

A VACUUM PUMP COMPRISING A RELIEF VALVE AND A METHOD OF ASSEMBLY OF THE RELIEF VALVE

FIELD OF THE INVENTION

- 5 The field of the invention relates to a relief valve for a multistage pump assembly and a method of assembling such a valve within an interstage cavity of the pump.

BACKGROUND

- 10 Relief or blow off valves within pumping systems to protect the pump against increases in pressure at the pump inlet are provided in many systems. They are subject to wear and may need servicing or replacing, particularly in pumps configured to pump corrosive fluids. In multistage pumps where the valves may be located in the interstage cavity, such valves are difficult to access. To address the issue of valves wearing more quickly than many other components of a
- 15 pump, cartridge relief valves have been designed which are self-contained, comprise several components and can be inserted as a working unit into the desired location. A drawback of these valves is that the material content and part count for such a cartridge relief valve is quite high.
- 20 It would be desirable to provide smaller relief valves with a lower part count, while still allowing for assembly and service of the valves.

SUMMARY

- 25 A first aspect provides a multiple stage rotary vacuum pump comprising: a stator comprising multiple pumping stages; at least one inter-stage divider separating two adjacent pumping stages; said at least one inter-stage divider comprising two walls defining a cavity therebetween, an upstream wall bounding an upstream pumping stage and a downstream wall bounding a downstream pumping stage of said two adjacent pumping stages; said cavity comprising at least a portion of
- 30 a pressure relief fluid flow path, said pressure relief fluid flow path providing a path from an outlet portion of said upstream stage towards an inlet portion of said upstream stage or towards an exhaust, said pressure relief fluid flow path

- 2 -

comprising an orifice, said orifice comprising a valve seat; and a pressure relief valve configured to move between a compressed and an elongated state, said pressure relief valve sealing said orifice when in said elongated state and being configured to move to said compressed state such that said orifice is not
5 obstructed, in response to pressure in said upstream stage rising above a predetermined value.

The inventors of the present invention recognised that although there are advantages to a cartridge valve assembly that allow easy insertion and removal
10 from the pump for replacement and servicing purposes, there are drawbacks with such an arrangement. In particular, these cartridges can be relatively large and have a high part count. The inventors of the present invention recognised that several of the components of such cartridge assemblies have functions that could be performed by other parts of the machine into which they are inserted. Thus,
15 were the valve assembly configured such that it cooperated with parts of the pump, some of the components could be dispensed with. With this in mind, a valve assembly is provided that has a compressed and elongated state and that is configured to seal with an orifice within the pump when in the elongated state. In this way the valve assembly can be compressed, and inserted into the pump in
20 the compressed state and then released to an elongated state where it seals with the orifice.

Thus, the valve seat is part of the pump itself and it is the valve sealing and biasing means which are the removable component. Providing a portion of a
25 valve that has a compressed non-sealing state, allows it to be inserted into the machine and removed from it, while when elongated it can be held in place.

In some embodiments, said pressure relief valve comprises retaining means for releasably retaining said valve in said compressed state.

30

The pressure relief valve may comprise retaining means such that it can be retained in the compressed state. This allows it to be inserted into and removed

- 3 -

from the pump without the need to hold it in the compressed state during this procedure.

5 In some embodiments, an outer sealing face of said valve comprises a receiving means configured to receive a tool for rotating said outer sealing face to release or engage said retaining means.

10 The retaining means may releasably engage with a cooperating means and in some cases the method for releasing and retaining may involve relative rotation of two parts of the valve assembly. Such relative rotation may be triggered using a tool that cooperates with a receiving means on the outer sealing face. The outer sealing face may be accessible when the valve is within the pump and allows the valve to be placed in the compressed state and removed for servicing or replacement.

15 In some embodiments, said retaining means comprises a hook and a retainer for retaining said hook, one of said hook and retainer being attached to a fixed end of said valve and the other of said hook and retainer to a sealing end, said valve being configured such that rotation of said sealing end of said valve engages or releases said hook from said retainer.

20 Although the retaining means can be formed in a number of ways, one simple yet effective means is to use a hook and retaining means for the hook, relative rotation between the hook and retaining means allowing them to engage when in the compressed state, and reverse rotation in the compressed state allowing them to disengage and return the valve assembly to the elongated state. In this way, with the use of compression force and a tool to rotate one end of the valve the valve assembly can be moved between the compressed and elongated state within the pump allowing it to be inserted and removed.

