

METHOD FOR WORKING THROUGH GROUND AND ROCK LAYERS WITH
DREDGERS OR EXCAVATORS AND APPARATUSES OPERATING ACCORD-
ING TO THIS METHOD

This invention relates to a method for working through ground layers, which are understood to include gravel, sand and clay layers or ground layers containing rock-like materials or consisting virtually exclusively
5 of rock masses such as rock layers, with dredgers or excavators such as suction hopper dredgers, suction cutter dredgers, bucket dredgers, grab dredgers, pull shovel pontoons or the like, wherein a part of the mechanical cutting or excavating component comes into
10 contact with the ground and/or rock layers for excavating.

In dredging operations with dredgers or excavators of different types, but mainly of the suction hopper type, use is already made of water jets which are inject-
15 ed under pressure into an area in front of the cutting or excavating component and which may or may not be mixed with air. The main purpose of injecting with water jets is to cause sandy grounds to fluidize, this by adding water, which enhances the cutting, suction and pumping
20 process and in sludge-like grounds causes stirring-up of the sludge particles in the water so that these can be displaced by the ambient natural water currents. The pressures used in this technique lie in the order of magnitude of 10 bar with a tendency to increase the
25 pressure to about 15-20 bar.

The invention now has different purposes which can be summarized as follows:

- 1) To reduce the mechanical cutting forces so that
 - a) harder ground types can be dredged with a similar or
30 lower power of the machines;
 - b) a higher cutting, suction and pressing production can be attained in identical ground types.
- 2) To reduce the wear on the cutting or excavating components, including the teeth thereof.



3) To obtain a still greater fluidization of the sandy materials, which will improve the pump efficiency.

In order to make this possible according to the invention, water jets are injected in the area where the cutting or excavating component is active at a pressure which is sufficiently high to cut open the ground layers, such as clay layers, and/or cause the ground layers, such as sand layers, to fluidize in the vicinity of the cutting or excavating component and, when the ground layers contain rock-like materials or consist virtually or exclusively of rock-like materials such as rock layers, to immediately remove broken-off and crushed materials from the location where the mechanical cutting or excavating component is active and to enhance the hydraulic fracturing in the non-crushed material in the immediate vicinity of the crushed material.

In order to cut open the ground masses or cause them to fluidize water jets are injected according to the invention at a pressure of at least 20 bar at the height of, through and/or behind the mechanical cutting or excavating component and at a pressure of at least 50 bar in front of the mechanical cutting or excavating component.

In determined conditions, when the ground layers contain rock-like materials or consist solely of rock-like materials, water jets are injected at pressures of at least 100 bar up to pressures of even at least 2000 bar in accordance with the requirement necessary to achieve the intended purpose.

Other details and advantages of the invention will become apparent from the following description of a method for working through ground and rock layers with dredgers or excavators and of the apparatuses operating according to this method.

This description is given solely by way of example and does not limit the invention. The reference numerals relate to the figures annexed hereto.

Figure 1 is a schematic view of the principle on which the method according to the invention is based in



the case of a tooth as mechanical cutting or excavating component.

Figures 2 and 3 are schematic representations in side view of the head of a suction hopper dredger during application of the method according to the invention.

Figure 4 is a side view of a tooth with adapter in a possible embodiment according to the invention, i.e. with at least one water jet under high pressure through the tooth.

Figure 4A is a side view of an adapter as according to a variant.

Figure 5 shows a cross-section along the line V-V of figure 4.

Figure 5A shows a longitudinal section along the same line of an adapter as according to figure 4A.

Figure 6 is a perspective view of an adapter with tooth mounted thereon in an embodiment according to the invention.

Figure 7 shows in perspective view a variant of the embodiment of figure 6.

Figure 8 illustrates schematically the operation of the teeth on a suction cutter dredger.

The method illustrated by the above stated figures is based on an optimal co-action of the mechanical cutting or excavating component of the dredger or excavator and the water jets injected under pressure as hydraulic cutting or excavating component, and on the strength of said pressure enabling it to fulfil its function satisfactorily.

