Intro Cutter Suction Dredge

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- General lay-out
- Working Method
- Cutter head
- Intro Cutting Theory (Sand and Rock)
- Mixing in cutter – spillage
- Operational Limits

Cutter Suction Dredgers

Small < 250 kW

Large > 2500 kW

Medium, 1500 kW

Components

- Pontoon
- Ladder
  - Cutter head + drive system
  - Suction line
  - Support system + winch
- Spuds
- Pumps + discharge system
- Side wires + winches
Working principle

- Cutter disintegrates or dislodges the material mechanically by rotating cutter head
- Swinging around working spud
- Progress by successive steps
- Material sucked up and transported through pipeline by use of centrifugal dredge pumps
CSD Work Method (2)
Stop at starboard, push dredger forward

CSD Work Method (3)
Start swing to portside

CSD Work Method (4)
Continue swing to portside

CSD Work Method (5)
Stop at portside, push dredger forward to next starboard cut
CSD Work Method (6)
Start swing to starboard

CSD Work Method (7)
Stop in center line

CSD Work Method (8)
Auxiliary spud is lowered

CSD Work Method (9)
Main spud is hoisted up
The spud-carrier with the hoisted main spud is moved forward.

Main spud is lowered.

Auxiliary spud is hoisted up.

Dredger starts swinging / dredging to starboard.
CSD Work Method

Continuation of starboard swing

Under and over cutting force balance

Side winch: pulling
Vert: lifting force needed

Side winch: breaking
Vert: pushing force needed

Discharge Methods

- Pipeline
- Barge loading

Discharge by pipeline
Barge loading

Cutter Head
- General
- Teeth systems
- Cutting process
- Mixing process
• Movie
Bucket wheels

Cutting Theory
Basic failure modes

Cutting in Sand
- Effect of pore pressure

Forces on the blade

\[ F = G \tan(\phi) \]

\( \phi \) = friction angle
Dilatancy

Dilatancy explained
Negative pore pressure (under pressure)

Forces on layer – effect of dilatancy

\[ T = S' \tan(\phi) \]

\[ S' = S - \mu \]

\[ S_0 = S' - \mu \]

\[ u = \frac{h}{k} \]

- \( S' \): effective stress
- \( S \): Total Stress
- \( u \): Pore water pressure
- \( S_0 \): \( S' - \mu \)

Pore water pressure is negative increase in effective stress
Increase in shear stress

- \( u \): pore pressure
- \( h \): cutting depth
- \( v \): cutting velocity
- \( k \): permeability
Cutting Sand:
- Larger Cutting forces with
  - Lower permeability (finer sand)
  - Increase cutting depth & velocity
  - Increase water depth

Under and over cutting force balance
- Side winch: pulling
  - Vert: lifting force needed
- Side winch: breaking
  - Vert: pushing force needed

Rock Cutting

Failure modes during Cutting
- Chip
- Shear crack
- Shear zone
- Plastic deformation
- Brittle-ductile transition
Forces during cutting

Rock cutting
- Large cutting forces
  - Strength Cutter and teeth
  - Teeth placement important
  - Tooth wear

Spillage

Spillage
- Low cutter
  - Rev.
- High cutter
  - Rev.
Cutter head production process in rock or gravel

The rotational speed of the cutter head causes spillage. Cutter acts as a pump.

The productivity c.q. spillage depends on the ratio:

- For sand the productivity is:
  \[ P \approx 2.5 \frac{Q_{\text{cmax}}}{uR_{\text{cmax}}} \]

- For rock the productivity is much lower

Influence of waves on operation

- CSD is a floating object
- Response due to wave loading as with other floating structures, but ....
  - Typical geometry of pontoon with ladder
  - Interaction with soil
    - Spud – Spud carriage system
    - Cutter head
- Numerical prediction still not satisfactory

Wave influence

- CSD not only decisive
  - Aux. Equipment
  - Coupling, de-coupling of floating pipeline
Application of CSD

- Nearly all kinds of soils (sand, clay, rock <30 MPa)
- Sensitive to wave conditions
- Stationary dredger (vulnerable for shipping)
- Some are self-propelled for mobilisation
- Max. dredging depth 30 m

Limiting Factors

- Excavation
  - Soil characteristics
  - Available power on cutter
- Side winches (max. power and velocity)
- Thickness and width of the layer to be dredged
- Dredging depth (ladder angle, spuds, vacuum limit)
- Pumping distance (pump- and pump drive characteristics)
- Shipping

Next Webinar: Intro Trailing Suction Hopper Dredge
- September 14 2016
- 14:00 – 15:00 CEST