

(19) **DANMARK**

(10) **DK/EP 4004371 T3**



(12)

Oversættelse af europæisk patentskrift

Patent- og
Varemærkestyrelsen

-
- (51) Int.Cl.: **F 04 B 43/00 (2006.01)** **F 04 B 43/08 (2006.01)** **F 04 B 43/10 (2006.01)**
F 04 F 5/10 (2006.01) **F 04 F 5/46 (2006.01)**
- (45) Oversættelsen bekendtgjort den: **2024-05-27**
- (80) Dato for Den Europæiske Patentmyndigheds bekendtgørelse om meddelelse af patentet: **2024-03-13**
- (86) Europæisk ansøgning nr.: **19749278.8**
- (86) Europæisk indleveringsdag: **2019-07-25**
- (87) Den europæiske ansøgnings publiceringsdag: **2022-06-01**
- (86) International ansøgning nr.: **EP2019070022**
- (87) Internationalt publikationsnr.: **WO2021013350**
- (84) Designerede stater: **AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR**
- (73) Patenthaver: **Altop Patents III B.V., Matjeskolk 23, 7037 DZ Beek (Montferland), Holland**
- (72) Opfinder: **SPEIJERS, Sam, Dorpsstraat 2, 6587 AX Middelhaar, Holland**
- (74) Fuldmægtig i Danmark: **Dennemeyer & Associates S.A, P.O. Box 700425, DE-81304 Munich, Tyskland**
- (54) Benævnelse: **FREMGANGSMÅDE OG SYSTEM TIL CYKLISK DRIFTSPUMPE**
- (56) Fremdragne publikationer:
WO-A1-2017/019560
US-A- 2 747 510
US-A- 3 857 651

DESCRIPTION

Description

[0001] The present invention relates to a method of transporting a material, to a system of transporting a material, and to a computer program to control the system and applying the method.

[0002] The material to be transported may be a more or less viscous substance in a horizontal or vertical system, but the method may also be applied in sub-sea conditions, such as for the mining and transport to the surface of materials e.g. nodules and other deposits found on deep sea ocean floors. In that case the material to be transported comprises solids present in a liquid, that is water.

[0003] WO-2017/019560 discloses a system and method of transporting a material through an interconnected series of tube member sections. The tube member has an inner space provided with inflatable flexible bladders. A downstream tube section holds the material to be transported. The bladders are selectively pressurized by means of a microprocessor controlled processor which controls a compressor for providing a pressure medium to the bladders. In a peristaltic sequence the bladders are pressurized and depressurized resulting in an inward or outward flexing of the bladders in order to transport the material through the tube member.

[0004] US-2,747,510 discloses a method of transporting a material by means of at least one series of interconnected tube stages, configured to be opened or closed by means of check valves. At least one downstream tube section thereof holds the material to be transported in multistage polyphase. The opening and closing of the tube stages is collectively crank controlled in opposite way. Thereto each of the tube sections have axially movable -in unison- housing sections as well as housing sections respectively fixed to a sub-frame. The interconnected tube sections each have a flexible inner tube which are controlled by pressurising or depressurising a pressure space chamber between the tube sections and the flexible inner tubes. A resulting inward or outward flexing of the flexible inner tubes provides the pumping action for closing and opening the respective tube sections. Successive parts of the material confined between the tube sections are controllably transported through the series of interconnected tube sections.

[0005] Claimed is a method of transporting a material by means of at least one series of interconnected tube sections at least one downstream tube section whereof holds the material to be transported, whereby a liquid jet is generated which accelerates the held material upstream out of at least the first downstream tube section into at least one opening upstream tube section which then holds the material part waiting for a next liquid jet to propagate that part to the next upstream tube section.

[0006] Further claimed is a system for transporting material comprising:

- at least one series of interconnected tube sections, whereby in operation tube sections of said series hold the material to be transported, and
- liquid jet generating means arranged in or embodied by the respective tube sections whereby the generated liquid jet accelerates material in at least a downstream tube section partly into an opening upstream tube section which then holds the material part.

