The Trailing Suction Hopper Dredger

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14 November 2016

Sectie Offshore & Dredging Engineering

Contents

TSHD Intro

Application of TSHD

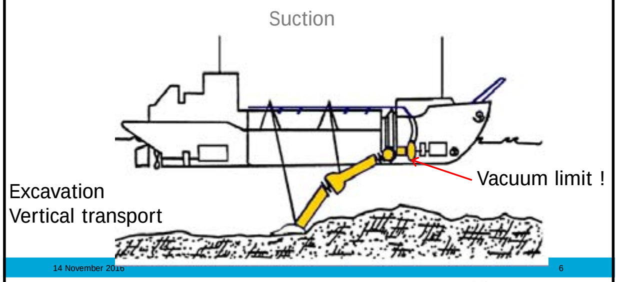
Before 1980

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

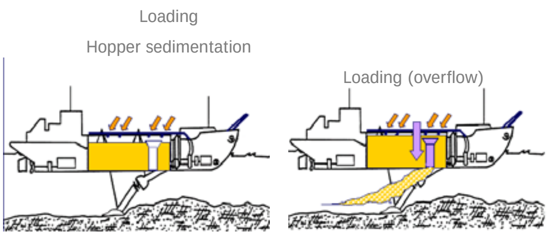
Application of TSHD

- 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

TSHD Process Discription



TSHD Process Discription



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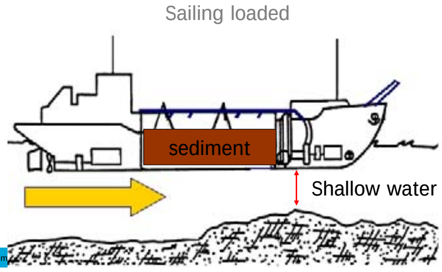
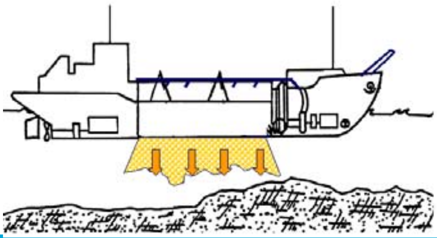


TSHD Process Discription

Discharge



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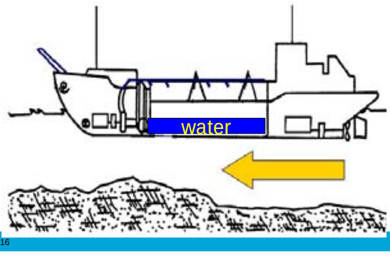
TSHD Process Discription

Sailing empty



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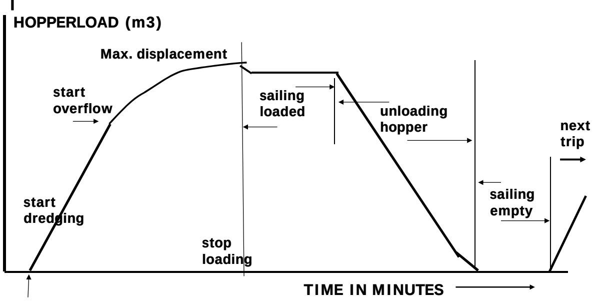
TSHD Load Graph



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Dredgemaster "Pijpenman"

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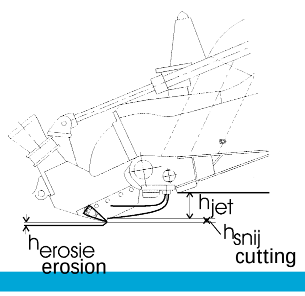
Sailing

