Drag Head Production

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Dredging A Way Of Life

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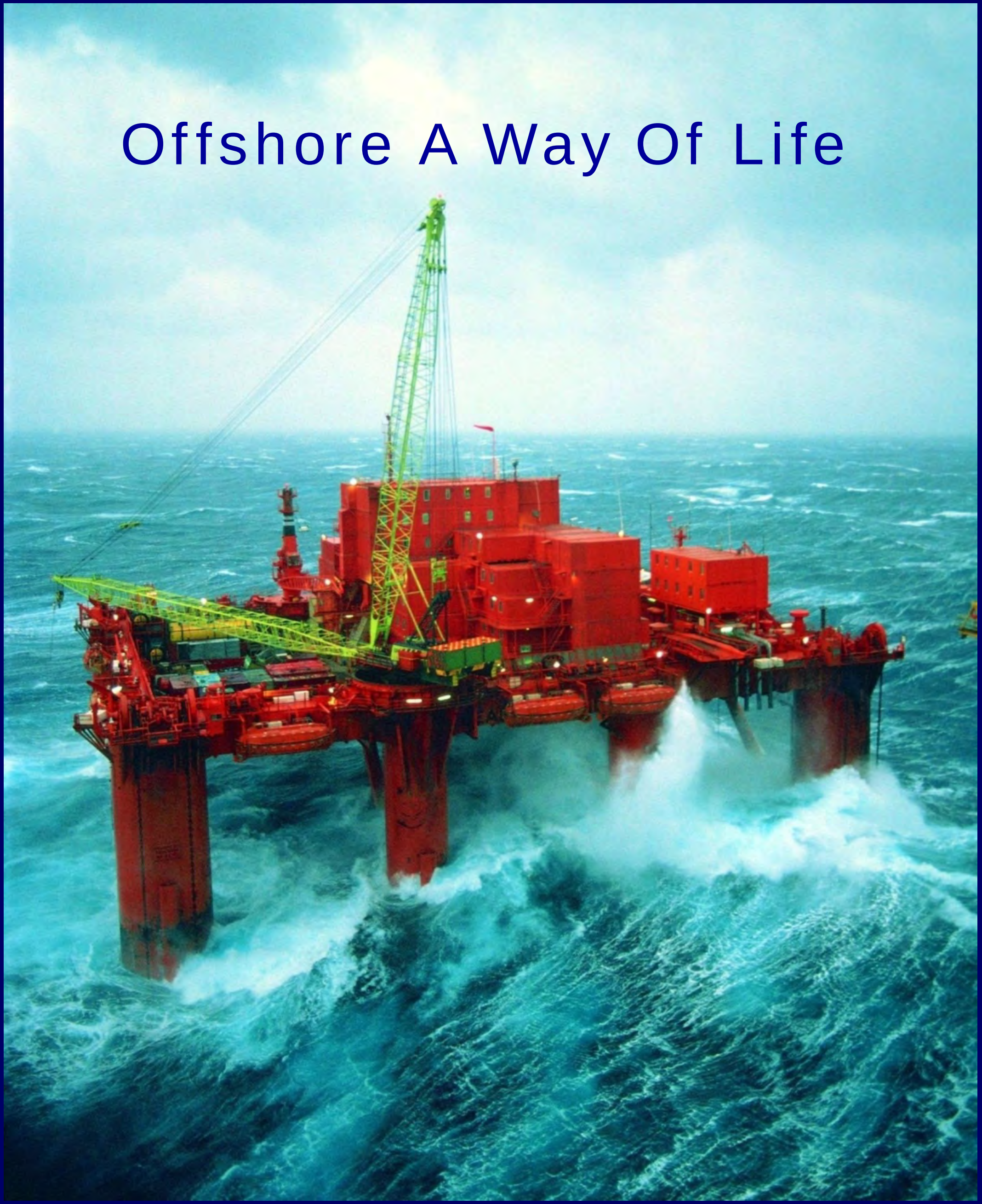

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What is Offshore & Dredging Engineering?