[0007] Such a method and system are known from US-3,857,651 which discloses a method of transporting a material by means of at least one series of interconnected -open- tube sections. At least one downstream tube section whereof holds the material to be transported, whereby a liquid jet is generated by means of cyclonic pumping which accelerates the held material upstream out of at least the first downstream tube section into at least one upstream open tube section which then transports by means of a next liquid jet that part to the next open tube section.

[0008] It is an object of the present invention to provide a method and accompanying system for effective transport of materials in general, with an emphasis on mining and lifting of nodules comprising useful compositions and metals.

[0009] Thereto the method according to the invention is characterized in that:

- by opening and closing the individually controlled tube sections, successive parts of the material confined between closed tube sections are stepwise transported through the series of interconnected tube sections, and
- that the interconnected tube sections which have a flexible inner tube fixed therein are controlled such that by pressurising or depressurising a pressure space between the tube section and the flexible inner tube a resulting inward or outward flexing of the flexible inner tube closes or opens the respective tube sections.

[0010] Further thereto the system according to the invention is characterized in that the interconnected tube sections:

- have a flexible inner tube fixed therein for individually controlling an opening and closing of the tube sections such that successive parts of the material confined between closed tube sections are stepwise transported through the series of interconnected tube sections, and
- have a pressure space between the tube section and the flexible inner tube such that a pressurising or depressurising of the pressure space results in an inward or outward flexing of the flexible inner tube which closes or opens the respective tube sections.

[0011] The inventor had the notion that the pumping of a material comprising solids in a liquid can only be performed by accelerating the solids therein. Since the extent of acceleration is limited in practise a stop and go cycle is suggested wherein the solids in the material are sequentially being held, accelerated by means of a liquid jet and then again held, but now at least partly upstream in a next tube section. During the acceleration phase the solids which are normally heavier than the liquid they are in, do not get the time to sink. So the repeated cycle of holding, acceleration and holding of in particular the solids safeguards their successive movement upstream from one tube section to the next upstream tube section.

[0012] By individually controlling the tube sections a stepwise sequential transport of at least one batch of material takes place. This advantageously leads to the possibility of successive batches being propelled during cycles in the series arrangement of successive tube sections. An even further advantage provides a parallel arrangement of such series if a higher yield of solids is required, such as may be the case in the mining of manganese nodules where the method is applied in a vertically aligned system in the deep sea. Such a parallel arrangement will turn out to have even further advantages in terms of pump efficiency because then pump actions in one series of tube sections and its neighbouring series may mutually operate in opposite phase.

[0013] Furthermore it is an advantage of the present invention that this embodiment of the control method and layout of the tube section may, either function as a controllable valve, or as a forcing pump, suction pump, that is a double acting pump for liquids with solids.

[0014] Another embodiment of the method according to the invention has the characterising features of claim 3.

[0015] Under deep sea conditions to the water, having a depth dependent pressure, only a wanted pressure difference will have to be added by the pump, to propel the confined material over one or more tube sections, in which case a common centrifugal or gearwheel pump will suffice.

[0016] An embodiment of the system according to the invention has the characterising features of claim 8.

[0017] This flaring promotes an unambiguous upstream directed flow of liquid and solids held by the downstream tube section into the upstream tube section, when the pressure space is pressurised.

[0018] A further embodiment of the system according to the invention has the characterising features of claim 9.

[0019] The programmable control by the processor safeguards a smooth course of the necessary control actions in the system. Furthermore appropriate actions can be taken by

means of operational software running in the processor, usually based on locally present sensors which provide actual control and timing parameter values.

[0020] At present the features according to the inventions will be elucidated further together with their additional advantages while reference is being made to the appended drawings, wherein similar components are being referred to by means of the same reference numerals. In the drawings:

Fig. 1 shows a system according to the invention having interconnected controllable tube sections here in a vertical configuration;

Fig. 2 shows a detail of a possible embodiment of a tube section according to the invention for use in the system of fig. 1;

Fig. 3 shows a top view on one-way means in the form of pivotally brackets mounted at one end of the tube section shown in fig. 2; and

Fig. 4 shows a matrix chart of the system of fig. 1 with interconnected tube sections depicted in a row denoted A-Z and in each column the open/closed state of the tube section in that row during the sequence of events denoted 1-14 while the material held is transported upstream.

