

C4i **ROBOTICS**

**NON-DESTRUCTIVE TESTING
SOLUTIONS AND TECHNOLOGIES**



C4I-SRU
Sludge Removal Unit

Sludge removal for in tank operations

the concept development of a (small), modular Sludge Removal Unit (SRU) that can be incorporated into our electrical robot design.

To successfully remove sludge, like salt sediments and densely packed semi solids, there are a number of procedures and methods that can be considered

We are basically looking at dredging with an agitator tool, to loosen the sludge and make it available for removal, through suction. Simply trying to remove sludge with a suction hose, will not be very efficient.

Methods available: There are 4 primary methods available to agitate sludge:

Cutter heads.

Cutter heads are used when there is a fixed boom such as a ladder dredge or excavator with a slurry pump attachment. These cutter heads usually rotate between 15 to 60 rpm and are equipped with specially designed cutter teeth around the attachment. The rotating cutter head breaks up consolidated material such as compacted sand, mud, and sludge, helping feed material into the pump. The cutter head is mainly used for beach dredging, river dredging or any other type of shallow water dredging of up to about 30-ft and without a liner present.

Water Jetting Systems.

Water-Jetting Systems are nozzles attached to the suction of a pump that shoots highpressure water jets to break up consolidated material, increasing the amount of material fed to the pump or dredge. Water jetting systems usually come equipped with a number of nozzles which can blast water several hundred psi.

Auger Dredges

Auger Dredges incorporate an archimedean type screw which is set at 90-degree angles to the suction pipe of a dredge. The auger acts similar to a cutter head in mechanically breaking up the target material and feeding the pump. Augers are ideal for applications where the material is consolidated with very little free medium/water within the slurry or if the bottom has a liner in place. This auger can also be equipped with wheels to make it perfect for liner-safe dredging applications

Mixers

Mixers are a unique mechanical mixing device added to dredges when the material is of significantly high viscosity or there is little to no free medium/water. Similar to how egg beaters operate, a mixer added to the dredge will mix the material in real time decreasing the viscosity and fluidizing the material to optimize it for pumping.



Conclusion:

Cutter heads: Cutter heads will not be suited for our application due to the damage the cutter teeth can do to the bottom plates of the tank.

Water Jetting Systems: These can obviously not be used in the tanks due to the fact that we will be adding water to the mix. A high pressure water jet can also be damaging to the tank floor.

Mixers: Mixers will not be useful for the same reason as the Cutter Heads.

Auger Dredges: These are the right tool for our application as the Archimedean screw, or Auger, can be working safely above the tank floor and agitate the sludge into a lower viscosity slurry and then be sucked away through our sump pump.

As mentioned, to be able to do tank cleaning we have our robot for general work, using the existing pump on the robot and the nozzle

For more high viscosity work and solids we need to look at Auger based units. Hereby an example and essentials compact solution in a single container

- robot with a thread disrupter (Auger)
- capable of doing work in sludge or underwater
- robust and well tried concept
- hydraulic propulsion system, length of hoses and cabling up to 100m stainless steel designing different modes of pressure wash, suction and disrupting

Larger units would need to be hydraulically driven due to the energy needed. We can build this and/ or buy a unit. I would prefer to build to set our own specifications and standards

So, we focus on the Auger Dredge to be developed into our SRU.

A. The Unit cannot be too wide, due to the Man Way restrictions.

B. Decide if we want to go for a free rotating auger; the rotation caused by the suction applied through the pump. The other option is to add a motor drive to the auger to rotate and push the sludge towards the suction opening.

C. If using a drive, the drive of the unit needs to be either electrical or hydraulic. Hydraulics would be able to keep the robot power consumption down and to have a wider choice of industrial available options. We will look into both options.

D. In the Hydraulic option, we need to add 2 high pressure hydraulic hoses in the umbilical; one supply hose and one return hose; or, in case we go with the electrical option, add a water tight motor unit, similar to the motors we use on the drives.

E. In case of the Hydraulic option: We need to add a small high pressure hydraulic pump and simple controller to drive the system, or a simple electrical speed controller.

F. Motors need to be mounted at 90 deg angle to minimize the width of the sled.

Electrical option

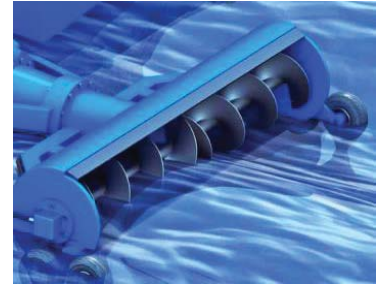
Motor connects in 90 deg angle, as the longitude line would make the dredge sled to wide.

The Sled is the metal casing that holds the Auger and the pump attachment.

One option is to mount the motor in front or straight up.

Both have their objections:

Straight in front, means that the motor is the first contact the robot makes. If the sludge is too high the motor need to be pushed through this, so that would make that location unlikely.



The straight up version requires a smaller housing to minimize the view blocking for the sonar and camera, A hydraulic system/motor would present the same issues.

The suction hose would be connected in the middle of the sled, as the auger system would rotate from both sides in, guiding the sludge to the middle.

Hydraulic option:

The entire hydraulic option would require two additional hoses for the power supply. This would fit in well with the Hydraulic Robot design, for future robots.

Pumps

We would prefer to replace the existing pump for an Eddy Pump.

An Eddy Pump works based on the Eddy current, it is not a centrifugal positive displacement or vortex pump. The Eddy pump is considered the most efficient type of pump for high specific gravity sludge. The price of a suited Eddy Pump is a lot higher than a sump pump.

Actions to be taken:



Decide on the option to be pursued:
Free wheeling, Electric or Hydraulic.

Engineer the design of the sled, with the auger tools inside, the connection to the motor and with the suction hose attachment.

A prototype then needs to be tested to check its functionality with sludge types, after which we can make adjustments to the sled, the auger type, and material make up, and the attachments.



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