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Method for carrying out material from a pressure chamber and conveyor device

The invention relates to a method for carrying out material from a pressure chamber, preferably for carrying out muck from the pressure chamber of earth pressure shields, in which pressure chamber material (muck) is stored mixed with a compressible gaseous medium and from where the muck is transported away by means of a conveyor device which at the same time acts as a pressure lock, wherein the material (muck) mixed with said compressible medium is pressed through an opened sliding valve of the conveyor device by the force of the pressure in the pressure chamber which pressure is larger than a smaller, normally atmospheric, pressure prevailing in the space at the outside of the pressure chamber (back space). The invention relates also to a conveyor device for carrying out said method.

From the area of tunnel construction - for example from hydro shields - it is known to carry out muck (excavation), which has been stripped in-situ in the stripping chamber, out of the stripping chamber through pipe conduits with the help of the liquid supporting the working face and to haul it away by pumps. This method suffers from the drawback that along with the muck huge amounts of liquid have to be transported and separated thereafter from the muck. The supporting liquid is recuperated. This calls for large separation plants. The soil extracted by the separation process still contains a high content of support liquid and is unfit for short-term soil-mechanical processing. This soil causes further costs for its shipping away and dumping. The disposal of the stripped muck and the support liquid comprised ther-

ein is thus very costly with shields working with supporting the working face by a liquid.

With EPB-shields (EPB = Earth Pressure Balanced) stripped soil, which is adequately impermeable by nature and conditioned by suitable agents, such as foams, is used for supporting the working face. So far, this soil has been transported away from the stripping chamber by screw conveyors. The compacted column of soil in the screw conveyor during the conveying process acts as a seal against the pressure in the stripping chamber and as a lock to the unpressurized rear shield space. The larger the permeability of the soil the larger has to be the length of the sealing column of soil and correspondingly the screw of the conveyor. The effectiveness of the stopper formed by the soil as a pressure seal for the chamber has its limits at a soil with a k -value greater than 10^{-5} m/s and at a support pressure above about 2 bar.

Soils with too great a permeability can no longer withstand the pore pressure in the soil stopper, thus making necessary a lock for material arranged at the end of the screw conveyor. Such locks for material are in a wider sense pumps, such as piston pumps, hose pumps and centrifugal pumps, as well as drawer-like and rotating lift-locks. They comprise rotating and moving parts which are subject to high wear. They normally require a system-related conditioning of the muck to be carried out which contradicts the object of achieving an extract as dry as possible. Their extraction capacity in relation to the hauling capacity of the shield is small. To increase the extraction capacity large constructions are necessary which can be accommodated in the shield space only at large tunnel cross-sections. This means that the yield capacity of the shield can not fully be uti-

lized. Therefore, such excavation equipment considerably reduces the economy of a heading machine.

() From DE-A-36 272 70 an EPB-shield is known where the loosened soil is transported out of the stripping chamber with a screw conveyor. The screw of the conveyor presses the stripped soil out of the pressure chamber towards a closable sliding valve outlet in the inner space of the shield, and from said outlet of the sliding valve the soil is carried away on a conveyor belt arranged below said outlet in the area of atmospheric pressure. As explained above, such a conveyor plant is unable to hold back the higher pressure in the pressure chamber if the soil is permeable. With permeable soils the sliding valve has to be closed and the excavation of soil has to be stopped.

The invention aims at developing a method and a device for carrying out material from a pressure chamber of the kind described in the introductory part of this description, which also allow the excavation of soils with a permeability $k > 10^{-5}$ m/s in a simple, wear-proof, space-saving and reliable manner.

() To achieve this aim the invention suggests a method according to claim 1, which is characterized in that the material (muck) is pressed through said opened inlet sliding valve into a conveyor chamber which is limited by said inlet sliding valve and by a closed outlet sliding valve against said back space which is subjected to said smaller pressure, and that the ejection of the material (muck) out of the conveyor chamber after closing of the inlet sliding valve is brought about by an abrupt opening of the outlet sliding valve causing sudden expansion of the compressed gaseous medium.