[0021] Fig. 1 shows a system 1 for transporting material mainly in the form of a liquid, such as water, in particular sea water wherein solids, such as nodules, in particular manganese nodules are present. The system 1 comprises a series of interconnected tube sections 2, but if required the system 1 may comprise two or more parallel operating series of such tube sections 2. Each tube section 2 can be controlled to open or close which will be described further hereinafter. If installed in vertical configuration to be applied in water e.g. deep sea all sections 2 are open and are lowered into the water on their own weight till the bottom of the sea is reached by the most downstream tube section 2 which is then closed, as seen in row 2B of the matrix chart of fig. 4. Narrower drawn tube sections 2A, 3C, 4E et cetera may be considered as non-return valves, but they may even be embodied by such multifunctional tube sections 2. Key with respect to the transport mechanism reflected by the chart is that at least part of the material confined between outer closed sections 2, is propagated between a closing most inner downstream section 2 and an upstream simultaneously opening most inner tube section 2. This will further be elucidated later.

[0022] To at least promote some extra propagation of the material, liquid jet generating means 3 in the form of a pump driven nozzle 4 are positioned under the material M to be accelerated and are arranged in the tube section 2 as shown in fig. 2.

[0023] Basic stepwise propagation in the direction of the arrows in fig.2 is however effected by the pressure action of the tube sections 2 which generate a liquid jet for tube section material to propagate, into so to say shift, into the simultaneously opening and material admitting/receiving upstream tube section 2. This way only the material which at its outer

boundaries is confined between closed tube sections 2 is stepwise in a stop and go fashion transported from one section to the next. So limited amounts of pump energy are required for such stepwise movements wherein the solids are accelerated during each step. During a stop the water pressure inside the sections is made equal to the pressure of the water outside. This prevents water or gas escaping from the water or material to expand unwantedly. Multiple successive trains of confined material can travel through the series of tube sections 2 in a controlled way as seen in fig. 4 or through a system 1 with several parallel connected series of tube sections.

[0024] In order to effect the pressure action the tube section 2 comprises a flexible inner tube 5 fixed in the downstream tube section 2. Between the tube section inner wall and the flexible inner tube 5 there is a pressure space 6 which may be pressurised or depressurised by means of a fluid liquid pump 7. The pump 7 which may also drive the nozzle 4 and may be a water pump which outputs possibly salt water having a pressure which is derived from the local water pressure at a depth where the tube sections 2 concerned are situated. In that case a limited amount of pump power is necessary since only the confined material needs to be lifted in each step which only requires a common centrifugal pump or a gearwheel pump. A pressurising of the space 6 results in an inward flexing of the flexible inner tube 5 forcing the material including water and solids within the flexible tube 5 out to the upstream tube section 2, as the tube section 2 directly downstream of that upstream section is closed. While a depressurising results in an outward flexing ultimately against the inner wall of the section 2 which may suck in material but more importantly makes space for said forced out material part to enter the flexible inner tube 4 of the upstream inner tube section.

[0025] In order to extra propel and accelerate the material out of the tube section the flexible inner tube may be flared radially outwardly in upstream direction. Then pressurising the space 5 provides an extra force to drive the material into the next section.

[0026] Timing of the opening and closing of the various tube sections to get to a kind of stepwise running upstream wave of the material is effected by a programmable processor μ . The processor is capable of generally bidirectional communicating a data address signal via a bus structure like in a computer bus, at least to the liquid jet generating means 3, 4, the controllable tube sections 2 and valves, as well as to sensors S which measure critical parameter quantities. These addresses are unique in order to allow the processor μ to control each and every of the controllable components of the system 1 by means of a computer program and with the help of the sensor parameters. In particular opening and closing actions required for executing the method of transporting the material are properly programmed. Possibly these actions in particular their individual durations dependent on the operating depth of or the pressure in the tube sections 2, and the kind and size of material, as well as the viscosity and/or the solid to liquid ratio of the material and/or velocities and/or degree of filling of a section 2 may be input though the bus to the software concerned.