Figure 1 is a very schematic view which serves to elucidate the method according to the invention. If reference is made with 1 to for instance a stone-like ground mass and with 2 to a tooth as the active part of a cutting or excavating component, it is then essential that the tooth structure (in a suction cutter dredger for instance) be disposed such that during cutting of the ground the impact point 3 of the tooth and the water jet 4 practically coincide.

Due to the action of the mechanical cutting implement on the ground (this concept also includes stone-like



ground masses) there results a first fracture zone 5 in the ground mass round the position where the mechanical cutting implement is active. In figure 1 the cutting implement is represented by a tooth 2, a water jet under high pressure is designated with 4, the fracture zone where the mechanical cutting implement has been active is designated 5 and the hydraulic fracture zone where water jet 4 injected under high to very high pressure has likewise been active is designated with 5'. It is essential to note herein that the water jet 4 injected under high to very high pressure must be directed precisely at the impact point 3 of tooth 2 because then the crushed stone-like materials are integrally removed from fracture zone 5. The tooth hereby has an improved efficiency and is less subject to wear. The hydraulic fracturing in fracturing zone 5' is also enhanced so that an improved break-away pattern of the material is formed.

When the pressure of the water jet covering this fracture zone is sufficiently high, for instance amounts to at least 100 bar, this fracture zone will then initiate further cracking, which results in hydraulic fracturing, and breakage remnants will be removed from the fracture zone. As a consequence hereof a lower cutting power will be noted and thus less wear because a large part of the broken-off materials associated with this fracture zone are removed by the water jet.

In order to realize an optimal co-action between the tooth and the high-pressure water jet, the nozzle through which water jet 4 is injected can be situated just behind tooth 2 (figure 2) while in the embodiment of figure 3 the tooth 2' is designed such that water jet 4' is injected through the tooth.

Because the teeth of dredgers wear exceptionally rapidly, particularly when work is being carried out in rock-like ground masses, a tooth structure is designed according to the invention which, referring to figures 4, 4A, 5, 5A and 6, have the following features.

Tooth 2' is mounted, as is usual, on an adapter 6 which for instance forms part of the rotating cutter or is fixed onto a transverse beam of the draghead.

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In the embodiment according to figures 4, 4A, 5, 5A, 6 and 7, at least one high-pressure conduit 7 is provided through adapter 6. This high-pressure conduit 7 ends in a short nozzle 8 or an extended nozzle 8' which, when tooth 5 2' is mounted on adapter 6, comes to lie in the line of the bore 9 running through tooth 2'.

This tooth structure results in a maximum co-action between tooth and high-pressure water jet, which results in a considerable reduction in the wear of the tooth.

10 When dredging is carried out in rock-like ground masses or rocks, the broken-off materials will be removed by the high-pressure water jets so that the teeth will operate in the most favourable conditions.

A variant of the embodiment described by figure 6

15 consists of providing two bores 9' through tooth 2' and providing the adapter with two nozzles 8 or 8'. Both bores 9' must be directed such that, as the outer end of tooth 2' wears, an injection by both water jets under high pressure toward the impact point of the tooth con-

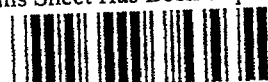
20 tinues to take place which becomes wider as the tooth wears.

Figure 8 shows very clearly the method according to the invention for a suction cutter dredger. The same figure shows schematically the operation of teeth 2 or 2'

25 in the ground or rock mass 10 for the same rotation direction and two opposed swinging movements of the suction cutter dredger. The rotation direction is indicated with arrows 11, the swinging movements with arrows 12 and 13.

30 It is noticeable that the water jets under high pressure are injected at least for a duration which corresponds with the time for which the teeth 2 or 2' are active, i.e. remain in contact with the ground mass for excavating or dredging. Due to the action of the high-

35 pressure water jets the broken materials are removed so that they do not obstruct the optimal operation of the teeth and ensure the increased lifespan of the teeth. The action of the high-pressure water jets also initiates and enhances the hydraulic fracturing.



