From the prior art dredging arrangements are known in which the dredging arrangement can be controlled to adapt to changing conditions, including to prevent choking when too much material and too little water gets into the suction pipe. U.S. Pat. No. 366,468 discloses a dredging apparatus which uses a simple valve which can open automatically or may be operated by a cable or rod if chocking occurs. Similarly, U.S. Pat. No. 528,022 discloses a valve which may be operated by an operator pulling on a rope to allow water to flow in and cut up the choking material. The dredging arrangement may be adapted on board of a vessel before being lowered to the underwater bottom. Alternative solutions require active components mounted on the dredging arrangement, which can require expensive and fragile components and power to be supplied to active components. Also, the use of hydraulic fluid forms an environmental risk.

SUMMARY

It is an object to provide a drag head which can be adapted to changing dredging condition in an easy and reliable way.

Therefore, according to an first aspect of the invention, there is provided a dredging arrangement for dredging material from an underwater bottom, the dredging arrangement comprising a drag head and a suction pipe, the drag head comprising a drag head body which is attachable to the suction pipe, the drag head comprising at least one moveable part, such as a visor or a valve, which can be controlled to change the dredging characteristics of the drag head, wherein the dredging arrangement comprises a wire connector, a wire controller and a transferring device, the wire connector being connectable to a wire via which a pulling force can be applied, wherein the transferring device is arranged to transfer the pulling force to at least one moveable part, and the wire controller is arranged to exert a controllable pulling force on the wire and also functions as hoisting device for lowering and lifting the dredging arrangement towards and from the underwater bottom.

The pulling force may be applied by a wire controllor positioned on board of a dredging vessel. The wire controller may be arranged to give out or take in wire and to control a pulling force exerted on the wire. The wire controller may be formed by or may comprise a winch. If the winch is the only wire controller then this winch has to be operated in constant tension mode, that means that the winch is giving out and taking in wire constantly to compensate the constantly changing difference between drag head and vessel or gantry.

The wire and the wire controller may also be provided by a heave compensator, for instance known from the prior art, now controlled differently, i.e. now also used for

controlling the dredging characteristics of the drag head besides it main function to tension the wire (preventing slackening of the wire).

According to an second aspect of the invention, there is provided a dredging vessel comprising a dredging arrangement for dredging material from an underwater bottom, the dredging arrangement comprising a drag head and a suction pipe, the drag head comprising a drag head body which is connected to the dredging vessel by means of the suction pipe, the drag head comprising at least one moveable part, such as a visor or a valve, which can be controlled to change the dredging characteristics of the drag head, wherein the dredging vessel comprises a wire connectable to the dredging arrangement for lifting and lowering the dredging arrangement from and to the underwater bottom, wherein the dredging arrangement comprises a wire connector, a wire controller and a transferring device, the wire connector being connectable to the wire via which a pulling force can be applied, wherein the transferring device is arranged to transfer the pulling force to the at least one moveable part, and wherein the wire controller is arranged to exert a controllable pulling force on the wire and also functions as hoisting device for lowering and lifting the dredging arrangement towards andfrom the underwater bottom.

The dredging vessel may be a trailing suction hopper dredger (TSHD).

According to an embodiment the dredging vessel comprises a wire controller, the wire controller being arranged to exert a controllable pulling force on the wire.

The wire controller may be formed as already described above. It may comprise a first wire control device and a second wire control device which work in cooperation with each other. The second wire control device is dynamically controlled during dredging, while the first wire control device is operated in case the second wire control device reaches an end position, i.e. a minimum and maximum position. In that case, the first wire control device and the second wire control device are operated oppositely, to bring the second wire control device back to the centre of its working area. The first wire control device may be formed by a winch, while the second wire control device may be formed by a heave compensator. Both may be positioned on (the deck of) the dredging vessel.

The wire controller is arranged to control a pulling force in a range wherein it is less than the force required for lifting the drag head from the underwater bottom and more than a minimum force to prevent slackening of the wire. The wire controller comprises means for dynamically controlling a pulling force during dredging.

The wire controller may also be arranged to exert a pulling force sufficient to lift the drag head from the underwater bottom.

According to an embodiment the dredging vessel comprises a gantry via which the wire can be guided from the wire controller to the dredging arrangement.

According to an embodiment the wire controller also functions as hoisting device for lowering and lifting the dredging arrangement towards and from the underwater bottom.

As described above, the wire controller may comprise first wire controller suitable for lifting and lowering the dredging arrangement and second wire controller for controlling the moveable parts and to compensate for heave motion.

