annular element and the other half of the at least two annular cavities located at a second interface between the upward facing surface of the lower annular element and the
30 downward facing surface of the outer annular element, respectively.

Figure 3 shows a detailed cross-section of the rotary interface of a swivel stack according to an embodiment of the invention.

The rotary interface shown in Figure 3 is largely identical to the rotary interface of Figure 2. Features with identical reference sign as in Figure 2 will not be described here.

35 In the interface shown in Figure 3, additional recesses 62 are provided in the outer annular element 18 on either side of the toroidal chamber 24a to fit two additional seal rings 64, piston orientated. The additional seal rings 64 may be referred to as isolation seals,

providing further isolation of the toroidal chamber 24a in the circumferential direction of the rotary interface.

Figure 4a and 4b show details of a stab-in tube 66 for use in a swivel stack 10 according to an embodiment of the invention.

5 In the through-holes 50 extending through the inner annular elements 12, 14, 16 of the swivel stack 10 a stab-in tube 66 can be placed to provide a conduit that runs between the base annular element 40 and the central annular element 18 associated with the respective through-hole connected to radial conduit 26 of the central annular element.

10 The stab-in tube 66 has closed end caps 68 and is provided with openings 70a, 70b in its side wall at the level of the radial conduit 44 of the base annular element 40 and the level of the radial conduit 26 in the central annular element 18, respectively.

In this manner a flow path for the fluid flowing through the stab-in tube is obtained that is leak-proof.

Figure 4A shows a cross-section of the stab-in tube 66. Figure 4B shows a
15 cross-section of a swivel stack with a stab-in tube 66 mounted in the through-holes 50 of the inner annular elements 12, 14, 16.

Figure 5 shows a perspective view of a swivel stack according to an embodiment of the invention.

20 The swivel stack 10 depicted here, comprises the base annular element 40, a number of rotary interfaces 72, 74, 76, 78 and a closing annular element 52.

Further, the swivel stack 10 comprises a pair of coupling arms 30 attached to one of the coupling rings 36. The coupling arms are configured to be coupled to a vessel (not shown) in which the swivel stack is mounted. The coupling arms provide a fixed orientation of the rotary interfaces with respect to the vessel.

25 On the outer cylindrical end surface of each rotary interface additional probing ports 80 can be present, which provide access to leak ports (not shown) in the hydraulic area H.

Figure 6 shows a perspective view of a manifold block in accordance with an embodiment of the invention.

30 When the swivel stack 10 is arranged on a turret mooring system on a floating object such as a vessel, the ports 44 for incoming/outgoing fluid on the base annular element 40 of the swivel stack can be coupled to riser lines 82 attached to a manifold structure (earthbound part) within the turret of the turret mooring system.

According to an embodiment, a riser line 82 is equipped with a pipe flange 84. The pipe flange 84 of the riser line 82 is then coupled to an associated port 44 on the base annular
35 element 40 by a flange 88 of spool piece 86 or connecting tube. The spool piece 86 is equipped with a spool piece flange 89 that is configured for connecting to the pipe flange 84 of the riser line 82. Spool pieces of different lengths and with different orientations of

connectors on the flanges 88, 89 can be used for making a fluid connection between a riser line 82 and a port 44 for incoming/outgoing fluid.

Figure 7 shows schematically an example of a floating offshore construction equipped with a swivel stack in accordance with an embodiment of the invention.

5 A floating production unit 1 such as an FPSO vessel, or in general an offshore vessel, is moored at a location at sea near a reservoir R in the seabed. Process equipment 2 on the vessel is shown schematically.

The floating production unit 1 is turret moored. In Figure 7, according to an embodiment, the floating production unit is shown as turret moored, by means of a turret
10 mooring system.

Turret mooring systems provide a turret mooring structure comprising a turret structure 3 such as a mooring buoy and a support structure mounted on either the outside or the inside of the floating production unit 1. The turret structure 3 is anchored to the seabed with anchoring lines 5. Riser lines 82 (and other lines and other equipments 90 such as umbilical
15 lines, gas/water injection lines, electric power lines, valves/shutters, etc.) are extending between the reservoir R under the seabed and the turret structure 3. The support structure, provided on the floating production unit 1, has a receptacle for receiving the turret structure 3, such that rotation of the floating production unit 1 about the turret structure 3 is still possible. In this manner, the floating production unit 1 can weathervane under influence of
20 wind, waves, currents and/or drifting ice and adopt the position of least resistance with regard to the environment, while the riser lines remain at their unrotated position.

A swivel stack 10 according to an embodiment of the invention is arranged in the turret mooring system to provide one or more rotary interfaces between the riser lines 82 and process equipment 2 on the floating vessel.

25 According to an embodiment, the inner and outer annular elements are obtained from steel forgings and machined to the desired final shapes. The steel forgings may be based on carbon steel or stainless steel.

