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Application of TSHD

Before 1980
- Maintenance Dredging
  - Deepening of harbours & entrance Channels
    - Maintenance due to siltation
    - Soft sediments (silt clay)
    - Not stationary (wires anchors), so less problems with shipping
**Application of TSHD**

- Capital Dredging (new projects)
- Most Reclamation works
- Less suitable:
  - Reclamation in combination with deepening
  - Short distance between dredging & reclamation.
  - Dredged material suitable for fill
  - Sediments in dredge area difficult for TSHD
- Increase in size and number -> shorter execution time

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**TSHD Process Description**

1. Suction
2. Excavation
3. Vertical transport
4. Vacuum limit!
5. Loading
6. Hopper sedimentation
7. Loading (overflow)
8. Sailing loaded
9. Shallow water
TSHD Process Description

Discharge

Sailing empty

TSHD Load Graph

Dredgemaster “Pijpenman”
**Sailing**

- Increase in size of TSHD’s
- Increase in sailing distance
- Sailing becomes a dominant phase
- Sailing speed important
- Special for TSHD
  - Shallow water: Squat effect
  - Manoeuvring

**The Dredging Phase**

- Draghead excavation process
  - Erosion by jets
  - Erosion due to inflowing water
  - Cutting with teeth
- Vertical transportation through suction pipe(s)
  - Vacuum limit
  - Pumping power
  - Discharge into hopper
  - Sedimentation

**Process Overview**

**Draghead components**
Draghead visor control

- Loose visor
- Fixed visor
- Active control with hydraulic cylinders

Draghead loose visor

Loose visor follows seabed
Variation:
  - Excavation depth
  - Angle of suction pipe
**draghead**

Fixed visor

In case cutting is needed

Overloading prevention

Active visor control

Cutting force

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**Draghead / suction pipe Equilibrium**

\[ f_{rij} = G \frac{X}{Z} \]

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**Process in Draghead**

<table>
<thead>
<tr>
<th>Jetting</th>
<th>cutting</th>
<th>erosion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil Type</td>
<td>Sand</td>
<td>Sand Clay</td>
</tr>
<tr>
<td>Energy from / needed</td>
<td>Jetpower</td>
<td>Trail power</td>
</tr>
<tr>
<td>Jetdischarge*jet pressure</td>
<td>F cutting * Trail speed</td>
<td>Discharge * Dp draghead</td>
</tr>
</tbody>
</table>

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**Limiting Factors**

- Jet production
  - Jetpower
- Erosion
  - Pressure difference Draghead
  - Discharge
- Cutting Production
  - Trail force, Draghead Equilibrium
- All affected by Soil Conditions
**Jets versus Erosion**

- Jetpower
  - Jet pressure * Jet discharge
  - Unlimited (efficiency is a problem)
- Erosion power
  - Discharge * pressure drop Draghead
  - Limited by 'Vacuum'
  - Limited by trail power (ships propulsion)
  - Limited by draghead equilibrium

**Jetting versus cutting**

- Trail power = trail force * trail speed
  - Relative low efficiency of ships propulsion
  - Draghead equilibrium

**Hopper Sedimentation**

**Loading & Overflow system**
Loading & Overflow system

- Loading system
  - Distribution of sediment
    - Influence on overflow losses
    - Influence on hopper load
    - Influence on trim of the hopper
- Overflow system
  - Adjustable in height

Overflow losses

- A sediment water mixture is discharged in the hopper
- Not all particles will settle. A certain fraction flows overboard
- Losses depend on (most important influences):
  - Discharge \( Q \) [m\(^3\)/s]
  - Hopper area \( L \times B \) [m\(^2\)]
  - Settling velocity of sediment

Settling Velocity

\[
F_s = \frac{D^2}{2} C_{sw} \frac{1}{2} \rho_s w_i^2
\]
\[
G = F_s
\]
\[
G = \frac{D^s g (\rho_s - \rho_w) D}{3 \rho_w L}
\]
\[
w_i = \frac{4 (\rho_s - \rho_w) g D}{3 \rho_w L}
\]
Viscosity is function of temperature
Solve by iteration or use Empirical formulae
Additional effects on settling velocity:
Concentration, PSD
\[ V_0 = Q(B^*L) \]

Ratio between vertical velocity and settling velocity:

\[ H^* = \frac{V_s}{w_s} = \frac{Q}{BLw_s} \]

\( w_s \) is a function of the particle size distribution.

In case \( H^* \gg 1 \)

100% overflow loss

No settling in the hopper.
### Maximum Cycle production

\[ P_{cycle} = \frac{m^3 \text{ unloaded}}{\text{cycle time}} \quad [\text{m}^3/\text{s}] \]

<table>
<thead>
<tr>
<th>Operation</th>
<th>Time (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unloading</td>
<td>300</td>
</tr>
<tr>
<td>Loading</td>
<td>70</td>
</tr>
<tr>
<td>Unloading</td>
<td>15</td>
</tr>
<tr>
<td>Turning etc.</td>
<td>10</td>
</tr>
<tr>
<td>Total cycle</td>
<td>725</td>
</tr>
<tr>
<td>Cycle period</td>
<td>27.4</td>
</tr>
</tbody>
</table>

**Optim. load**

\[ \tan (\alpha) = P_{cycle} \times \frac{m^3 \text{ unloaded}}{\text{cycle time}} \quad [\text{m}^3/\text{s}] \]

- **Long sailing distance**
- **Short sailing distance**
**Carrying Capacity**

Restriction by volume  
Restriction by weight

- Low density soils
- High density soils

**Hopper volume & loading capacity**

<table>
<thead>
<tr>
<th></th>
<th>Loading cap</th>
<th>Max. Hopper</th>
<th>Hopper</th>
<th>106 10%</th>
<th>10% 13%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>(ton)</td>
<td>(m³)</td>
<td>(ton)</td>
<td>(m³)</td>
<td>(m³)</td>
</tr>
<tr>
<td>Hopper X</td>
<td>2300</td>
<td>1800</td>
<td>1.29</td>
<td>17846</td>
<td>12541</td>
</tr>
<tr>
<td>Hopper Y</td>
<td>41000</td>
<td>22000</td>
<td>1.86</td>
<td>22000</td>
<td>21579</td>
</tr>
</tbody>
</table>

**Discharging methods**

- Discharging through bottom doors
- Rainbowing
- Pumping Ashore

Decreasing production
Pumping ashore + Rainbowing

- Hopper fluidization
- With jet system
- Concentration control
- Minimizing rest load
Bow connection

Rain sowing

Hopper self-discharge system

Hopper self-discharge system
Hopper self-discharge system

Power systems

Diesel electric pump
Pump in fore ship

Diesel direct pump
Pump in aft ship
Final Remarks

TSHD is the workhorse of the dredging industry
The increase in scale created new markets
  • Price per m$^3$ decreased
  • Execution time decreased

Still a lot of development to be expected
  Process automation
  Increase in production