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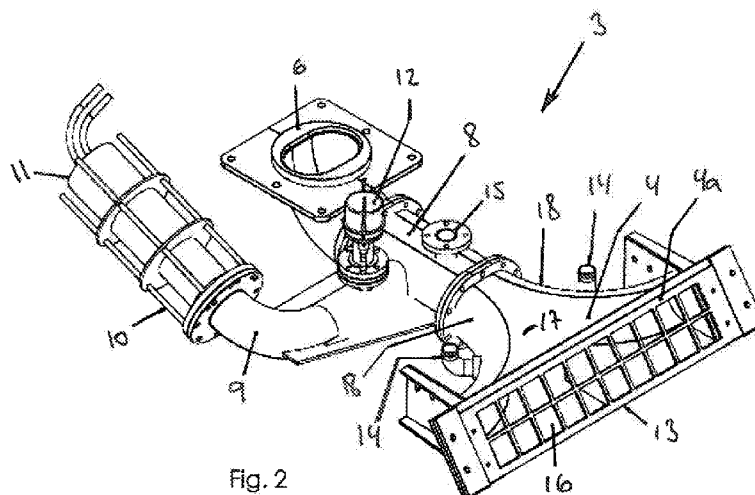
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(54) **Title:** WET SALT HARVESTER



(57) **Abstract:** Described is an intake funnel (3) for a wet salt harvester (1). The intake funnel has an inlet end (4) connectable to a cutter head (5) and an outlet end (6) connectable to a pump installation (7). The intake funnel (3) comprises a middle section (8) arranged between the inlet end (4) and outlet end (6). The middle section (8) is provided with a branch pipe (9) with a valve (10) for allowing liquid to be introduced into the intake funnel (3). The intake funnel (3) is provided with a grate plate (13) located at a front end (4a) of the inlet end (4) of the intake funnel (3). The intake funnel (3) is peculiar in that the intake funnel (3) is provided with a number of inlet ports (14) for injecting pressurized liquid in the opposite direction of suction flow towards the funnel inlet grate plate (13).

WET SALT HARVESTERTechnical Field

5 The present invention relates to an intake funnel for a wet salt harvester. The intake funnel has an inlet end connectable to a cutter head and an outlet end connectable to a pump installation, where the intake funnel comprises a middle section arranged between the inlet end and the outlet end. The middle section is provided with a branch pipe having a valve for allowing liquid to be introduced into the intake funnel. The intake
10 funnel is further provided with a grate plate located at the front inlet end of the intake funnel. The invention also relates to a wet salt harvester comprising such an intake funnel.

Background Art

15 A wet salt harvester of the above mentioned kind is commonly known within the wet salt extraction industry and is used to harvest salt slurries from salt rich water areas, such as ponds. During operation of such harvester the cutter head is cutting solar salt deposited on the floor of the water area. The solar salt slurry (salt + water) containing brine mixed
20 with salt crystals is pulled through the intake funnel by means of the intake / suction side of the downstream pump installation, and conducted further on toward a salt processing plant where the salt is further separated from the brine water, yielding the final harvested solar salt product. The salt particles being drawn into the suction intake funnel may vary in size, with the larger average sized salt particles having shown that the possibility
25 exists whereas repeated clogging of the inlet end, inlet grate, and/or the inside the intake funnel often occurs. This partial-to-full clogging condition will allow suction pump cavitations to occur due to an improper mixture ratio of slurry concentration (salt + water) within the intake funnel. Such cavitations cannot be allowed, as they result in a reduced slurry flow beginning at the inlet funnel, continuing through the suction pump as well as
30 the discharge piping connected to the discharge side of the pump. This will ultimately lead to overheating and breakage of the pump installation, plus clogged discharge piping typically results in excessive downtime of the overall salt harvesting system which may damage other downstream equipment.