[0027] The tube section 2 as shown in fig. 2 and 3 in top view comprise a one-way means 8 fixed therein for preventing solids in the material to move downstream. These means 8 are

formed here as non-return brackets which in fig. 2 pivot or possibly flex in upstream direction only. Fig. 2 shows that a mounting ring 9 is fixed to the inner wall of the tube section 2. The brackets pivot 10 is fixed to the inner wall via the ring 9 at the end of the section 2. Here the ring 9 also comprises the nozzle 4 and helps to effectively clamp an end part of the flexible inner tube 5. This eases production of the tube sections.

[0028] Returning to the chart of fig. 4 it is best seen in rows 8-14 that in the case as shown there are three material filled sections 2 which are one by one gradually stepwise shifted -in this case upstream- to the right by the controlled closing and simultaneous opening of in this case the two inner sections which adjoin the confined material. Lesser or more sections may be filled with material which requires lesser or more local pump power and will influence the friction forces exerted on in particular the repeatedly flexing inner tube 5. It is also possible to confine the material section or sections between two or more sections on each side thereof, while the most inner sections are simultaneously closed and opened.

REFERENCES CITED IN THE DESCRIPTION

Cited references

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

Patent documents cited in the description

- [WO2017019560A \[0003\]](#)
- [US2747510A \[0004\]](#)
- [US3857651A \[0007\]](#)

FREMGANGSMÅDE OG SYSTEM TIL CYKLISK DRIFTSPUMPE**PATENTKRAV**

1. Fremgangsmåde til transport af et materiale (M) ved hjælp af mindst en serie af sammenkoblede rørsektioner (2; 1A–14Z) hvoraf mindst en nedstrøms rørsektion (2) holder materialet (M), der skal transporteres, hvorved en væskestråle genereres som accelererer det holdte materiale (M) opstrøms ud af mindst den første nedstrøms rørsektion (2) ind i mindst en åbnende opstrøms rørsektion (2) som derefter holder materialedelen (M), der afventer at en næste væskestråle viderefører denne del til den næste opstrøms rørsektion (2), kendetegnet ved at:

- ved åbning og lukning af de individuelt styrede rørsektioner (2; 1A–14Z), transporteres efterfølgende dele af materialet (M), som er indespærret mellem lukkede rørsektioner (2; 1A–14Z) trinvist gennem serien af sammenkoblede rørsektioner (2; 1A–14Z), og

- de sammenkoblede rørsektioner (2; 1A–14Z) som har et fleksibelt indvendigt rør (5) fikseret deri styres således, at ved påførsel af tryk eller trykaflastning af et trykrum (6) mellem rørsektionen (2; 1A–14Z) og det fleksible indvendige rør (5) lukker eller åbner en deraf følgende indadgående eller udadgående bøjning af det fleksible indvendige rør (5) de respektive rørsektioner (2; 1A–14Z).

2. Fremgangsmåde ifølge krav 1, kendetegnet ved at væskestrålen som rettes mod materialet (M), der skal transporteres, genereres:

- gennem en pumpedrevet dys (4) i rørsektionen (2) nedstrøms i forhold til det holdte materiale, og/eller

- af en rørsektion (2) nedstrøms i forhold til det holdte materiale (M), hvis rørsektion har det indadgående bøjende, indvendige rør (5), hvis trykrum (6) er pumpedrevet (7).

3. Fremgangsmåde ifølge krav 2, kendetegnet ved at pumperne (4, 7) reagerer, hvis de tilsluttes til dertil beregnede, hovedsagligt lodret tilpassede rørsektioner (2) under dybhavstilstande til vandet med et dybdeafhængigt tryk, baseret på en difference i vandtryk i forhold til det lokale vandtryk.

4. System (1) til transport af materiale (M), som omfatter:

- mindst en serie af sammenkoblede rørsektioner (2; 1A–14Z), hvorved rørsektioner (2) i ovennævnte serier under drift holder materialet, der skal transporteres, og

- midler til generering af væskestråler (3) anordnet i eller omfattet af de respektive rørsektioner (2; 1A–14Z), hvorved den genererede væskestråle accelererer materiale (M) i mindst en nedstrøms rørsektion (2) delvist ind i en åbnende rørsektion (2) som derefter holder materialedelen, kendetegnet ved at de sammenkoblede rørsektioner (2; 1A–14Z):