Once the dredging arrangement is in position on the underwater bottom, the wire controller may control the pulling force in a range less than needed for lifting the dredging arrangement from the underwater bottom, but sufficient for controlling the position of the moveable part and/or moving behavior of the moveable part, while the wire is kept under tension.

According to a third aspect of the invention, there is provided a method for dredging material from an underwater bottom using a dredging arrangement, the dredging arrangement comprising a drag head and a suction pipe, the drag head comprising a drag head body which is attached to the suction pipe, the drag head further comprising at least one moveable part, such as a visor and a valve, which can be controlled with respect to the drag head body to change the dredging characteristics of the drag head, the dredging arrangement being connected by a wire to wire controller to lift and lower the dredging arrangement from and to the underwater bottom, wherein the method comprises

a) lowering the dredging arrangement to an underwater position with the drag head positioned on the underwater bottom,

b) dredging by dragging the drag head over the underwater bottom in a dredging direction by means of a dredging vessel,

the dredging arrangement comprising a wire connector and a transferring device, the wire connector being connectable to the wire via which a controllable pulling force can be applied by the wire controller, wherein the transferring device is arranged to transfer the pulling force to the at least one moveable part, wherein the method further comprises:

b1) controlling the wire controller to dynamically control a pulling force exerted on the wire during dredging.

As a result, the position and/or moving behavior of the moveable part can be controlled during dredging.

During lifting and lowering, the pulling force is at least equal to a lifting force required for lifting the dredging arrangement. As a result, during lifting and lowering the moveable parts will be pulled to an end position. For instance, in case the moveable part is the visor, the visor will be in its most upward position during lifting and lowering. During dredging the pulling force will be less than the required lifting force but more than a minimum force to

CLAIMS

1. Dredging arrangement for dredging material from an underwater bottom ~~(6)~~, the dredging arrangement comprising a drag head ~~(10)~~ and a suction pipe ~~(2)~~, the drag head ~~(10)~~ comprising a drag head body ~~(11)~~ which is attachable to the suction pipe ~~(2)~~, the drag head ~~(10)~~ comprising at least one moveable part ~~(12, 14)~~, such as a visor or a valve, which can be controlled to change the dredging characteristics of the drag head ~~(10)~~,

wherein the dredging arrangement comprises a wire connector ~~(15)~~, a wire controller ~~(5)~~ and a transferring device ~~(16)~~, the wire connector ~~(15)~~ being connectable to a wire ~~(4)~~ via which a pulling force can be applied, wherein the transferring device ~~(16)~~ is arranged to transfer the pulling force to the at least one moveable part ~~(12, 14)~~, and the wire controller ~~(5)~~ is arranged to exert a controllable pulling force on the wire ~~(4)~~ and also functions as hoisting device for lowering and lifting the dredging arrangement towards and from the underwater bottom ~~(6)~~.

2. Dredging arrangement according to claim 1, wherein a biasing device ~~(17)~~ is provided exerting a biasing force on the at least one moveable part ~~(12, 14)~~ and wherein the wire connector ~~(15)~~ and the transferring device ~~(16)~~ are arranged such that the transferred pulling force opposes the biasing force.

3. Dredging arrangement according to any one of the preceding claims, wherein the at least one moveable part is a visor ~~(12)~~, the visor ~~(12)~~ being rotatable with respect to the drag head body ~~(11)~~ about a rotational axis ~~(RA)~~ which, in use, is substantially horizontal and perpendicular to a dredging direction ~~(DD)~~.

4. Dredging arrangement according to claim 3, wherein the drag head ~~(10)~~ comprises a biasing device ~~(17)~~ exerting a biasing force on the visor ~~(12)~~ such that the visor ~~(12)~~ is biased in a downward direction.

5. Dredging arrangement according to claim 4, wherein the biasing device ~~(17)~~ comprises at least one of a mechanical spring, an hydraulic spring, a gas spring.

6. Dredging arrangement according to any one of the claims 4 - 5, wherein the wire connector ~~(15)~~ and the transferring device ~~(16)~~ are positioned such that the transferred pulling force opposes the biasing force.

7. Dredging arrangement according to any one of the claims 1 - 2, wherein the moveable part is a valve ~~(14)~~ provided to open and close an opening ~~(18)~~ in the drag head ~~(10)~~ or lower part of the suction pipe ~~(2)~~ to allow water to enter.

8. Dredging arrangement according to claim 7, wherein the drag head ~~(10)~~ or suction pipe ~~(2)~~ comprises a biasing device ~~(17)~~ exerting a biasing force on the valve ~~(14)~~ such that the valve ~~(14)~~ is biased towards a closed position.