According to one embodiment of the method according to the invention the transport of the material (muck) from the pressure chamber to the conveyor chamber is assisted by a conveyor means, such as a screw conveyor, installed between the pressure chamber and said conveyor chamber.

According to the invention the ejection energy in the conveyor chamber may be increased by additional gas introduced into the closed conveyor chamber filled with material (muck), which additional gas has a pressure larger than the pressure in the pores the material (muck) in the conveyor chamber.

According to the invention agents, for example foaming agents, may be added to the muck which agents are adapted to decrease the permeability of the muck whereby the amount of the added agents is selected such that the expansion of the compressible gaseous medium in the conveyor chamber is retarded against the time required for opening the outlet sliding valve.

A conveyor device for carrying out the method according to the invention is adapted to press out material from the pressure chamber, preferably muck from the pressure chamber of earth pressure shields, through an opened sliding valve by means of the pressure in the pressure chamber which pressure is larger than the smaller, normally atmospheric, pressure prevailing in the space at the outside of the pressure chamber (back space). According to the invention the path of extraction between the pressure chamber and said back space is provided by an empty pipe-like conveyor chamber with smooth walls, which conveyor chamber is limited by an inlet sliding valve against the pressure chamber and by a outlet sliding valve against said back space, said outlet sliding valve being adapted to be quickly opened towards the back

space, and that the sliding valves are controllable such that one sliding valve can be opened only when the other sliding valve is closed.

According to one embodiment of the invention said conveyor device comprises a conveyor means, such as a screw conveyor, which is connected with its inlet side to the pressure chamber and with its outlet side to the inlet portion of said conveyor chamber.

Thus, according to the method and the device according to the invention the excavation of material (muck) from a pressure chamber is achieved by using, in a surprisingly simple manner, the energy stored in a compressed medium - such as a gas, a gas mixture, foam or foamed suspension - in the pores in the muck at the moment of depressurisation. This method is preferably developed for tunnel construction. The same method could be used in analogue manner in other industries, where muck-like substances are to be carried out of pressurized containers, for example in primary matter industries, the chemical industry, garbage dressing and garbage disposal.

The method and the device according to the invention are principally independent of a conveyor means, such as a pump or a screw conveyor, connected in front of the conveyor chamber. The conveyor chamber is a simple cell which only serves to form a closable space, and it comprises no rotating parts or mechanical drives. Thus, the conveyor chamber is very insensitive under operation. It requires little space and may be accommodated in the shield space in a simple manner.

The times needed for charging and discharging the conveyor chamber are short, thus enabling a fast cycle sequence and a

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large throughput. Thus, the conveyor device according to the invention is most adapted to satisfy the excavation demands of a shield heading machine.

The material to be carried out may be conditioned with very little water, thus yielding favourable conditions for an economic excavation and simple re-storage.

In tunnel construction often varying layers of different kinds of soil have to be excavated, which can not homogeneously be mixed or conditioned. When inhomogenous mixtures of pore-poor, largely impervious soils and highly gas and water pervious soils have to be excavated under holding the pressure, it may occur that the change of the kinds of soil during excavation results in a situation where the muck to be excavated exhibits such a small porosity that the expansion energy stored in the muck is not sufficient to bring about a complete and sufficiently fast extraction. This tendency is enhanced by a moderate pressure gradient.

In order to enable a reliable use of the method suggested also under these conditions an accumulator for pressurized gas is alternatively arranged at the inlet area of the conveyor chamber which, if necessary, provides additionally required expansion energy and which may become connected if inhomogenous soil mixtures of different cohesion or soils with a small expansion energy have to be excavated.

The movement of the sliding valves and/or the addition of gas from said accumulator for pressurized gas into the conveyor chamber may be electronically program-controlled.

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The invention will be explained with reference to the Figures 1 to 3.