35 Further, in order to prevent unwanted and excessively large objects from entering the intake funnel, an inlet grate plate is typically installed at the front end of the inlet end of

the intake funnel. The actual grate size and shape will vary in terms of actual grate opening size, and the overall volumetric flow metered through the grate area. This is typically selected depending on the size and composition of the salt crystals to be harvested. Over time salt deposits and pond debris may build up on the surface of such grate plate, which will cause a reduced flow of the salt water slurry into the intake funnel and eventually suction pump cavitations or reduced slurry flow through the discharge piping.

Summary of the Invention

It is the object of the present invention to provide an intake funnel manifold system for a wet salt harvester, where the problems associated with reduced, restricted or interrupted process flow of a liquid slurry solution into the intake funnel, which ultimately result in pump cavitations, are eliminated or significantly reduced.

According to the invention this is achieved by an intake funnel of the kind mentioned in the introduction, and being characterized in that the intake funnel comprises a middle section arranged between the inlet end and the outlet end, said middle section being provided with a branch pipe having a valve for allowing liquid to be introduced into the intake funnel, said intake funnel further being provided with grate plate being located at a front end of the inlet end of the intake funnel and the intake funnel furthermore being provided with a number of inlet ports for injecting pressurized liquid in a direction towards the grate plate.

It is hereby obtained that the problems associated with poor flow of slurry into the intake funnel and pumping cavitations inside within the intake funnel at least partly may be reduced. By providing the intake funnel with a number of inlet ports for injecting to directly inject pressurized liquid in direction towards the inlet grate plate where salt deposits and debris build up on the surfaces of the grate plate may effectively be removed by forcing the deposits away from the grate plate, clearing the grate openings for unobstructed slurry suction flow. Deposits built up on the internal funnel walls at the inlet end may also be removed in this way. Further, as the intake funnel is provided with a branch pipe for introducing liquid, the harvester inlet funnel chamber is allowed to fill with liquid whenever partial pumping cavitation is detected. Other miscellaneous related operational problems related to interrupted liquid flow or pump cavitations are minimized, thus ensuring a constantly pumped discharge flow.

In principle any suitable liquid which does not conflict with the salt slurry may be used for this cleaning operation and also for introduction into the intake funnel through the branch pipe, however, as the harvester is intended for operation in salt rich water areas, the most natural selection of liquid would be native salt pond water available in abundant quantities Alternatively, a fresh water supply source provided onboard the salt harvester vessel may be applied for this cleaning operation.

The liquid fresh or salt water supply solution used for this cleaning operation is preferably injected by means of a high volume high pressure pump to quickly ensure proper debris cleanout of the funnel chamber and the inlet grate.

The intake funnel may further be provided with a pressure and flow sensor device, which by measuring the negative pressure (suction) and volumetric flow of liquid slurry solution inside the funnel chamber will give an indication of the amount of deposits on the inlet grate plate as well as the percentage level of liquid-to-solid concentration flowing through the funnel. Thus the risk of reduced flow of slurry and pumping cavitations can be automatically monitored and modulated for optimal discharge flow. The pressured salt (or fresh) water being injected through the inlet ports in the direction of flow towards the inlet grate plate may also be controlled by such pressure/flow sensor monitoring.

The separate pumping system for delivering pressurized salt water to the inlet ports may be connected to said pressure and flow sensor device.

The pressure sensor may be situated in the middle section or within the branch pipe of the suction funnel. In a simple embodiment of the invention said pressure and flow sensor device may be connected to instrumentation close to the operator allowing the operator to react accordingly. However, in a preferred embodiment said pressure and flow sensor device is connected to the modulating bypass valve in the branch pipe for automatically opening and closing said valve by suitable means in response to the measured slurry pressure and flow within the funnel chamber. In such preferred embodiment the pressure sensor is a hydraulic pressure transducer whereas the linear needle valve is a variable displacement, modulating bypass valve.