It is therefore necessary in this option to ensure by means of valves the water flow rate under high pressure to at least the "active" or operational teeth.

When the invention is applied on suction hopper dredgers, a plurality of dispositions of the high-pressure water jets can be devised. Reference is made once again to figures 2 and 3 as an example of suction hopper dredgers. The nozzles for high-pressure water jets 4 of at least 50 bar are mounted on the heel plate 14 of draghead 15 and provide a first hydraulic working of the ground. A second row of nozzles is arranged behind teeth 2, this such that water jets 4' of at least 20 bar are directed toward the outer end of teeth 2, with a second row of nozzles for injecting water jets 4" of at least 20 bar toward the interior of the draghead 15 to cause the already cut material to undergo an additional cutting operation. In such a suction hopper dredger use can also be made of the above described tooth structure which enables injection of the water jets through tooth 2' with its adapter 6. If water jets 4 are caused to act from the heel plate 14 of draghead 15 in one line between respective teeth 2 or 2', these water jets then provide an initially vertical cutting or fracture plane in one line between teeth 2 or 2', while water jets 4' and 4" with the teeth 2 or 2' co-acting therewith cause further fracture of the intermediate ground material of these vertical planes.

In firm clay layers and harder sand layers the above described arrangement offers very great advantages, since with the currently applied techniques it is only possible to dredge with suction hoppers with a great propulsion power or with a stationary suction cutter dredger. In dredging with an apparatus according to the invention in said harder sand layers or firm clay layers the efficiency increases because the ground layers are already partly broken, simultaneously or not, by the action of the high-pressure water jets.

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1. Method for working through ground layers, which are understood to include gravel, sand and clay layers or ground layers containing rock-like materials or consisting virtually exclusively of rock masses such as rock layers, with dredgers or excavators such as suction hopper dredgers, suction cutter dredgers, bucket dredgers, grab dredgers, pull shovel pontoons or the like, wherein a part of the mechanical cutting or excavating component comes into contact with the ground and/or rock layers for excavating, characterized in that water jets are injected in the area where the mechanical cutting or excavating component is active at a pressure which is sufficiently high to cut open the ground layers, such as clay layers, and/or cause the ground layers, such as sand layers, to fluidize in the vicinity of the cutting or excavating component and, when the ground layers contain rock-like materials or consist virtually exclusively of rock-like materials such as rock layers, to immediately remove broken-off and crushed materials from the location where the mechanical cutting or excavating component is active and to enhance the hydraulic fracturing in the non-crushed material in the immediate vicinity of the crushed material.

2. Method as claimed in claim 1, characterized in that in order to cut open the ground masses or cause them to fluidize water jets are injected at a pressure of at least 20 bar at the height of, through and/or behind the mechanical cutting or excavating component and at a pressure of at least 50 bar in front of the mechanical cutting or excavating component.

3. Method as claimed in claim 1, characterized in that when the ground layers contain rock-like materials or consist exclusively of rock-like materials, water jets are injected at pressures of at least 100 bar and more up to pressures of even at least 2000 bar in accordance with the requirement necessary to achieve the intended purpose.

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4. Method as claimed in either of the claims 1 and 2, applied to dredging by means of a suction hopper dredger, the draghead of which is equipped with teeth which extend in line transversely of the displacement direction of the draghead, characterized in that water jets are injected at a pressure of at least 50 bar in front of said teeth as seen in the direction of movement of the draghead.

5. Method as claimed in claim 4, characterized in that water jets are injected at a pressure of at least 20 bar behind said teeth as seen in the direction of movement of the tooth and thus in front of suction hoppers of the draghead.

6. Method as claimed in claim 4, characterized in that water jets are injected at a pressure of at least 20 bar between said teeth as seen in the direction of movement of the tooth and thus in front of suction hoppers of the draghead.

7. Method as claimed in claim 4, characterized in that water jets are injected at a pressure of at least 20 bar through said teeth as seen in the direction of movement of the tooth and thus in front of suction hoppers of the draghead.