Offshore & Dredging Engineering covers everything at sea that does not have the purpose of transporting goods & people and no fishery.

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The TSHD

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The Christobal Colon (46000 m^3)

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The Amsterdam

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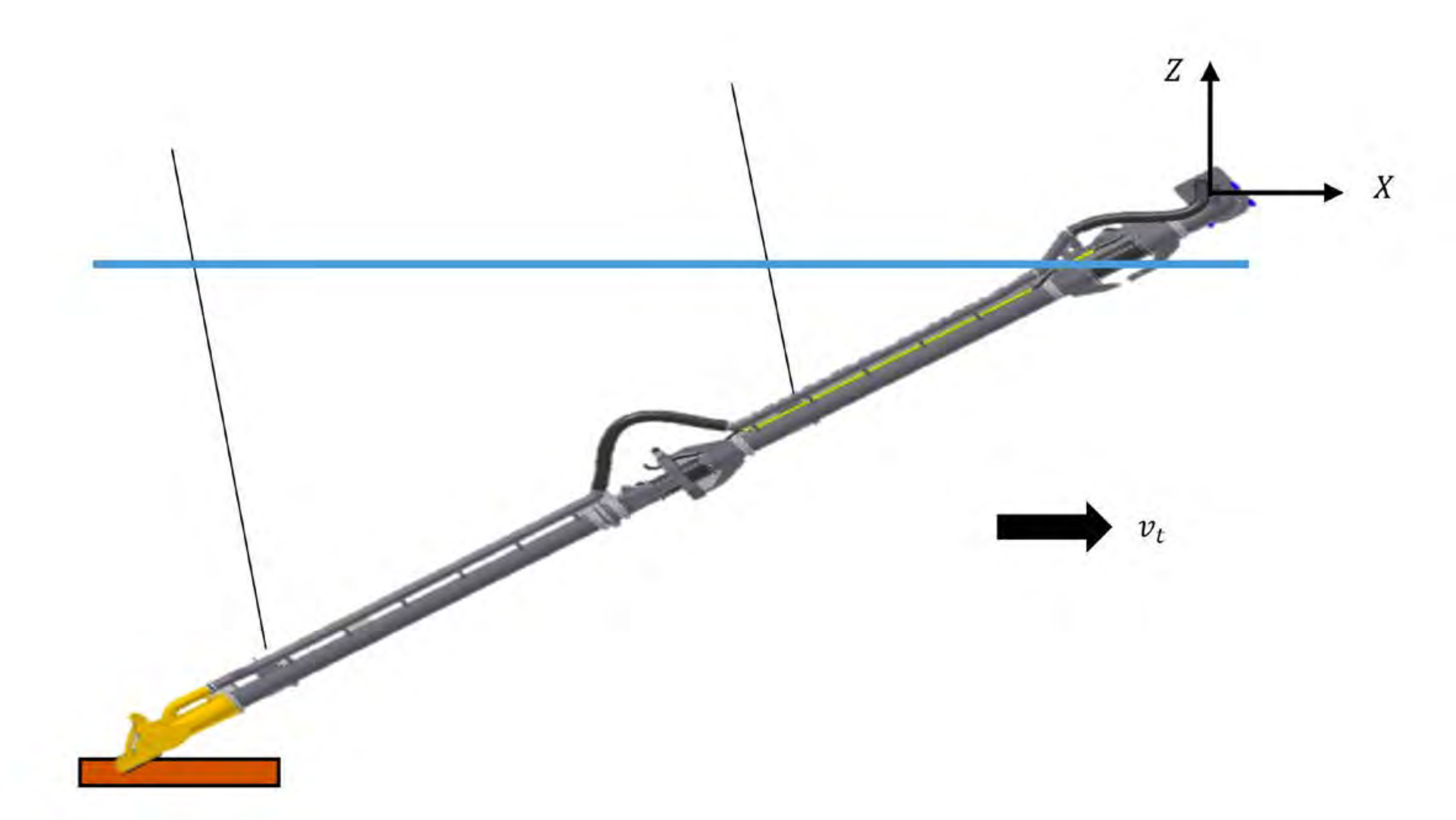
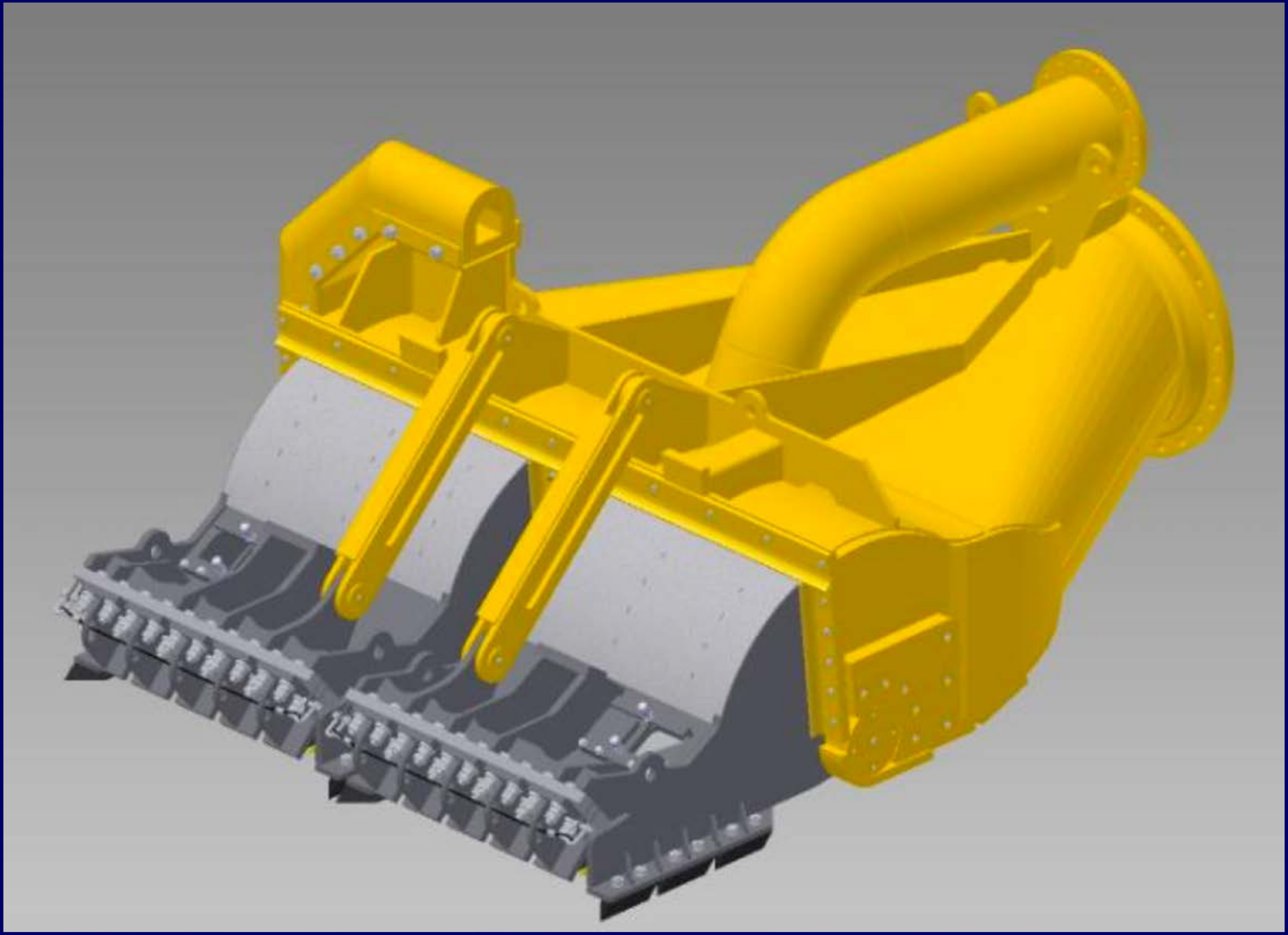
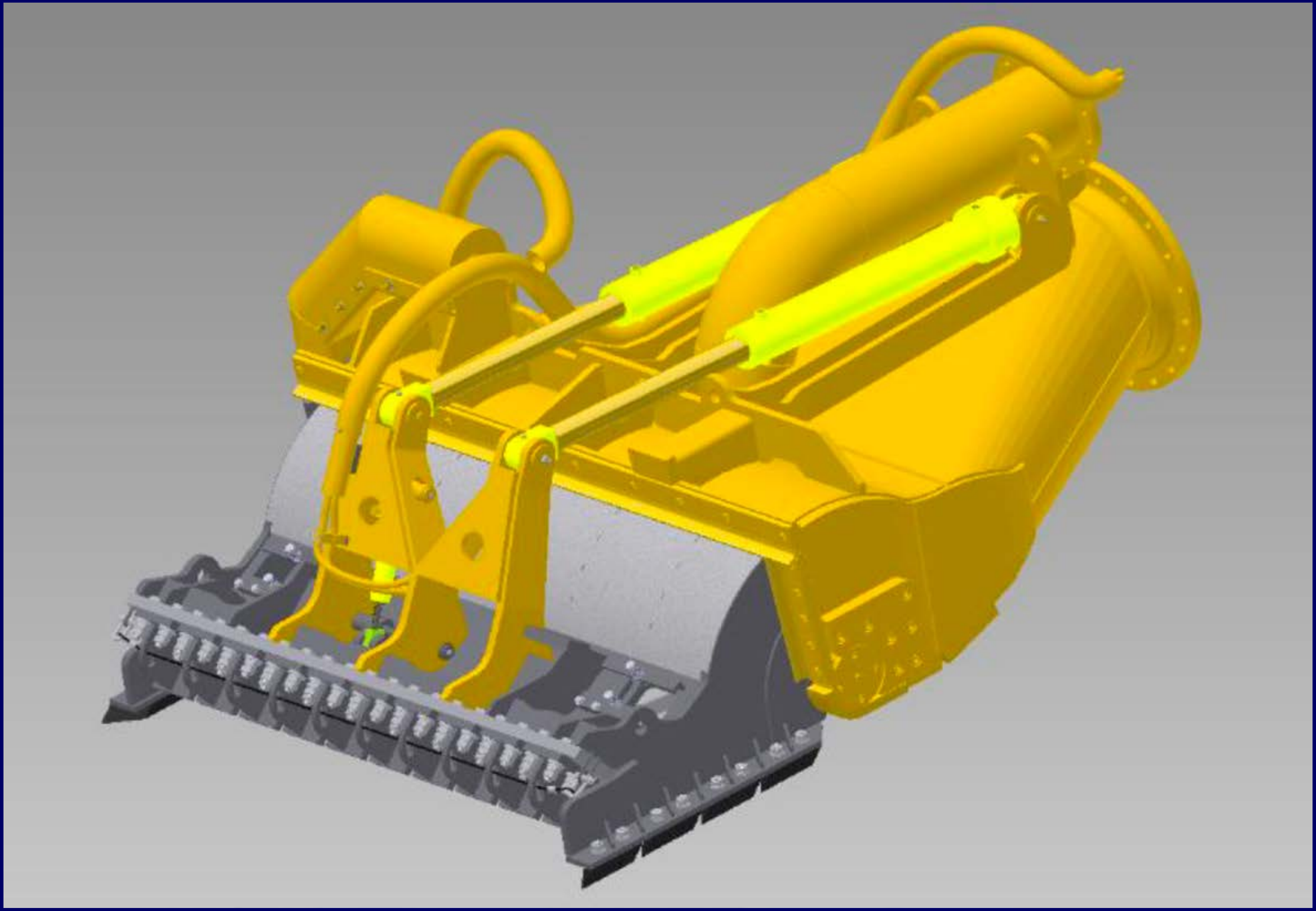
The suction pipe and draghead