30

- 4 -

In some embodiments, said orifice is located in one wall of said inter-stage divider and comprises an outlet of said upstream pumping stage.

Although the orifice may be located at a number of different points within the flow path, in some cases it is in the outer wall of the interstage divider. In this position it is relatively easy to access and provides a convenient way of sealing the flow path from the upstream pumping chamber.

In other embodiments, said cavity comprises a pumping fluid flow path, said pumping fluid flow path providing a path from said outlet portion of said upstream stage towards an inlet portion of said downstream stage, said pumping fluid flow path and said pressure relief fluid flow path comprising said orifice, at a junction of said paths.

In some embodiments, a portion of said fluid flow path from said outlet portion of said upstream stage to said orifice comprises a combined pressure relief fluid path and pumping fluid flow path.

An alternative arrangement that may provide an effective reuse of flow paths is where the pumping fluid flow path from the upstream stage to the downstream stage and the pressure relief fluid flow path from the outlet of the upstream stage are shared for a portion of their lengths within the cavity. In some cases the orifice is located at the point of divergence between the two paths such that the pressure relief path is blocked when the valve is closed and provides a flow path when the valve is open.

In some embodiments, said pressure relief valve is configured to extend between said two walls, a fixed end of said valve being mounted in said downstream wall and a sealing end of said valve extending to said upstream wall when said valve is in said elongated state.

- 5 -

Providing a pressure relief valve comprising a sealing face adapted to seal with a valve seat that is part of the pump allows the valve to be made of fewer components and to be relatively compact. In order for it to be stably held in position in use, in some embodiments the valve extends between the two walls
5 and a spring within the valves pushes the sealing face against the valve seat when in the elongated state.

In some embodiments, said vacuum pump comprises a recess for receiving said fixed end of said valve.

10

In order for the valve to be stably retained in this position it may be advantageous if the pump comprises a recess for receiving then end of the valve remote from the sealing end and holding it in a fixed position. In the embodiment where the valve extends between the two walls, the downstream wall may comprise the
15 recess for receiving the fixed end of the valve thereby holding it in position.

Where the valve seals an orifice between the pumping fluid flow path and pressure relief fluid flow path, the recess may be in the wall of the pressure relief fluid flow path. In either case, when the valve is compressed using the retaining means it can be removed from the recess and taken out of the pump for
20 servicing.

A second aspect provides a method of assembling a valve within an inter-stage cavity between walls separating two adjacent pumping stages, said method comprising: inserting a pressure relief valve retained in a compressed state by
25 retaining means, between said walls of said inter-stage cavity, said pressure relief valve comprising a sealing end for engaging with a valve seat in an orifice within a pressure relief fluid flow path and an opposing end, said pressure relief fluid flow path passing through said inter-stage cavity and connecting an outlet portion of an upstream stage to an inlet portion of said upstream stage or to an
30 exhaust; locating said valve within said fluid flow path; and releasing said valve from said compressed state such that said valve moves to an extended state and a sealing end of said valve mates with said valve seat in said orifice.

In some embodiments, said orifice is located in an upstream wall of said cavity; and said locating step comprises locating said opposing end of said valve within a recess in a downstream wall of said inter-stage cavity; and releasing said valve
5 from said compressed state such that said valve moves to an extended state and said sealing end mates with said valve seat in said upstream wall.

In other embodiments, said orifice is located in a wall of a pumping fluid flow path within said cavity, said orifice linking said pumping fluid flow path and said
10 pressure relief fluid flow path; and said locating step comprises locating said opposing end of said valve within a recess in a wall of said pressure relief fluid flow path; and releasing said valve from said compressed state such that said valve moves to an extended state and said sealing end mates with said valve seat in said orifice.

15 In some embodiments, said retaining means comprises an engaging portion adapted to rotatably engage with a retainer, said engaging portion being attached to one of said sealing or opposing ends and said retainer being attached to the other of said sealing or opposing ends, said step of releasing said valve from said
20 compressed state comprises rotating said sealing end such that said retainer disengages with said engaging portion.

In some embodiments, said engaging portion comprises a hook.