- har et fleksibelt indvendigt rør (5) fikseret deri til individuel styring af en åbning og lukning af rørsektionerne (2; 1A–14Z), således at efterfølgende dele af materialet (M) som er indespærret mellem lukkede rørsektioner (2; 1A–14Z) transporteres trinvist gennem serien af sammenkoblede rørsektioner (2; 1A–14Z), og

- har et trykrum (6) mellem rørsektionen (2; 1A–14Z) og det fleksible indvendige rør (5), således at påførsel af tryk eller trykaflastning af trykrummet (6) medfører en indadgående eller udadgående bøjning af det fleksible indvendige rør (5) som lukker eller åbner de respektive rørsektioner (2; 1A–14Z).

5. System (1) ifølge krav 4, kendetegnet ved at midlet til generering af væskestråler (3) omfatter en pumpedrevet dyse (4) i den nedstrøms rørsektion (2), som er positioneret under materialet (M) som skal accelereres.

6. System (1) ifølge krav 4 eller 5, kendetegnet ved at systemet (1) omfatter en flydende væskepumpe (7), som er tilsluttet til trykrummet (6).

7. System (1) ifølge et af kravene 4–6, kendetegnet ved at styrbare væskepumper (4, 7) er beregnet til at fungere på en gruppe af hovedsageligt lodret tilpassede, sammenkoblede rørsektioner (2; 1A–14Z) under dybhavstilstande til vandet med et dybdeafhængigt tryk, hvor hver væskepumpe (7), som genererer vand, har et tryk som er afledt af det lokale dybdeafhængige tryk.

8. System (1) ifølge et af kravene 4–7, kendetegnet ved at det fleksible indvendige rør (5), som er fikseret i rørsektionen (2), is udspiles radialt udad i opstrøms retning.

9. System (1) ifølge et af kravene 4–8, kendetegnet ved at systemet (1) omfatter en programmerbar processor (μ), som er i stand til mindst at kommunikere et dataadressesignal til midlet til generering af væskestråler (3) og rørsektionerne (2; 1A–14Z), som hver kan adresseres unikt, for at generere efterfølgende stråler med matchende åbnings- og lukkeindgreb på rørsektionerne (2; 1A–14Z), og hvis processor (μ) er programmeret, således at ovennævnte materialedeler (M) drives opstrøms som en løbende bølge fra den ene til den næste rørsektion (2; 1A–14Z).

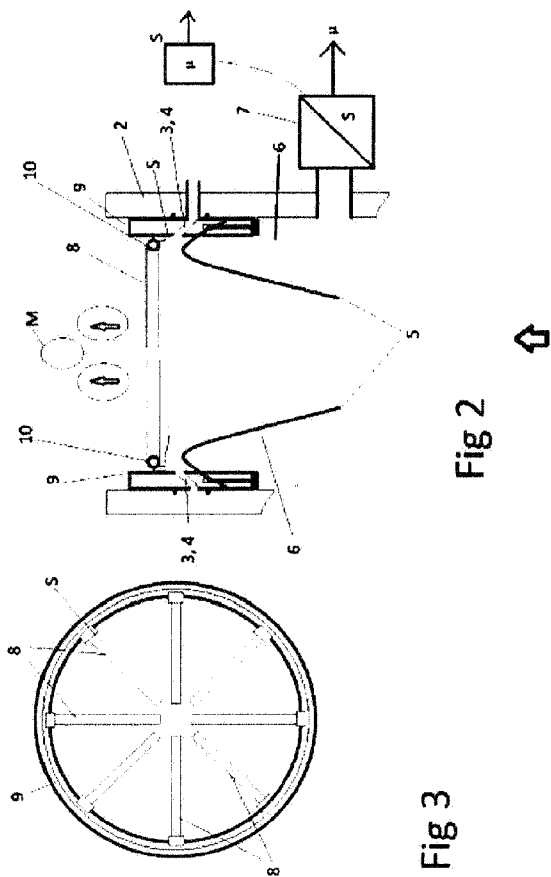
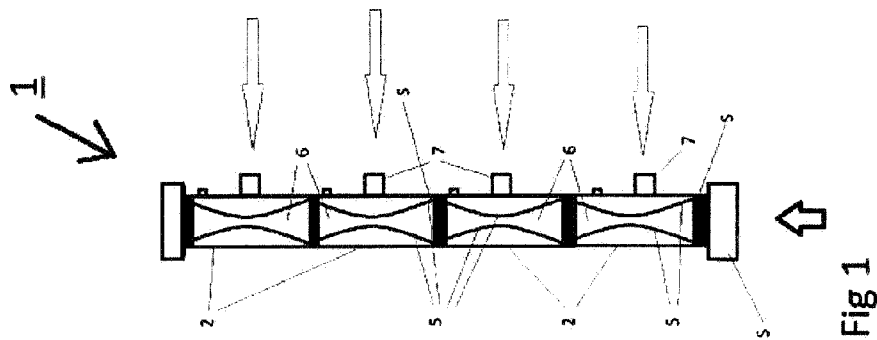
10. System (1) ifølge krav 9, kendetegnet ved at systemet (1) omfatter sensorer (S) anordnet til at kommunikere med processoren (μ) for at forsyne driftsmængder dertil, såsom for eksempel de omgående væsketryk og væskehastigheder i rørsektionen(erne) (2; 1A–14Z).