Figure 1A-E show a schematic illustration of the different phases of a working cycle of the method according to the invention,

Figures 2A-E show a schematic illustration of the method according to the invention according to Figures 1A-E supplemented with an accumulator for pressurized gas,

Figure 3 shows an example of an application of a conveyor chamber according to the invention in an EPB-shield.

Figures 1A-E illustrate the mode of operation of the conveyor chamber 2 according to the invention. The conveyor chamber is arranged between a pressure chamber 1, in which high pressure prevails, and a carry-out element in the space 3 of lower pressure. The conveyor chamber is closable against the pressure chamber 1 by a sliding valve 4 and against the low-pressure space 3 by the sliding valve 5.

During phase Figure 1A the pressurized material 6, which is to be carried out of the pressure chamber 1, extends to the sliding valve 4, which is in its closed position 4/1. The sliding valve 5 is still in its opened position 5/2 following the preceded discharge of the conveyor chamber. In phase Figure 1B the sliding valve 5 is moved to its closed position 5/1. Low pressure prevails in the empty conveyor chamber 2. Thereafter, in phase Figure 1C the sliding valve 4 is moved to its open position 4/2. The over-pressure in the pressure chamber 1 presses the muck (excavation) 6 into the empty conveyor chamber 2. In phase Figure 1D the sliding valve 4 is moved to its closed position 4/1. In the conveyor

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chamber 2 there is a separated muck volume 7 loaded with over-pressure in its pores. In phase Figure 1E the sliding valve 5 is abruptly brought to its open position 5/2.

The pore over-pressure in the muck 7, which pressure is larger than the pressure in the low-pressure space 3, presses the muck volume 7 out of the conveyor chamber 2 and the depressurized muck 8 exits in the low-pressure area. Thus, the state of phase Figure 1A has been regained, and a new excavation cycle may start.

In Figure 2 the conveyor chamber 2 is provided with an accumulator⁹ for pressurized gas in its inlet area. The operation sequence of the phases Figure 2A to 2C correspond to those of Figures 1A to 1C. In phase Figure 2D the sliding valve 4 is moved to its closed position 4/1. In the conveyor chamber 2 there is a separated muck volume 7 which is subjected to pore over-pressure. The accumulator⁹ for pressurized gas is loaded with the pressure which is higher than the pore over-pressure. By opening the connection valve between the accumulator 9 and the conveyor chamber 2 the pore over-pressure in the closed conveyor chamber 2 will increase. In phase Figure 2E the sliding valve 5 is abruptly brought into its open position 5/2. Simultaneously with or immediately after the opening of the sliding valve 5 the accumulator⁹ for pressurized gas ejects a further pulse of pressurized gas into the inlet area of the conveyor chamber 2. The expansion pressure of the gas pulse and the increased pore over-pressure in the muck 7 vis-a-vis the low-pressure space 3 press the muck volume 7 out of the conveyor chamber 2, and the depressurized muck 8 exits into the area of low pressure. Thus, the situation of phase Figure 2A has been regained, and a new excavation cycle may start.

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Figure 3 illustrates an example for an application of the conveyor device according to the invention in an EPB-shield heading machine 10. The pressure or stripping chamber 12 arranged at the head of the shield 11 is closed at its rear end by the funnel-shaped rear wall of the stripping chamber, which exerts pressure against the working face 14 with its cutting edge 13 and thus seals the pressure chamber at the front side. A cutting wheel 15 strips the soil at the working face. The soil supports the working face by means of the driving of the shield and the pressure of the foam which is pressed through conduit 16 against the working face 14 and into the stripping chamber 12 and which is mixed into the stripped muck in the stripping chamber by the rotational movement of the cutting wheel.

The muck 17 is pressed into the screw conveyor 18 which is suitably installed between the stripping chamber 12 and the conveyor device 19 in order to achieve a continuous supply of muck to the conveyor device 19 according to the invention. The conveyor device 19 discharges on a conveyor belt 20. The conveyor device consists of an inlet portion 21, which substantially is subjected to the pressure in chamber 12, the conveyor chamber 22 and an outlet element 23. The sliding valve 24 is arranged between the inlet portion 21 and the conveyor chamber, and the sliding valve 25 is arranged between the conveyor chamber and the outlet element 23. To extract the muck from the pressure chamber 12 the same steps as described with regard to Figure 1 or 2 take place in the conveyor device 19.