In addition, the slurry by weight exiting the wet salt harvester may be measured by means of a liquid slurry solution density meter that transmits a command signal to add make-up salt water via the bypass valve initially to modulate optimal discharge flow,

and/or to inject pressurized inlet "cleanout water" via said inlet ports to further cleanout the inlet grate plate.

5 The middle section of the intake funnel may additionally be provided with an inlet opening for pumping additional or makeup fresh water under pressure into the intake funnel in order to prevent cavitations. For this purpose, the harvester may advantageously be equipped with a fresh water supply tank. To pump fresh water into the intake funnel should be seen as a backup solution, which typically will be manually
10 operated or through an automated timing sequence and is only used when other mentioned methods are not adequately preventing pumping cavitations. Fresh water has been known to immediately dissolve salt brine crystals within a salt water pond. Thus fresh water will provide an optimal procedure to quickly eliminate built up salt on the inner surfaces of an intake funnel, thereby allowing the slurry to flow in a more optimum manner through the intake funnel, pumps and discharge piping.

15 The front face of the inlet portion of the intake funnel is advantageously and typically formed as a rectangular shape with its longer sides being horizontal, or parallel to the pond floor surface. In order to match this form for optimized fluid flow the cross section of the intake funnel is throughout formed to lie within a rectangle. In a more specific
20 embodiment, the intake funnel is throughout formed with a horizontal flat bottom surface, a horizontal flat top surface and two curved, preferably semi-circular, sides. This design allows the salt slurry to easily flow through at a higher volumetric rate than if the intake funnel is formed circular. This shape will also allow the funnel to be as close as possible to the salt bed floor in a typical pond without touching the salt bed layer itself.

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Brief Description of Drawings

The invention will now be explained in further details with reference to the drawing being diagrammatical, and where

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Fig. 1 shows a schematic top side view of the intake funnel portion of a wet salt harvester, located behind a typical salt cutting head, according to the invention, and

Fig. 2 shows in greater details an intake funnel according to the invention for a wet salt
35 harvester.

Detailed Description

In Fig. 1 is seen a schematic view of a wet salt harvester 1, which comprises an intake funnel 3. The intake funnel has an inlet end 4 being connected to a cutter head 5 and an outlet end 6 being connected to a pump installation 7. During operation of such harvester the cutter head 5 is submerged into a salt rich water area, cutting built-up layers of solar salt deposited on the pond floor of the water area. The salt slurry containing salt water mixed with salt crystals is sucked through the intake funnel 3 by means of the pump installation 7 and conducted further on to a salt processing plant, not shown.

As mentioned in the introduction practice has shown that pumping cavitations are often occurring within the intake funnel 3 due to clogging at the inlet end 4 of and/or inside the intake funnel 3 resulting in a lack of slurry concentration inside the intake funnel 3. Such cavitations cannot be allowed as they besides from being critical for the inner surface of the funnel and possible the pump installation result in reduced slurry flow and consistency of flow throughout the funnel; ultimately damaging, overheating, and breakage of the pump installation as well as a reduction of optimized turbulent slurry flow, or clogged discharge piping.

In order to meet the problems associated to cavitations inside the intake funnel 3 in a relatively simple and reliable manner, the intake funnel 3, as shown in greater details in Fig. 2, is typically provided with a middle section 8 arranged between the inlet end 4 and outlet end 6, which middle section 8 is provided with a branch pipe 9 with a flow modulating bypass linear needle valve 10. By connecting the branch pipe 9 with e.g. a salt water source, indicated by reference 11, it is in this way possible by operating the valve 10 to introduce salt water into the intake funnel 3. Thus, whenever the operator of the harvester observes pumping cavitations creating operation problems, salt water is introduced into the intake funnel 3 via said branch pipe 9, hence reducing cavitations, providing a more constant liquid supply source to the pump system and a more constant discharge flow.