11. System (1) ifølge et af kravene 4–10, kendetegnet ved at rørsektionen (2; 1A–14Z) omfatter envejsmidler (8) fikseret deri for at hindre at tørstoffer i materialet (M) bevæges nedstrøms.

12. Computerprogram, som indeholder instruktioner der medfører at systemet (1) ifølge krav 9 eller 10 udfører fremgangsmåden ifølge ethvert af kravene 1–3.

DRAWINGS

Drawing



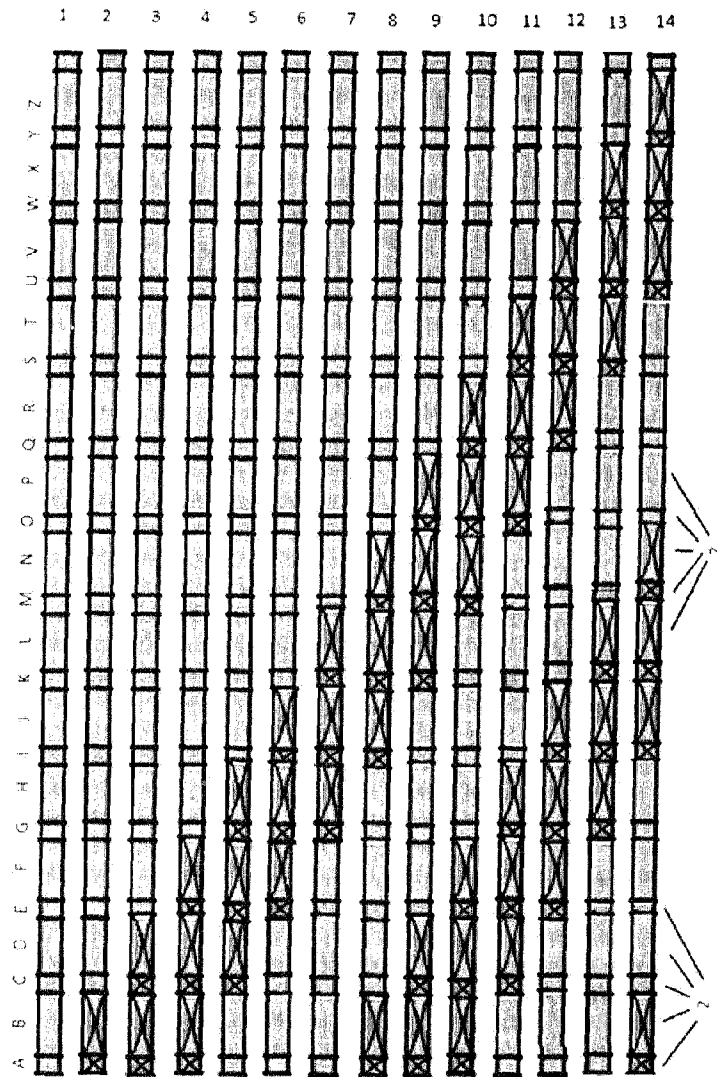


Fig 4