The invention has been described with reference to some embodiments. The swivel stack shown is described here by way of an example. Configurations with a different number
30 of rotary interfaces can be constructed within the scope of the invention.

Obvious modifications and alterations will occur to the person skilled in the art upon reading and understanding the preceding detailed description, which is to be considered in all respects only as illustrative and not restrictive. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the
35 scope of the appended claims. The scope of the invention is, therefore, indicated by the appended claims rather than by the foregoing description.

References

	Floating production unit	1
	Processing equipment	2
	Turret structure	3
5	Anchoring line	5
	Swivel stack	10
	Inner annular elements	12, 14, 16
	Cylindrical outer end surface	15
	Upward surface	12a
10	Downward surface	16a
	Outer annular element	18
	Downward facing surface	18a
	Upward facing surface	18b
	Outer cylindrical surface	20
15	Cylindrical inner surface	22
	Recess	24
	Toroidal chamber	24a
	Conduit	26
	Annular cavities	28, 30, 32, 34
20	Coupling ring or drive ring	36
	Pair of drive arms	38
	Base annular element	40
	Lower support annular element	42
	Inlet/outlet ports	44
25	Flow-line	46
	Through-hole	50
	Closing annular element	52
	Bolt	54
	Face seal type seal ring	56
30	Bushing	58
	O-ring seal groove	60
	Additional recess	62
	Isolation seal	64
	Stab-in tube	66
35	Opening	70a, 70b
	Rotary interface	72, 74, 76, 78
	Probing port	80

	Riser line	82
	Pipe flange	84
	Spool piece	86
	Spool piece flange	88
5	Equipment	90
	Interface	A1, A2
	Rotating axis	A
	Pitch diameter	DP
10	Radial gap	G
	Hydraulic area	H
	Radial width of chamber	B
	Height of chamber	C
	Vertical force	F1, F2
15	Reservoir	R
	First outer radius	RO1
	Second outer radius	RO2
	Third outer radius	RO3
	First inner radius	RI1
20	Second inner radius	RI2
	Radial width	W
	Interspace	X

Claims

1. Swivel stack for transfer of fluid across a rotary interface around a rotation axis between an incoming flow-line and an outgoing flow-line,
the swivel stack comprising:
 - 5 a group of inner annular elements that comprises a lower annular element, an upper annular element and a central annular element;
the lower annular element being centered around the rotation axis with an inner radius and a first outer radius;
the upper annular element being centered around the rotation axis with the inner radius
10 and the first outer radius;
the central annular element being centered around the rotation axis and having an outer cylindrical end surface, positioned between the lower annular element and the upper annular element, the central annular element having the inner radius and a
15 second outer radius, with the second outer radius between inner radius and first outer radius, in a manner that a circular trench is present between an upward facing surface of the lower annular element and a downward facing surface of the upper annular element, the downward and upward facing surfaces each being perpendicular to the rotating axis;
the swivel stack further comprising:
 - 20 an outer annular element centered around the rotation axis and having an inner end surface with a second inner radius and a third outer radius, with the third outer radius larger than the first outer radius and the second inner radius being substantially equal to the second outer radius with a gap between the outer annular element and the
25 central inner annular element; the downward and upward facing surfaces of the outer annular element being directly adjacent to the upward facing surface of the lower annular element and the downward facing surface of the upper annular element, respectively;
the inner end surface of the outer annular element abutting the flat cylindrical end surface of the central annular element and provided with a circular trench, such that a
30 toroidal chamber is formed between the central annular element and the outer annular element,
wherein the upward facing surface of the lower annular element and the downward facing surface of the upper annular element have a first stepped surface and the
upward and downward facing surfaces of the outer annular element have a second
35 stepped surface, and the first and second stepped surfaces are configured in a manner that at least two annular cavities centered around the rotation axis and having a rectangular cross-section are provided, half of the at least two of the annular cavities at

- a first interface between the downward facing surface of the upper annular element and the upward facing surface of the outer annular element and the other half of the at least two annular cavities at a second interface between the upward facing surface of the lower annular element and the downward facing surface of the outer annular element, respectively, and
- wherein a radial width of the toroidal chamber is equal to or smaller than a height of the toroidal chamber, and the radial width of the toroidal chamber is smaller than a width of the two annular cavities combined.
2. Swivel stack according to claim 1, wherein a face seal type seal ring is arranged in each of the at least two annular cavities.
3. Swivel stack according to claim 1 or claim 2, wherein in each interface said half of the at least two annular cavities are separated from each other by an interspace in radial direction.
4. Swivel stack according to any one of the preceding claims 1 – 3, wherein in a radial direction each of the annular cavities is defined between an outward edge on one annular element selected from the group of inner annular elements and an inward edge on the outer annular element; surfaces of the inward and outward edges being parallel to the direction of the rotation axis, and in the direction parallel to the rotation axis each of the annular cavities is defined at the first interface between the upward facing surface of the outer annular element and the downward facing surface of the upper annular element and at the second interface between the downward facing surface of the outer annular element and the upward facing surface of the lower annular element.
5. Swivel stack according to any one of the preceding claims 1 – 4, wherein each of the annular cavities is defined by a width WS in the radial direction and a depth HS in the direction parallel to the rotation axis.
6. Swivel stack according to any one of preceding claims 1 – 5, wherein an annular additional recess above and an annular additional recess below the circular trench in the inner end surface of the outer annular element are provided; each additional recess fitted with a piston orientated seal ring.