- 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

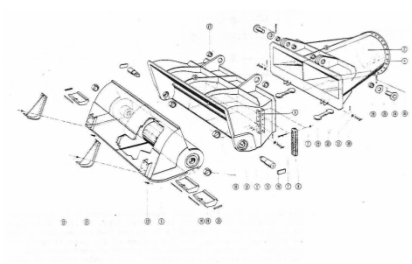
The Dredging Phase

- 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



Dragheads

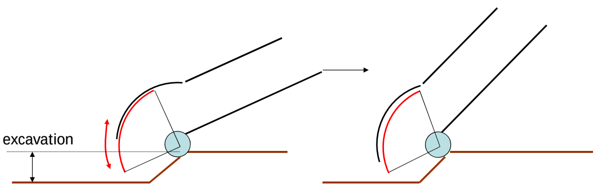
Different Dragheads

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



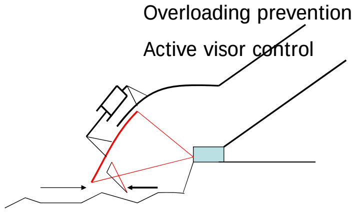
draghead

Fixed visor

In case cutting is needed

Overloading prevention

Active visor control



Cutting force

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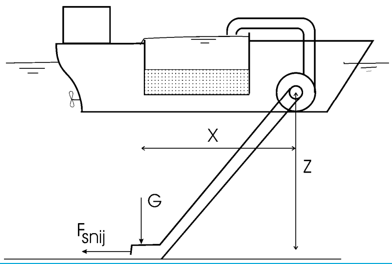
Draghead / suspension pipe Equilibrium

$$F_{snij} = G\frac{X}{Z}$$



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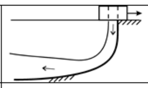
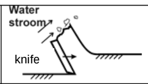
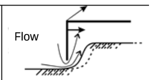
Process in Draghead

	Jetting	cutting	erosion
Mechanism			
Soil Type	Sand	Sand Rock Clay	Sand Soft Clay
Energy from / needed	Jetpower Jetdischarge*jet pressure	Trail power F cutting * Trail-speed	Suction power Discharge * Dp draghead

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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

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Jets versus Erosion

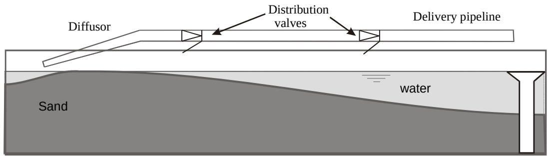
- Jetpower
  - Jet pressure * Jet discharge
  - Unlimited (efficiency is a problem)
- Erosion power
  - Discharge * pressure drop Draghead
  - Limited by ‘Vacuum’
  - Limited by trail power (ships propulsion)
  - Limited by draghead equilibrium

Jetting versus cutting

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

Hopper Sedimentation

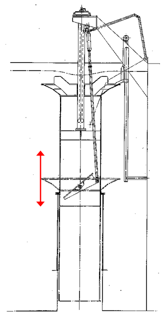
Loading & Overflow system



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 system



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 [m3/s]
  - Hopper area L*B [m2]
  - Settling velocity of sediment

Settling Velocity

$$F_w = \tfrac{\pi}{4} D^2 C_D \tfrac{1}{2} \rho_w w_0^2$$

$$G = F_w$$

$$G = \tfrac{\pi}{6} D^3 g \left(\rho_s - \rho_w\right)$$

$$w_0 = \sqrt{\frac{4\left(\rho_s - \rho_w\right) g D}{3 \rho_w C_D}}$$

$$w_0 = \sqrt{\frac{4(\rho_s - \rho_w)gD}{3\rho_w C_D}} \qquad C_D = f\left(\frac{w_0 D}{\nu}\right)$$

Viscosity is function of temperature

Solve by iteration or use

Empirical formulae

Additional effects on settling velocity:

Concentration, PSD

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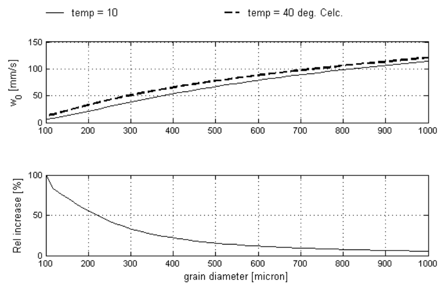
Settling velocity



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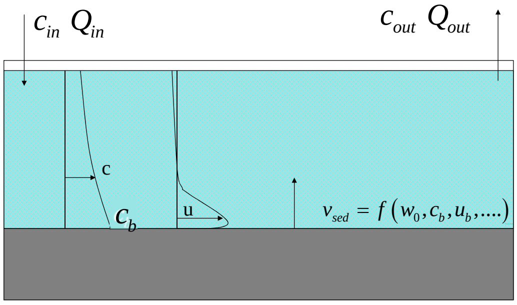
Schematic Process Overview



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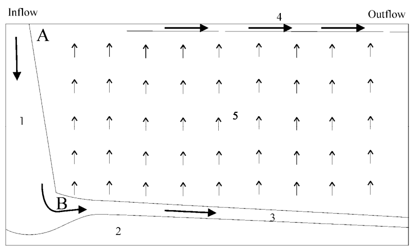
Flow field in hopper