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Claims

1. Method for carrying out material from a pressure chamber, preferably for carrying out muck from the pressure chamber of earth pressure shields, in which pressure chamber material (muck) is stored mixed with a compressible gaseous medium and from where the material (muck) is transported away by means of a conveyor device which at the same time acts as a pressure lock, wherein the material (muck) mixed with said compressible medium is pressed through an opened sliding valve of the conveyor device by the force of the pressure in the pressure chamber which pressure is larger than a smaller, normally atmospheric, pressure prevailing in the space at the outside of the pressure chamber (back space), c h a r a c t e r i z e d in that the material (muck) is pressed through said opened inlet sliding valve (4,24) into a conveyor chamber (2,22) which is limited by said inlet sliding valve and by a closed outlet sliding valve (5,25) against said back space (3,23) which is subjected to said smaller pressure, and that the ejection of the material (muck) out of the conveyor chamber after closing of the inlet sliding valve (4,24) is brought about by an abrupt opening of the outlet sliding valve (5,25) causing sudden expansion of said compressed gaseous medium.

2. Method according to claim 1, c h a r a c t e r i z e d in that the transport of the material (muck) from the pressure chamber (1,21) is assisted by a conveyor means (18), such as a screw conveyor, installed between the pressure chamber (21) and said conveyor chamber (22).

3. Method according to claim 1 or 2, c h a r a c t e r i z e d in that the ejection energy in the conveyor chamber (2,22) is increased by additional gas introduced into the closed conveyor chamber filled with material (muck) (7),

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which additional gas has a pressure larger than the pressure in the pores of the material (muck) in the conveyor chamber.

4. Method according to any of the preceding claims, characterized in that agents, for example foaming agents, are added to the material (muck) (6,17) adapted to decrease the permeability of the material (muck) whereby the amount of the added agents is selected such that the expansion of the compressible gaseous medium in the conveyor chamber is retarded against the time required for opening the outlet sliding valve (5,25).

5. Conveyor device for carrying out the method according to any of claims 1 to 4, which conveyor device (19) is adapted to press out material from a pressure chamber (1,12), preferably material (muck) from the pressure chamber of earth pressure shields, through an opened sliding valve (24) by means of the pressure in the pressure chamber which pressure is larger than the smaller, normally atmospheric, pressure prevailing in the space at the outside of the pressure chamber (back space), characterized in that the path of extraction between the pressure chamber (1,12) and said back space (3,23) is provided by an empty pipe-like conveyor chamber (2,22) with smooth walls, which conveyor chamber is limited by an inlet sliding valve (4,24) against the pressure chamber (1,21) and by a outlet sliding valve (5,25) against said back space, that said outlet sliding valve is adapted to be quickly opened towards the back space (3,23), and that the sliding valves (4,5;24,25) are controllable such that one sliding valve can be opened only when the other sliding valve is closed.

6. Conveyor device according to claim 4, characterized in that a conveyor means (18), such as a screw conveyor, is connected with its inlet side to the pressure

chamber (1,21) and with its outlet side to the inlet portion (21) of said conveyor chamber (22).

7. Conveyor device according to claim 5 or 6, c h a r a c-
t e r i z e d in that it is provided with an accumulator
(9) for pressurized gas, which enables the injection of gas
into the closed conveyor chamber (2,22) which gas has a hig-
her pressure than the gas in the pores of the material
(muck) (7) in the conveyor chamber (2,22).

8. Conveyor device according to claim 7, c h a r a c t e r-
i z e d in that the movement of the sliding valves
(4,5;24,25) and/or the addition of gas from the accumulator
(9) for pressurized gas into the conveyor chamber (2) is
electronically program-controlled.