8. Method as claimed in claim 4, characterized in that at the height of said teeth water jets are injected at a pressure of at least 20 bar in the direction of the inside of the draghead.

9. Method as claimed in any of the claims 1-3, characterized in that it is applied to dredging by means of a suction cutter dredger.

10. Method as claimed in any of the claims 1-3, characterized in that it is applied to dredging by means of a bucket dredger.

11. Method as claimed in any of the claims 1-3, characterized in that it is applied to dredging by means of a pull shovel pontoon and grab dredgers.

12. Method as claimed in any of the claims 9, 10 and 11, characterized in that means can be provided to cause the high-pressure water jets to operate only during the effective operation of the cutting or excavating compo-

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nent of the suction cutter dredger, bucket dredger or pull shovel pontoon.

13. Apparatus for working through ground layers, which are understood to include gravel, sand and clay layers or ground layers containing rock-like materials or consisting virtually exclusively of rock masses such as rock layers, with dredgers or excavators, suction hopper dredgers, suction cutter dredgers, bucket dredgers, grab dredgers, pull shovel pontoons or the like, wherein a part of the cutting or excavating component comes into contact with the ground layers for excavating, characterized in that the part of said component which comes into contact with the ground layer is provided with nozzles for injecting water into the ground layer at high to very high pressure, which is understood to mean a pressure of at least 20 bar at the height of, through, between and/or behind the mechanical cutting or excavating component and at a pressure of at least 50 bar in front of the mechanical cutting or excavating component, in gravel, sand or clay layers, and a pressure of at least 100 bar up to pressures of even at least 2000 bar in accordance with the requirement necessary to achieve the intended purpose in ground layers containing rock-like materials or consisting virtually exclusively of rock-like masses.

14. Apparatus as claimed in claim 13, applied on a suction hopper dredger, the draghead of which is equipped with teeth which extend in a line transversely of the displacement direction of the draghead, characterized in that nozzles are provided between said teeth for injecting high-pressure water jets.

15. Apparatus as claimed in claim 13, applied on a suction hopper dredger, the draghead of which is equipped with teeth which extend in a line transversely of the displacement direction of the draghead, characterized in that nozzles are provided on the draghead for injecting high-pressure water jets which are mounted behind said teeth in order to inject the water jet under the tooth in the direction of the outer end thereof.

16. Apparatus as claimed in claim 13, applied on a suction hopper dredger, the draghead of which is equipped





with teeth which extend in a line transversely of the displacement direction of the draghead, characterized in that nozzles are also provided for injecting water jets under high pressure in the direction of the interior of the draghead.

17. Apparatus as claimed in claim 13, applied on a suction hopper dredger with a heel plate, characterized in that nozzles are mounted thereon for injecting high-pressure water jets in the direction of the ground layer for excavating or dredging.

18. Apparatus as claimed in claim 13, applied on a suction cutter dredger, the arms of which are equipped with teeth which are mounted on so-called adapters, characterized in that said teeth are provided with nozzles for injecting high-pressure jets toward the impact point of the teeth.

19. Apparatus as claimed in claim 13, applied on a bucket dredger, characterized in that the edge of each bucket which comes into contact with the ground layer during excavation or dredging is provided with nozzles for injecting water jets at high pressure.

20. Apparatus as claimed in claim 13, applied on a pull shovel pontoon, characterized in that the edge of the shovel which comes into contact with the ground layer during excavation or dredging is provided with nozzles for injecting water jets at high pressure.

21. Tooth with adapter for use in an apparatus as claimed in any of the claims 14-20, characterized in that both the tooth and the adapter on which it is mounted have at least one axial bore for injecting water jets under high pressure in the direction of the position where the tooth comes into contact with the ground layer or rock.

22. Tooth as claimed in claim 21, characterized in that said axial bore is divided in the tooth itself into at least two separate bores which are directed such that, as the outer end of the tooth wears, injection by said water jets under high pressure continues to take place toward the impact point of the tooth.

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