The California draghead

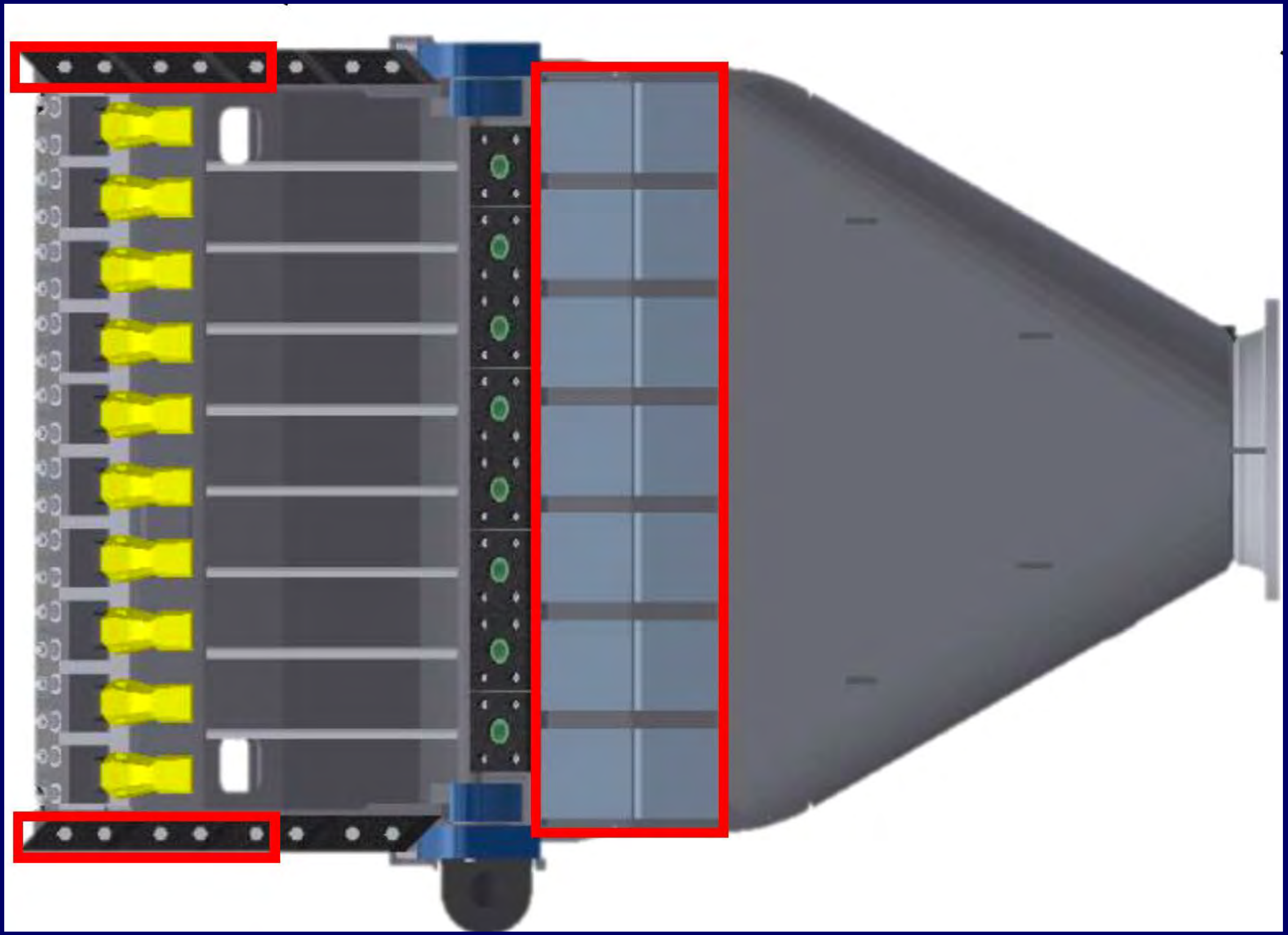


The Holland draghead

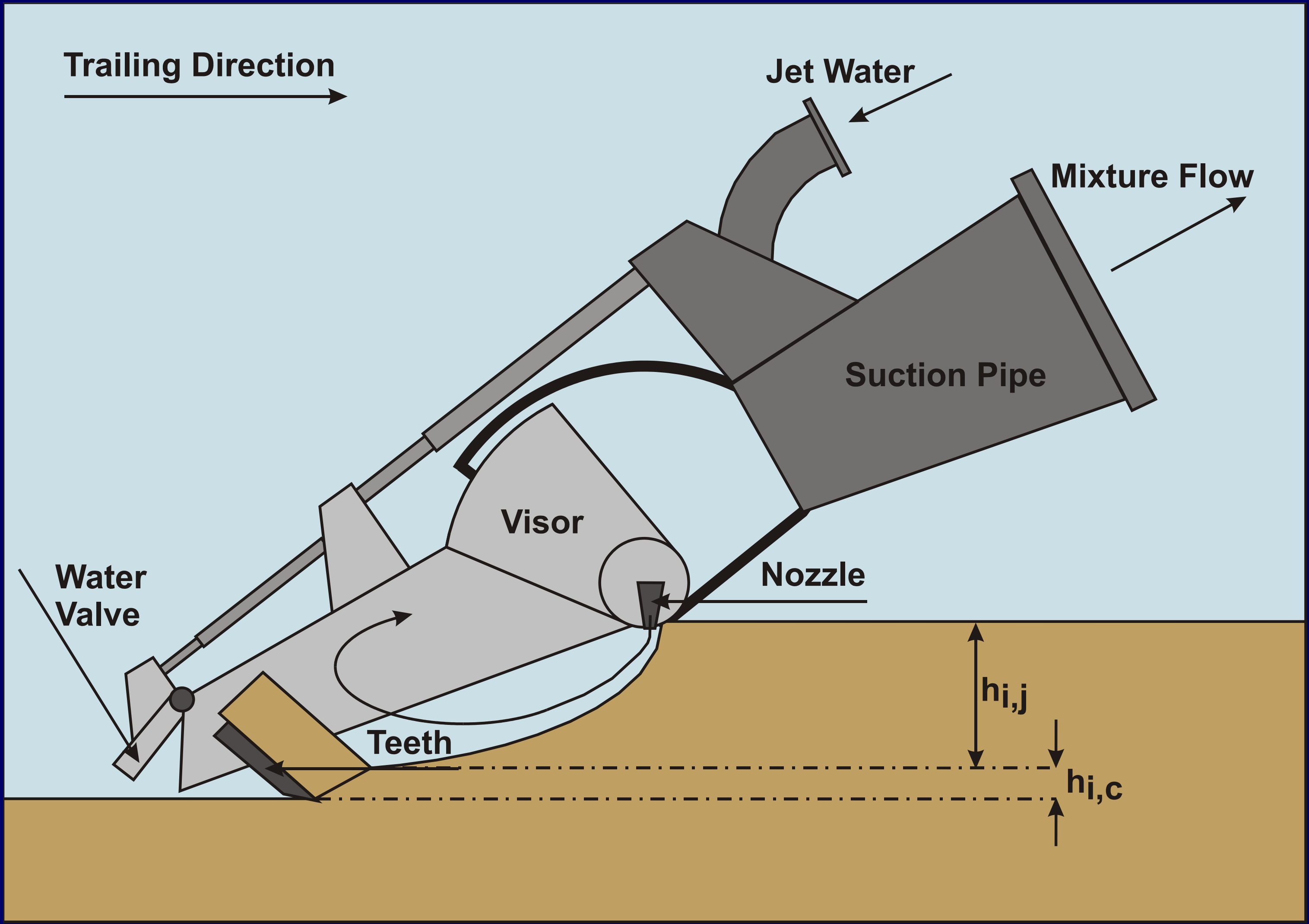


The draghead with blades and jets

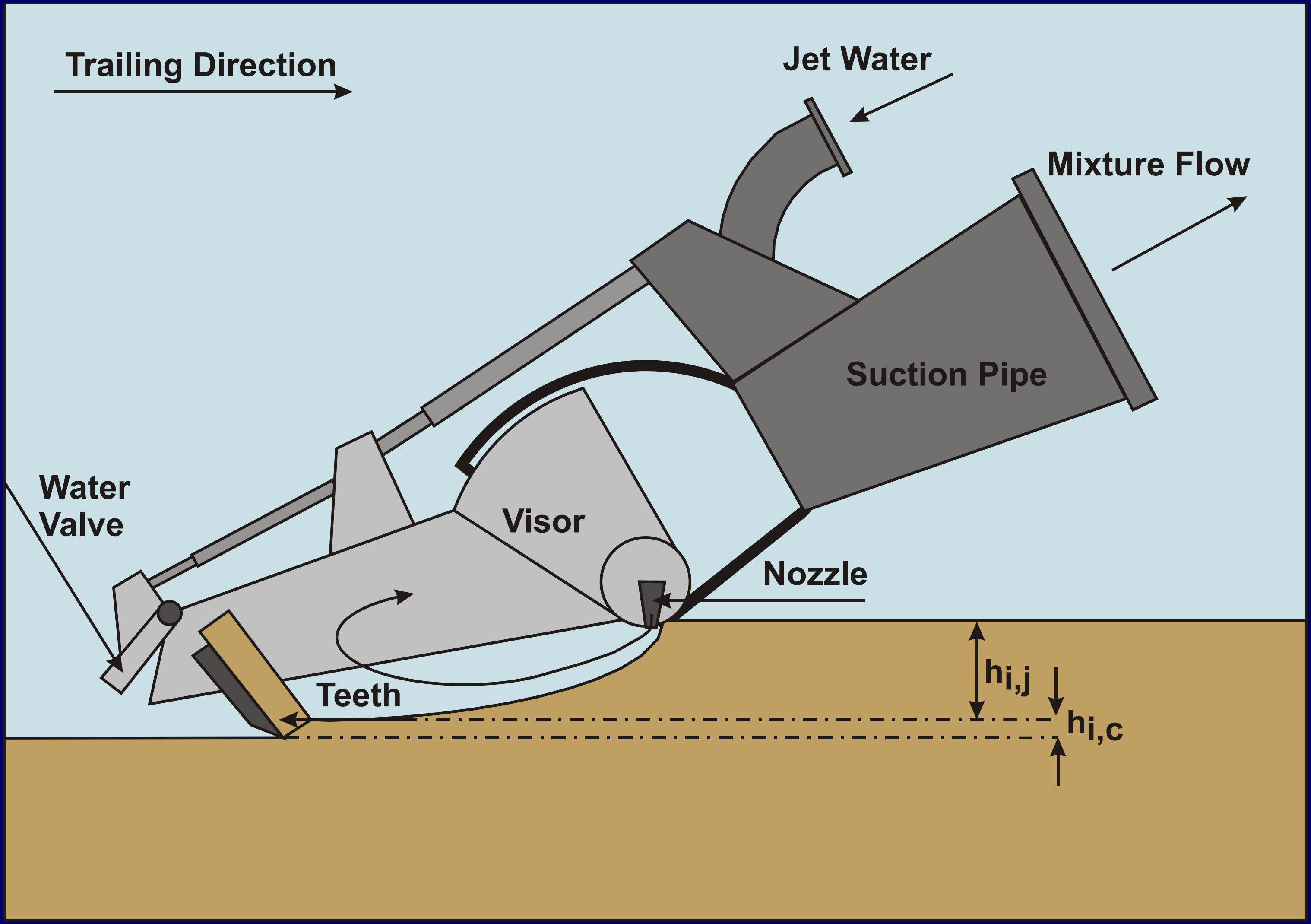
The draghead



The working principles



The working principles