25 In some embodiments, said step of releasing said valve from said compressed state comprises engaging a receiving means on an outer face of said sealing end with a tool and rotating said tool until said retainer releases said engaging portion.

30 Further particular and preferred aspects are set out in the accompanying independent and dependent claims. Features of the dependent claims may be

- 7 -

combined with features of the independent claims as appropriate, and in combinations other than those explicitly set out in the claims.

Where an apparatus feature is described as being operable to provide a function,
5 it will be appreciated that this includes an apparatus feature which provides that function or which is adapted or configured to provide that function.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described further, with
10 reference to the accompanying drawings, in which:
Figure 1 shows a relief valve according to a first embodiment;
Figure 2 shows a section through the pump showing the position of the relief valve according to Figure 1;
Figure 3 shows a relief valve according to a further embodiment;
15 Figure 4 shows a flow diagram illustrating steps in a method of assembling a valve within a pump according to an embodiment; and
Figure 5 shows a flow diagram illustrating steps in a method of removing a valve assembly from the pump.

DESCRIPTION OF THE EMBODIMENTS

Before discussing the embodiments in any more detail, first an overview will be provided.

The valve is configured for insertion into a pump interstage cavity in a stator in
25 one example in a clamshell stator. The interstage is hollow with a wall facing towards the upstream stage and another wall facing towards the downstream stage. The valve is configured to open or close a pressure relief flow path from the outlet portion of the upstream stage back to the inlet portion of the upstream stage in cases of raised pressure at the outlet portion of the upstream stage,
30 thereby protecting the downstream stage(s) from these pressure rises.

- 8 -

The valve seat is formed in the pressure relief flow path and in some embodiments at one end of this flow path in one of the walls. A region of the cavity between the walls provides the pressure relief flow path to return the gas to the inlet of the same stage.

5

In embodiments, the valve has a plunger, spring, and guide/support.

Figure 1 shows a valve assembly according to a first embodiment. The valve assembly 10 is shown in the elongated state between an upstream wall 60 and a downstream wall 62 of the interstage cavity.

The valve assembly is configured such that it can be locked into a compressed state by pushing on valve plunger 30 and compressing the spring 20, when the spring 20 is compressed, plunger 30 can be rotated using a tool in depression 32 so that a hook 40 on the end of the valve stem is retained in an asymmetrical slot 50 in the guide/support 47. In this state the whole assembly is small enough to slide in the cavity between the interstage walls 60, 62.

The valve assembly is manoeuvred to its location opposite the valve seat opening which comprises an orifice 64 in upstream wall 60, the orifice comprising the valve seat. The support end 47 of the valve assembly is located in a depression in the downstream wall 62, and then when in position the plunger 30 can be rotated in the opposite direction to release hook 40 from slot 50 so that the valve moves to its elongated, closed position with the valve plunger 30 sealing with the valve seat in orifice 64. In this position the valve assembly is held in place.

Protrusions 45 extend out from valve support 47 and act to stabilise the valve assembly against lateral or angular movement helping retain it securely in place. When there is a rise in pressure in the upstream stage above a predetermined amount, then the force on plunger 30 is sufficient to compress spring 20 and the plunger 30 moves away from the valve seat in orifice 64 and a pressure relief

flow path is opened. When the pressure in the upstream stage falls below this critical value then the valve will close again sealing the pressure relief path.

To remove the valve for servicing or cleaning, the plunger 30 is pushed back
5 towards the guide/support 47, via the seat opening 64, then rotated using depression 32 such that the hook 40 re-engages with slot 50. Once locked in the compressed state the valve can be easily withdrawn from the interstage

Figure 2 shows schematically the interstage walls 60, 62 of the interstage cavity
10 with the different flow paths. There is a pressure relief flow path 65 sealed by a valve assembly 10 according to the embodiment of figure 1. The pressure relief flow path extends from orifice 64 in the outlet portion of the upstream pumping stage to an orifice 68 in the inlet portion of the upstream pumping stage. The orifice 64 comprises the valve seat for the valve assembly 10. There is a
15 separate pumping flow path 67 flowing from orifice 66 in the outlet portion of the upstream pumping stage to orifice 69 in the interstage wall 62, orifice 69 providing access to the inlet portion of the downstream stage. The two flow paths 65 and 67 are isolated from each other. They may have different forms within the cavity, provided that the two flow paths are bounded in some way so that they are
20 isolated from each other.