In addition, the intake funnel shown in Fig. 2 is provided with a grate plate 13, which is located at the front end 4a of the inlet end 4 of the intake funnel 3, so as to prevent unwanted or excessively large objects from entering the intake funnel 3 from the cutter head 5. Over time deposits mainly in form of salt deposits may build up on the surface of such grate plate and cause poor flow of slurry into the intake funnel and eventual cavitations. In order to remove deposits which over time build up on the surface of the

grate plate 13 it is suggested according to the present invention that the intake funnel is further provided a number of inlet ports 14 for injecting pressurized salt water in direction towards the grate plate 13, hence forcing deposits away from the grate plate 13.

5 The pressured salt water being injected through said inlet ports 14 may be controlled by a pressure and flow sensor 12. As seen in Fig. 2 such pressure and flow sensor device 12 may be provided in connection with the branch pipe 9. By measuring the pressure and flow inside the branch pipe 9 the pressure and flow sensor device 12 gives an indication of the amount of deposits on the grate plate 13 as well as the level of solid
10 concentration inside the intake funnel 3 and thus the risk of poor flow of slurry into the intake funnel and cavitations. The pressure and flow sensor device may alternatively be situated in the middle section 8. By means of such pressure and flow sensor device 12 the operator may be warned about possible problems related to poor flow of slurry and cavitations and react accordingly by injecting pressurized salt water through the inlet
15 ports 14 in direction towards the grate plate 13 and opening the valve 10, respectively. A separate pumping system, not shown, for delivering pressurized fresh or salt water to the inlet ports 14 may be triggered by said pressure and flow sensor device 12. Further, in the preferred embodiment shown in Fig. 2 said pressure and flow sensor device 12 is connected to the valve 10 in the branch pipe 9 for automatically opening and closing said
20 valve 10 by suitable means in response to the measured pressure. In such preferred embodiment the pressure sensor 12 is a hydraulic pressure transducer whereas the valve 10 is a linear needle valve.

As further seen in Fig. 2, the middle section 8 of the intake funnel 3 is provided with an
25 inlet opening 15 for pumping fresh water under pressure into the intake funnel 3 in order to prevent cavitations. For this purpose, the harvester is equipped with a fresh water supply tank, not shown. Fresh water pumped into the intake funnel 3 will immediately dissolve salt crystals in the salt water and/or built up on the inner surfaces of the intake funnel, thereby allowing the slurry to resume flowing in a more optimum manner through
30 the intake funnel 3. However, as fresh water will quickly decrease the salt concentration in the slurry, this option should merely be regarded as a backup solution, which is only used, when the other primary methods of utilizing the modulating linear needle valve 10 fail.

The front end 4a of the inlet end 4 of the intake funnel 3 is formed as a rectangle with its longer sides being horizontal and the intake funnel 3 is throughout formed with a horizontal flat bottom surface 16, a horizontal flat top surface 17 and two semicircular sides 18. This design allows the salt slurry to easily flow through at a higher rate than if the intake funnel 3 is formed circular. This shape will also allow the funnel to be as close as possible to the salt bed in a pond without touching the salt itself.

During operation of the wet salt harvester installed with the preferred shown intake funnel 3 the hydraulic pressure transducer 12 transmits a signal to the linear needle valve 10, which is actuated in accordance to open or close. The hydraulic pressure transducer 12 has an adjustable negative pressure set point to trigger the actuation of the linear needle valve 10. The pump suction or "negative pressure" is measured at the intake funnel 3 with the hydraulic pressure transducer 12. An established set point to operate the pump installation 7 at optimal flow is determined during testing and equipment setup. As an example the hydraulic pressure transducer 12 may be setup to operate up to about 500 mmHg at "normal" operating conditions. Once the intake funnel 3 becomes restricted by excess solids from salt harvesting the negative Pressure will increase above 500 mmHg, which is sensed by the hydraulic pressure transducer 12, and the linear needle valve 10 will then open accordingly. The higher the negative pressure becomes, the larger the corresponding the linear needle valve 10 will be opening to compensate, or modulate an increased amount of salt water flow through the pump. This keeps the harvested salt slurry moving through the pump system and discharge piping, reducing the settling of solids within the salt slurry and preventing discharge pipes from clogging.