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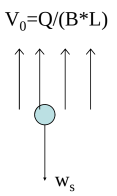

Ratio between vertical velocity and settling velocity:

$$H^* = \frac{v_0}{w_s} = \frac{Q}{BLw_s}$$

w_s is a function of the particle size distribution

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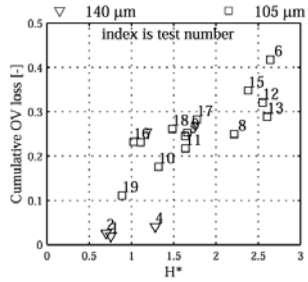

In case H*>>1

100 % overflow loss

No settling in the hopper

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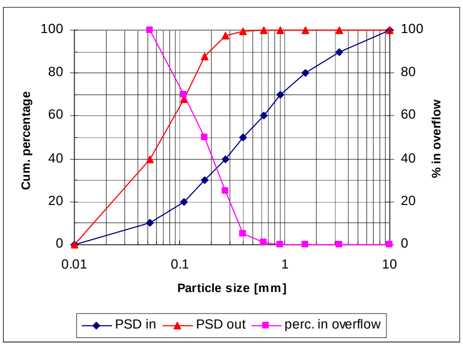

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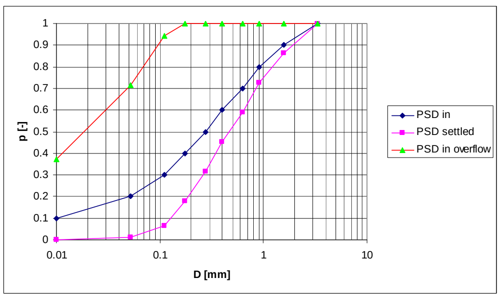

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Maximum Cycle production

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

Hopper X		
Unloaded	20000	m3
Sailing Empty	300	min
Loading	70	min
Sailing Loaded	330	min
Unloading	15	min
Turning etc.	10	min
Total cycle	725	min
Cycl prod	27.6	m3/min

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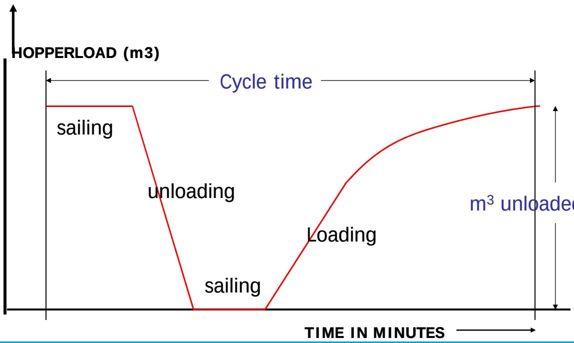
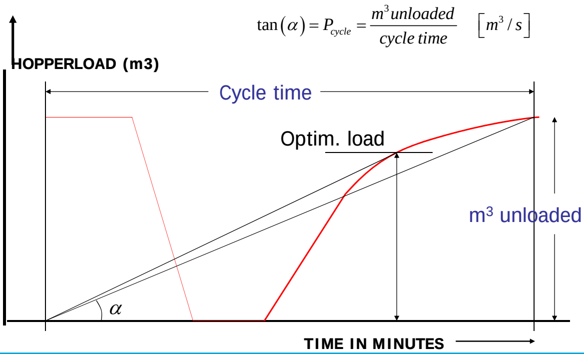


TU Delft

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



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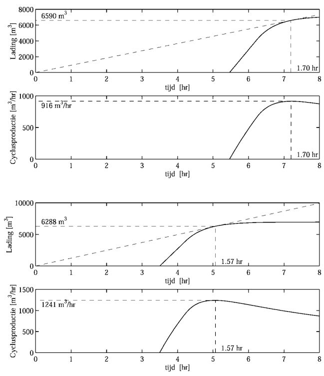

Long sailing distance

Short sailing distance

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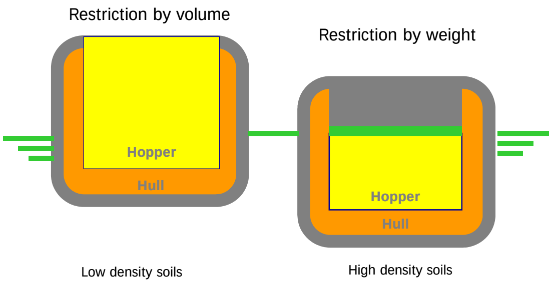
Carrying Capacity