9. Dredging arrangement according to claim 8, wherein the wire connector ~~(15)~~ and the transferring device ~~(16)~~ are positioned such that the transferred pulling force opposes the biasing force.

10. Dredging arrangement according to any one of the preceding claims, wherein the transferring device ~~(16)~~ comprises one or more pulleys ~~(161)~~ and a transferring cable ~~(162)~~ being guided by the one or more pulleys ~~(161)~~, wherein the wire connector ~~(15)~~ is connected to one of the pulleys ~~(161)~~ being a moveable pulley, the transferring cable ~~(162)~~ being arranged to transfer the pulling force from the wire connector ~~(15)~~ to the moveable part ~~(12, 14)~~.

11. Dredging arrangement according to any one of the claims 1 – 9, wherein the transferring device ~~(16)~~ comprises a hydraulic force transmitter ~~(164, 165, 166, 167)~~.

12. Dredging arrangement according to any one of the claims 1 – 9, wherein the transferring device ~~(16)~~ comprises a lever ~~(163, 163')~~ which is connected to the wire connector ~~(15)~~ and to the at least one moveable part ~~(12, 14)~~.

13. Dredging vessel ~~(1)~~ comprising a dredging arrangement for dredging material from an underwater bottom ~~(6)~~, the dredging arrangement comprising a drag head ~~(10)~~ and a suction pipe ~~(2)~~, the drag head ~~(10)~~ comprising a drag head body ~~(11)~~ which is connected to the dredging vessel ~~(1)~~ by means of the suction pipe ~~(2)~~, the drag head ~~(10)~~ comprising at least

one moveable part (12, 14), such as a visor or a valve, which can be controlled to change the dredging characteristics of the drag head (10), wherein the dredging vessel (1) comprises a wire (4) connectable to the dredging arrangement for lifting and lowering the dredging arrangement from and to the underwater bottom (6),

wherein the dredging arrangement comprises a wire connector (15), a wire controller (5) and a transferring device (16), the wire connector (15) being connectable to the wire (4) via which a pulling force can be applied, wherein the transferring device (16) is arranged to transfer the pulling force to the at least one moveable part (12, 14), and wherein the wire controller (5) is arranged to exert a controllable pulling force on the wire (4) and also functions as hoisting device for lowering and lifting the dredging arrangement towards and from the underwater bottom (6).

14. Dredging vessel (1) according to any one of the claims 13, wherein the dredging vessel (1) comprises a gantry (3) via which the wire (4) can be guided from the wire controller (5) to the dredging arrangement.

15. Method for dredging material from an underwater bottom (6) using a dredging arrangement, the dredging arrangement comprising a drag head (10) and a suction pipe (2), the drag head (10) comprising a drag head body (11) which is attached to the suction pipe (2), the drag head (10) further comprising at least one moveable part (12, 14), such as a visor and a valve, which can be controlled with respect to the drag head body (11) to change the dredging characteristics of the drag head (10), the dredging arrangement being connected by a wire (4) to wire controller (5) to lift and lower the dredging arrangement from and to the underwater bottom (6), wherein the method comprises

a) lowering the dredging arrangement to an underwater position with the drag head (10) positioned on the underwater bottom (6),

b) dredging by dragging the drag head (10) over the underwater bottom (6) in a dredging direction (DD) by means of a dredging vessel (1),

the dredging arrangement comprising a wire connector (15) and a transferring device (16), the wire connector (15) being connectable to the wire (4) via which a controllable pulling force can be applied by the wire controller (5), wherein the transferring device (16) is arranged to transfer the pulling force to the at least one moveable part (12, 14), wherein the method further comprises:

b1) controlling the wire controller ~~(5)~~ to dynamically control a pulling force exerted on the wire ~~(4)~~ during dredging.

16. Method according to claim 15, wherein the pulling force is controlled dynamically during dredging in a range which lies below the lifting force required for lifting the dredging arrangement from the underwater bottom ~~(6)~~ and more than a minimum force to prevent slackening of the wire ~~(4)~~.

17. Method according to any one of the preceding claims 15 – 16, wherein the wire controller comprise first wire controller ~~(51)~~ and second wire controller ~~(52)~~, and wherein action a) is performed by the first wire controller ~~(51)~~ and action b1) is performed by the second wire controller ~~(52)~~.

18. Method according to claim 17, wherein action b1) comprises temporarily operating the first and second wire controller ~~(52, 53)~~ in opposite directions.

19. Method for dredging material from an underwater bottom ~~(6)~~ using a dredging arrangement according to any one of the claims 1 – 12 or using a dredging vessel according to any one of the claims 13 – 14.