In another embodiment not shown the pressure relief valve is a blow off valve as opposed to a recirculating pressure relief valve, and in this case the pressure relief path 65 will not extend to an orifice 68 in the inlet portion of the upstream
25 pumping stage but will rather extend to an orifice into an exhaust passage of the pump.

Figure 3 schematically shows an alternative embodiment, where pumping flow path 67 and pressure relief flow path 65 share a same path for the initial part of
30 the flow path from an orifice 66 in the outlet portion of the upstream wall.

- 10 -

The two paths diverge at orifice 64 which comprises a valve seat and mates with the plunger or sealing end of valve assembly 10. The valve assembly acts to open or close the portion of pressure relief path 65 downstream of the orifice 64 which portion leads to orifice 68 in the inlet portion of the upstream stage of the pump. The pumping flow path 67 proceeds to an outlet 69 leading to the inlet portion of the downstream stage.

In this embodiment the valve and orifice are within the fluid flow path and the valve assembly does not contact the interstage walls. As for the valve assembly 10 of Figures 1 and 2, this valve assembly has a spring and retaining means (not shown), such that the spring can be compressed and then the valve assembly retained in the compressed state for removal from the pump. Similarly it can re-inserted into the pump in the compressed state and rotation of the valve plunger can lead to release of the retaining means and the valve reaching its elongated state in which state it mates with the orifice.

In this embodiment there is a depression in the fluid flow path for retaining the support end of the valve assembly 10.

As for the embodiment of Figure 2 there is an alternative arrangement for this pressure relief valve (not shown) in which the valve acts as a blow off valve and in this case pressure relief path 65 does not extend back to the inlet portion of the upstream pumping stage but rather extends to an exhaust passage of the pump.

Figure 4 shows a flow diagram illustrating steps in a method of inserting a pressure relief valve into a pump according to an embodiment. In this method the valve assembly is placed in a compressed state, and in this state it is inserted into an inter-stage cavity located between the walls of adjacent pumping chambers. A support end of the valve is located within a recess in a downstream wall of the inter-stage cavity and the sealing end of the valve is rotated to release the retaining means such that the valve moves to an elongated state and the

- 11 -

sealing means seals with a sealing face on an orifice within the pump. the valve assembly is held in place by the spring force between the orifice and the recess.

Figure 5 shows a flow diagram illustrating steps in a method for removing a valve assembly from an inter-stage cavity of a pump in order to service or replace the valve. In this method, the valve assembly is compressed and the sealing end of the valve is rotated such that retaining means on the valve assembly are engaged and the valve assembly is held in the compressed state. In this state the valve assembly can be removed from the interstage cavity.

10

Although illustrative embodiments of the invention have been disclosed in detail herein, with reference to the accompanying drawings, it is understood that the invention is not limited to the precise embodiment and that various changes and modifications can be effected therein by one skilled in the art without departing from the scope of the invention as defined by the appended claims and their equivalents.

15

- 12 -

REFERENCE SIGNS

	10	valve assembly
	20	spring
	30	plunger
5	32	depression
	40	hook
	45	protrusions
	47	support
	50	slot
10	60, 62	interstage walls
	64	orifice/valve seat
	65	pressure relief flow path
	67	pumping flow path
	66	orifice in wall 60
15	68	orifice in wall 60
	69	orifice 69 in wall 62

CLAIMS

1. A multiple stage rotary vacuum pump comprising:
a stator comprising multiple pumping stages;
5 at least one inter-stage divider separating two adjacent pumping stages;
said at least one inter-stage divider comprising two walls defining a cavity
therebetween, an upstream wall bounding an upstream pumping stage and a
downstream wall bounding a downstream pumping stage of said two adjacent
pumping stages;
10 said cavity comprising at least a portion of a pressure relief fluid flow path,
said pressure relief fluid flow path providing a path from an outlet portion of said
upstream stage towards an inlet portion of said upstream stage or towards an
exhaust, said pressure relief fluid flow path comprising an orifice, said orifice
comprising a valve seat; and
15 a pressure relief valve configured to move between a compressed and an
elongated state, said pressure relief valve sealing said orifice when in said
elongated state and being configured to move to said compressed state such that
said orifice is not obstructed, in response to pressure in said upstream stage
rising above a predetermined value.
20
2. A multiple stage rotary vacuum pump according to Claim 1, wherein said
pressure relief valve comprises retaining means for releasably retaining said
valve in said compressed state.
- 25 3. A multiple stage rotary vacuum pump according to claim 2, wherein an
outer sealing face of said valve comprises a receiving means configured to
receive a tool for rotating said outer sealing face to release or engage said
retaining means.
- 30 4. A multiple stage rotary vacuum pump according to claim 2 or 3, wherein
said retaining means comprises a hook and a retainer for retaining said hook,
one of said hook and retainer being attached to a fixed end of said valve and the