The hydraulic pressure transducer 12 also transmits a signal to induce high pressure water flow into the two inlet ports 14, which is typically triggered via the hydraulic pressure transducer sensor 12 reading a negative pressure signal at a higher set point, which as an example may be setup to operate at approx 650 mmHg, or 150mm Hg beyond the 500mm Hg set point which triggers the primary flow assisting valve 10.

The introduction or injection of salt water through the branch pipe (9) and the inlet ports 14, respectively continues as long as needed based on the automated sensor readings. In general, the introduction will continue until the suction pressure is brought back up to the normal operating condition within the funnel. With the above values used as examples, the two inlet ports 14 are de-energized, when the negative pressure sensing

drops down below the 650 mmHg set point, yet slightly above the 500 mmHg set point value as sensed by the pressure and flow sensor 12. As the negative pressure drops below the 500 mmHg set point, valve 10 will begin closing, proportional to the sensor reading of 12. The control software for the flow bypass linear needle valve 10 will preferably also monitor the salt water volumetric flow through the discharge piping beyond pump installation 7 using setup parameters such as velocity and pressure.

The salt water or fresh water introduced into the intake funnel 3 at the various locations can be introduced by a variable pressure by varying the pump setup parameters for the respective pumps. This provides a more or less aggressive funnel cleanout flow depending on the type of materials in the slurry. The same materials can have different reactions based on ambient temperature and different climate conditions may affect growth of the material, which could lead to an easier or more difficult task of breaking up and removing compacted or built-up salt brine material from the funnel and funnel grate based on the specific salt water pond material properties being harvested.

The linear needle valve according to the invention may be a variable opening linear needle valve.

Claims

1. An intake funnel (3) for a wet salt harvester (1), said intake funnel having an inlet end (4) connectable to a cutter head (5) and an outlet end (6) connectable to a pump installation (7), wherein the intake funnel (3) comprises a middle section (8) arranged between the inlet end (4) and outlet end (6), said middle section (8) being provided with a branch pipe (9) having a valve (10) for allowing liquid to be introduced into the intake funnel (3), said intake funnel (3) furthermore being provided with a grate plate (13) being arranged at a front end (4a) of the inlet end (4) of the intake funnel (3), and the intake funnel (3) furthermore being provided with a number of inlet ports (14) for injecting pressurized liquid in a direction towards the grate plate (13).
2. An intake funnel (3) according to claim 1, wherein the intake funnel (3) is provided with a pressure and flow sensor device (12) for measuring the pressure and flow inside the intake funnel (3).
3. An intake funnel (3) according to claim 2, wherein said pressure and flow sensor device (12) is connected to a high pressure pump for delivering pressurized liquid to the inlet ports (14).
4. An intake funnel (3) according to claims 2 or 3, wherein the pressure and flow sensor device (12) is situated in the branch pipe (9).
5. An intake funnel (3) according to any of claims 2-4, wherein the pressure and flow sensor device (12) is connected to the valve (10) of the branch pipe (9) for automatically opening and closing said valve (10) by suitable means in response to the measured pressure and flow.
6. An intake funnel (3) according to claim 4, wherein the pressure sensor (12) comprises a hydraulic pressure transducer and the valve (10) comprises a linear needle valve.
7. An intake funnel (3) according to claim 1, wherein the middle section (8) of the intake funnel (3) is provided with an inlet opening (15) for pumping fresh water under pressure into the intake funnel (3).

8. An intake funnel (3) according to claim 1, wherein the front (4a) of the inlet end (4) of the intake funnel (3) is formed as a rectangle with its longer sides being horizontal, and the intake funnel (3) is throughout formed with a horizontal flat bottom surface (16), a horizontal flat top surface (17) and two curved, preferably semicircular sides (18).

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