equipment and require separation and/or drying out the particles from the slurry. Also, such methods only provide information about an average grain size. Furthermore, as the increase of the settled bed is a relatively slow process and the other processes for analyzing require taking out a sample, drying and then analyzing; information about the average grain size is only available with a certain delay, typically in the order of 5 – 10 minutes. Consequently, adjusting the dredging or mining process can only be done with a delay.

In case the mixture of water and collected material is to be discharged via a discharge pipe line, for instance from a loading space or directly after it has been collected, detailed information about the grain size of the collected material is also advantageous, as this information can be used to determine an appropriate discharge flow speed, in which settling of the collected material inside the discharge pipe line is prevented or at least minimized. This aspect is important in both dredging and mining.

BRIEF DESCRIPTION

~~One object is to~~Embodiments of the present application provide a method and a device for obtaining more detailed information about the grain size of collected material, i.e. material collected from an underwater bottom such a dredged or mined material. ~~An other object is to~~The embodiments further provide a method and a device for obtaining information about the grain size of the collected material more quickly.

~~This object is achieved by~~According to a first aspect, there is provided a measurement device for performing measurements on a mixture of water and collected material, the measurement device comprising a pipe section through which the mixture can be guided, wherein the pipe section comprises a window, and the measurement device comprises an image capturing device arranged to capture an image of the collected material through the window~~.~~, wherein the measurement device further comprises a density measurement device for measuring a density of the mixture.

Collected material may be dredged material or mined material.
The material collected from an underwater bottom is transported through a pipe towards the loading space of a vessel and/or the mixture is discharged via a discharge pipe line. Discharge may take place directly or may take place from a loading space.

The pipe section may be part of a collecting pipe for collecting material from an underwater bottom, but may also be part of a discharge pipe line for discharging the mixture. The pipe section may be positioned upstream of downstream of a pump for

winches can be controlled.

According to ~~an~~ a second aspect, there is provided a vessel, such as a dredging vessel or a mining vessel, comprising a measurement device as described above. The dredging vessel may for instance be a trailing suction hopper dredger or a cutter suction dredger.

According to ~~an~~ a third aspect, there is provided a vessel for collecting material from an underwater bottom, the vessel comprising a collecting pipe which has a free end , which free end can be lowered to an underwater position, the vessel comprising a collecting device located at or in the vicinity of the collecting pipe, the vessel further comprising a pump, wherein the collecting pipe comprises a pipe section, the pipe section comprising a window, and ~~the~~ wherein the vessel comprises a measurement device ~~comprises~~ comprising an image capturing device arranged to capture an image of the collected material through the window~~.~~, and a density measurement device for measuring the density of the mixture.

The device may be a drag head, a cutter or a mining tool. The collecting pipe can be lowered by a hoisting device.

According to an embodiment the vessel comprises a discharge pump for discharging the mixture via a discharge pipe line, the discharge pipe line comprising a pipe section, the pipe section comprising a window, and the measurement device comprises an image capturing device arranged to capture an image of the collected material through the window.

The pump for collecting and discharging may be one and the same pump or may be separate pumps.

According to an embodiment the dredging vessel comprises a control unit arranged to receive and analyse at least one image captured by the image capturing device and generate control signals to control at least one of a collecting pump, a discharge pump, a visor , a water flap, a hoisting device, a water valve or one or more swing winches in dependence on the at least one captured image, in particular in dependence of determined information about one of an average grain size and a grain size distribution of the collected material.

This allows to quickly control and optimize the dredging process in response to the information obtained from the images. Instead of the average grain size and/or a grain size distribution of the collected material, other information relating to the grain size may be used as well to generate control signals.

According to ~~an~~ a fourth aspect there is provided a mining vessel comprising a

measurement device as described above.

According to ~~an~~ a fifth aspect there is provided a method of transporting a mixture of water and collected material, wherein the method is part of a dredging or mining process, and wherein the method comprises:

- collecting material from an underwater bottom or from loading space by loosening material from the underwater bottom or from the loading space and mixing the material with water creating the mixture of water and collected material,

- operating a pump to pump the mixture through a pipe,

- capturing at least one image of the collected material flowing through the pipe and analyzing the at least one image,

- controlling at least one of the ratio of water and collected material in the mixture and the operating speed of the pump based on the captured image.

The pump may be a collecting pump or a discharge pump. The pipe may be a collecting pipe or a discharge pipe line or may be in fluid communication with one of those.

Controlling the operating speed of the pump may be advantageous when collecting material to optimize the collecting process.

Controlling the operating speed of the pump may be advantageous to prevent or at least minimize settling of collected material inside the pipe line and/or prevent or at least minimize excessive wear of an inside of the (discharge) pipe line. This may in particular be advantageous in case the material is to be discharged via a discharge pipe line to a remote location, for instance from a mining or dredging vessel to the shore.

According to an embodiment the method is part of a dredging or mining process, the method comprises:

- collecting material from an underwater bottom or from loading space by loosening material from the underwater bottom or from the loading space and mixing the material with water creating the mixture of water and collected material.

According to an embodiment analyzing the at least one image comprises determining information about at least one of an average grain size and a grain size distribution of the collected material.