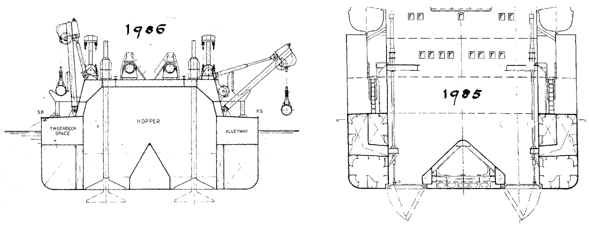
Hopper volume & loading capacity

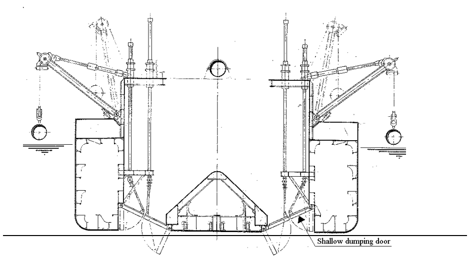
				1.3	1.85	1.9	2
	Loading cap	max. hopper	Hopper		load [m3]	load [m3]	load [m3]
	max. draugth	volume	density				
	[ton]	[m3]					
Hopper X	23200	18000	1.29	17846	12541	12211	11600
Hopper Y	41000	22000	1.86	22000	22000	21579	20500

Discharging methods

- Discharging through bottom doors
- Rainbowing
- Pumping Ashore

↓ Decreasing production





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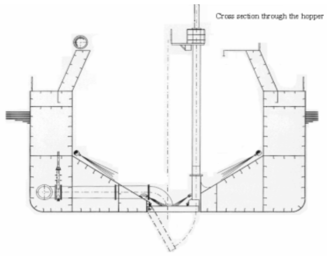

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Pumping ashore + Rainbowing

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

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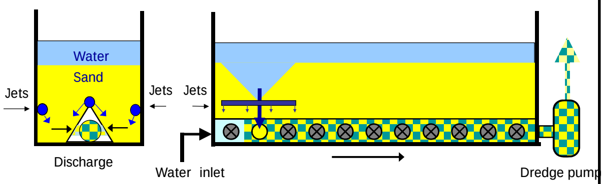
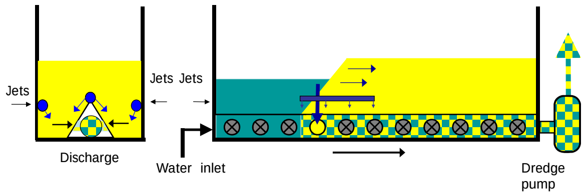
Bow connection

Rain bowing

Hopper self-discharge system



Hopper self-discharge system



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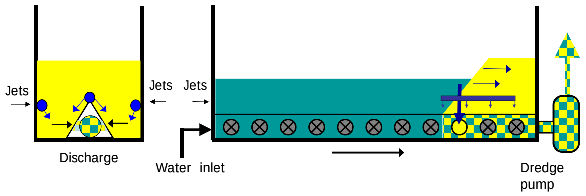
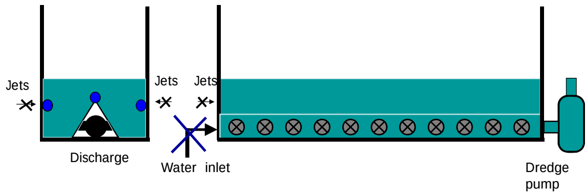
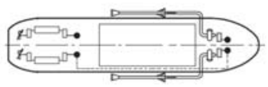


Hopper self-discharge system

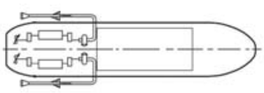


Power systems



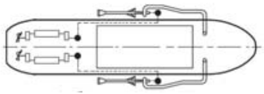
Diesel electric pump

Pump in fore ship

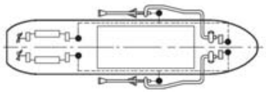


Diesel direct pump

Pump in aft ship



Diesel electric with OWP



Diesel electric with OWP
and Inboard pump

Final Remarks

TSHD is the workhorse of the dredging industry
The increase in scale created new markets

- Price per m3 decreased
- Execution time decreased

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