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:
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 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 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:
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 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~~ the circular trench, such that a 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 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 at least two annular cavities and an interspace between said annular cavities in the same interface 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.

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.

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.

10. Swivel stack according to any one of the preceding claims 8 or 9, 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
further comprising a radial conduit extending from the through-hole to a port on an outer cylindrical end surface of the base annular element.

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.

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.

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.

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 RI1 and a first outer radius;
centering the upper annular element around the rotation axis with the inner radius RI1 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~~ the 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,

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 at least two annular cavities and an interspace between said annular cavities in the same interface combined.