According to an embodiment controlling the ratio of water and collected material in the mixture can be done by one or more of

- controlling a rotational speed of the pump,

- controlling a position of a visor provided on a drag head of a trailing suction hopper dredger,
- controlling a water flap provided on the drag head of a trailing suction hopper dredger,

Claims

1. Measurement device for performing measurements on a mixture of water and material collected from a mining or dredging operation, the measurement device comprising a pipe section through which the mixture can be guided, wherein the pipe section comprises a window, and the measurement device comprises an image capturing device arranged to capture an image of the collected material through the window, wherein the measurement device further comprises a density measurement device for measuring a density of the mixture.

2. Measurement device according to claim 1, wherein the measurement device comprises a control unit arranged to receive an image captured by the image capturing device and analyse the image to determine information about the collected material, such as about an average grain size and a grain size distribution of the collected material.

3. Measurement device according to claim 2, wherein the control unit is arranged to analyse the image to determine information about at least one of the average grain size and the grain size distribution of the collected material using image recognition techniques.

4. Measurement device according to any one of the preceding claims, comprising a light source, for instance a flash light, arranged to generate a light beam to light at least part of the ~~slurry~~ mixture in the image of the image capturing device.

5. Measurement device according to claim 4, wherein the lights source is ring-shaped light source positioned concentrically with respect to a viewing direction of the image capturing device.

~~6. Measurement device according to any one of the preceding claims, comprising a density measurement device for measuring a density of the mixture.~~

~~7~~6. Measurement device according to any one of the preceding claims, wherein the

image capturing device is arranged to capture an image which has a movement blur of less than 100 μm, preferably less than 50μm.

87. Measurement device according to claim ~~7~~6, wherein the image capturing device is arranged to capture an image with a shutter time of 0,00001s or less.

98. Measurement device according to any one of the preceding claims, wherein the window is arranged to withstand a pressure difference of 30 bar, preferably 35 bar, between an inside of the pipe section and an outside of the pipe section.

~~10~~9. Measurement device according to any one of the preceding claims, wherein the image capture device is arranged to capture images in black and white.

~~11~~10. Measurement device according to any one of the preceding claims, wherein the image capturing device is set to capture an image with a focusing area positioned at a distance behind the window, the distance being in the range of 1 – 5 mm.

~~12~~11. Measurement device according to any one of the preceding claims, wherein the control unit (22) is arranged to generate control signals to control at least one of a pump, a visor (33) , a water flap (34), a hoisting device, a water valve or swing winches based on one or more captured images of the collected material, for instance in dependence on determined information about the collected material.

~~13~~12. Vessel (100), such as a dredging vessel or a mining vessel, comprising a measurement device according to any one of the claims 1 – ~~12~~11.

~~14~~13. Vessel for collecting material from an underwater bottom during a mining or dredging operation, the vessel comprising a collecting pipe which has a free end, which free end can be lowered to an underwater position, the vessel comprising a collecting device located at or in the vicinity of the collecting pipe, the vessel further comprising a pump (30, 60) ,

wherein the collecting pipe comprises a pipe section, the pipe section comprising a window, and wherein the vessel comprises ~~the~~ a measurement device comprisinges an

image capturing device arranged to capture an image of the collected material through the window, and a density measurement device for measuring the density of the mixture.

~~15~~14. Vessel according to any one of the claims ~~13~~12 - ~~14~~13, wherein the vessel comprises a discharge pump for discharging the mixture via a discharge pipe line, the discharge pipe line comprising a pipe section, the pipe section comprising a window, and the measurement device comprises an image capturing device arranged to capture an image of the collected material through the window.

~~16~~15. Vessel according to any one of the claims ~~13~~12 - ~~15~~14, wherein the dredging vessel comprises a control unit (22) arranged to receive and analyse at least one image captured by the image capturing device and generate control signals to control at least one of a collecting pump (30), a discharge pump (60), a visor (33) , a water flap (34), a hoisting device (50), a water valve or one or more swing winches in dependence on the at least one captures image, in particular in dependence of determined information about one of an average grain size and a grain size distribution of the collected material.

~~17~~16. Mining vessel comprising a measurement device according to any one of the claims 1 – ~~12~~11.

~~18~~17. Method of transporting a mixture of water and collected material, wherein the method is part of a dredging or mining process, and wherein the method comprises:

- collecting material from an underwater bottom or from loading space by loosening material from the underwater bottom or from the loading space and mixing the material with water creating the mixture of water and collected material,

- operating a pump to pump the mixture through a pipe,

- capturing at least one image of the collected material flowing through the pipe and analyzing the at least one image,

- controlling at least one of the ratio of water and collected material in the mixture and the operating speed of the pump based on the captured image.

~~19. Method according to claim 18, wherein the method is part of a dredging or mining process, the method comprises: collecting material from an underwater bottom or from loading space by loosening material from the underwater bottom or from the loading space and mixing the material with water creating the mixture of water and collected material.~~

~~20~~18. Method according to ~~any one of the~~ claims ~~18 – 19~~17, wherein analyzing the at least one image comprises determining information about at least one of an average grain size and a grain size distribution of the collected material.

~~21~~19. Method according to ~~any one of the~~ claims ~~18~~ 17 ~~–~~ or ~~20~~18, wherein controlling the ratio of water and collected material in the mixture can be done by one or more of

- controlling a rotational speed of the pump,
- controlling a position of a visor provided on a drag head of a trailing suction hopper dredger,
- controlling a water flap provided on the drag head of a trailing suction hopper dredger,
- controlling a depth of the excavation tool by a hoisting device (50),
- controlling a water valve provided on the collecting pipe of a cutter dredger and
- controlling a swing speed of a cutter dredger by swing winches.