- 14 -

other of said hook and retainer to a sealing end, said valve being configured such that rotation of said sealing end of said valve engages or releases said hook from said retainer.

- 5 5. A multiple stage rotary vacuum pump according to any one of claims 1 to 4, wherein said orifice is located in one wall of said inter-stage divider and comprises an outlet of said upstream pumping stage.
- 10 6. A multiple stage rotary vacuum pump according to any one of claims 1 to 4, wherein said cavity comprises a pumping fluid flow path, said pumping fluid flow path providing a path from said outlet portion of said upstream stage towards an inlet portion of said downstream stage, said pumping fluid flow path and said pressure relief fluid flow path comprising said orifice, at a junction of said paths.
- 15 7. A multiple stage rotary vacuum pump according to claim 6, wherein a portion of said fluid flow path from said outlet portion of said upstream stage to said orifice comprises a combined pressure relief fluid flow and pumping fluid flow path.
- 20 8. A multiple stage rotary vacuum pump according to any one of claims 1 to 5, wherein said pressure relief valve is configured to extend between said two walls, a fixed end of said valve being mounted in said downstream wall and a sealing end of said valve extending to said upstream wall when said valve is in said elongated state.
- 25 9. A multiple stage rotary vacuum pump according to any preceding claim, wherein said vacuum pump comprises a recess for receiving a fixed end of said valve.
- 30 10. A method of assembling a valve within an inter-stage cavity between walls separating two adjacent pumping stages, said method comprising:

- 15 -

inserting a pressure relief valve retained in a compressed state by retaining means, between said walls of said inter-stage cavity, said pressure relief valve comprising a sealing end for engaging with a valve seat in an orifice within a pressure relief fluid flow path and an opposing end, said pressure relief fluid flow path passing through said inter-stage cavity and connecting an outlet portion of an upstream stage either to an inlet portion of said upstream stage or to an exhaust;

5

locating said valve within said fluid flow path; and

releasing said valve from said compressed state such that said valve

10 moves to an extended state and a sealing end of said valve mates with said valve seat in said orifice.

11. A method according to claim 10, wherein said orifice is located in an upstream wall of said cavity; and

15

said locating step comprises locating said opposing end of said valve within a recess in a downstream wall of said inter-stage cavity; and

releasing said valve from said compressed state such that said valve moves to an extended state and said sealing end mates with said valve seat in said upstream wall.

20

12. A method according to claim 10, wherein said orifice is located in a wall of a pumping fluid flow path within said cavity, said orifice linking said pumping fluid flow path and said pressure relief fluid flow path; and

said locating step comprises locating said opposing end of said valve

25 within a recess in a wall of said pressure relief fluid flow path; and

releasing said valve from said compressed state such that said valve moves to an extended state and said sealing end mates with said valve seat in said orifice.

30

13. A method of assembling a valve according to any one of claims 10 to 12, wherein said retaining means comprises an engaging portion adapted to rotatably engage with a retainer, said engaging portion being attached to one of said

- 16 -

sealing or opposing ends and said retainer being attached to the other of said sealing or opposing ends, said step of releasing said valve from said compressed state comprises rotating said sealing end such that said retainer disengages with said engaging portion.

5

14. A method of assembling a valve according to claim 13, wherein said engaging portion comprises a hook.

15 A method of assembling a valve according to claim 13 or 14, wherein said
10 step of releasing said valve from said compressed state comprises engaging a receiving means on an outer face of said sealing end with a tool and rotating said tool until said retainer releases said engaging portion.