7. Swivel stack according to any one of preceding claims 1 – 6, wherein in each interface an annular bushing is arranged and the radially outermost annular cavity is separated from the annular bushing by a second interspace in radial direction.
- 5 8. Swivel stack according to any one of preceding claims 1 – 7, wherein each of the lower annular element, upper annular element and central annular element are configured with at least one through-hole extending in the direction parallel to the rotation axis, the at least one through-hole having a corresponding position in each of the lower annular element, upper annular element and central annular element.
- 10 9. Swivel stack according to claim 8, wherein the central annular element is configured with at least one radial conduit running from one of the at least one through-hole to the outer cylindrical end surface, the radial conduit arranged for fluid communication with the toroidal chamber.
- 15 10. Swivel stack according to any one of the preceding claims, further comprising a base annular element having at least one through-hole with a position corresponding to the position of the at least one through-hole in each of the lower annular element, upper annular element and central annular element, and
- 20 further comprising a radial conduit extending from the through-hole to a port on an outer cylindrical end surface of the base annular element.
- 25 11. Swivel stack according to any one of the preceding claims 9 – 10, wherein the outer annular element further has at least one radial conduit extending from the through-hole to a port on an outer cylindrical end surface of the outer annular element.
- 30 12. Swivel stack according to any one of the preceding claims 8 – 11, wherein a stab-in pipe is arranged in the correspondingly positioned through-holes of the lower annular element, upper annular element and central annular element, the stab-in pipe running between the radial conduit of the base annular element and the radial conduit of the central annular element.
- 35 13. Turret mooring system comprising a swivel stack for transfer of fluid across a rotary interface around a rotation axis between an incoming flow-line and an outgoing flow-line in accordance with any one of the preceding claims 1 – 12.

14. Floating offshore construction either provided with a swivel stack for transfer of fluid across a rotary interface around a rotation axis between an incoming flow-line and an outgoing flow-line according to any one of the preceding claims 1 – 12 or comprising a turret mooring system according to claim 13.

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15. Method for manufacturing a swivel stack for transfer of fluid across a rotary interface around a rotation axis between an incoming flow-line and an outgoing flow-line, the method comprising:
- providing a group of inner annular elements that comprises a lower annular element, an upper annular element and a central annular element;
- centering the lower annular element around the rotation axis with an inner radius R1 and a first outer radius;
- centering the upper annular element around the rotation axis with the inner radius R1 and the first outer radius;
- centering the central annular element around the rotation axis and providing the central annular element with an outer cylindrical end surface;
- positioning the central annular element between the lower annular element and the upper annular element, the central annular element having the inner radius and a second outer radius, with the second outer radius between inner radius and first outer radius, in a manner that a circular trench is present between an upward facing surface of the lower annular element and a downward facing surface of the upper annular element, the downward and upward facing surfaces each being perpendicular to the rotating axis;
- the method further comprising:
- centering an outer annular element around the rotation axis, the outer annular element having an inner end surface with a second inner radius and a third outer radius, with the third outer radius larger than the first outer radius and the second inner radius being substantially equal to the second outer radius with a gap between the outer annular element and the central inner annular element; the downward and upward facing surfaces of the outer annular element being directly adjacent to the upward facing surface of the lower annular element and the downward facing surface of the upper annular element, respectively;
- positioning the inner end surface of the outer annular element abutting the flat cylindrical end surface of the central annular element,
- providing a circular trench in the inner end surface of the outer annular element, such that a toroidal chamber is formed between the central annular element and the outer annular element,

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providing the upward facing surface of the lower annular element and the downward facing surface of the upper annular element with a first stepped surface;
providing the upward and downward facing surfaces of the outer annular element with a second stepped surface; the first and second stepped surfaces being configured in a manner that at least two annular cavities centered around the rotation axis and having a rectangular cross-section are provided, half of the at least two annular cavities at a first interface between the downward facing surface of the upper annular element and the upward facing surface of the outer annular element and the other half of the at least two annular cavities at a second interface between the upward facing surface of the lower annular element and the downward facing surface of the outer annular element, respectively, wherein a radial width of the toroidal chamber is equal to or smaller than a height of the toroidal chamber, and the radial width of the toroidal chamber is smaller than a width of the two annular cavities combined.