Jetting

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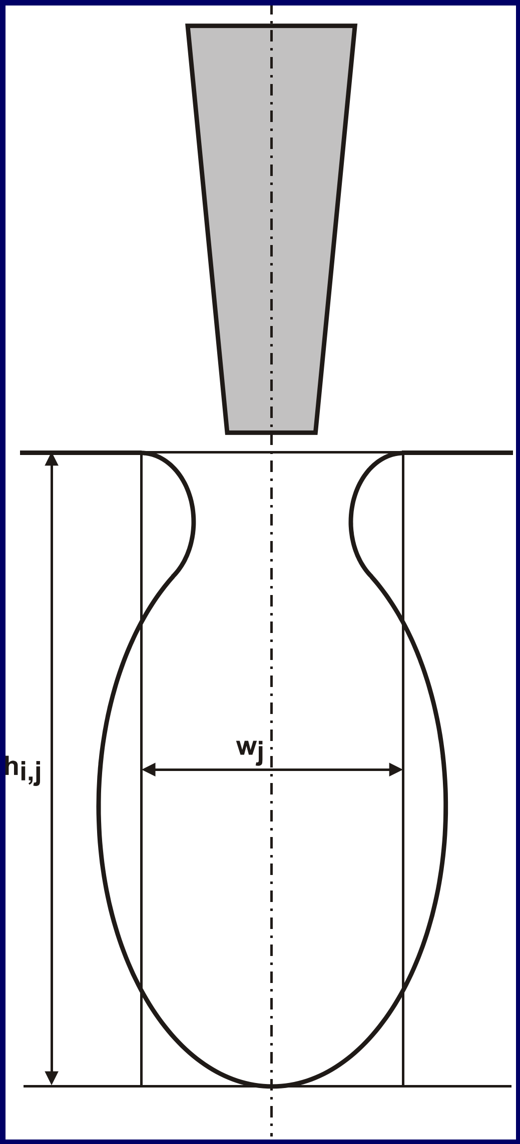
The jetting in a draghead



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The jet power

$$Q_j = v_j \cdot \frac{\pi}{4} \cdot \left(\alpha \cdot D_j\right)^2$$

$$v_j = \left(\frac{2 \cdot \Delta p_j}{\rho_l}\right)^{1/2}$$

$$Q_j = \left(\frac{2 \cdot \Delta p_j}{\rho_l}\right)^{1/2} \cdot \frac{\pi}{4} \cdot \left(\alpha \cdot D_j\right)^2$$

$$P_j = \Delta p_j \cdot Q_j = \Delta p_j \cdot \left(\frac{2 \cdot \Delta p_j}{\rho_l}\right)^{1/2} \cdot \frac{\pi}{4} \cdot \left(\alpha \cdot D_j\right)^2$$

$$P_j = \left(\frac{2}{\rho_l}\right)^{1/2} \cdot \frac{\pi}{4} \cdot \alpha^2 \cdot \Delta p_j^{3/2} \cdot D_j^2$$

The specific energy/penetration depth

$$E_{sp} \cdot Q_s = \Delta p_j \cdot \left(\frac{2 \cdot \Delta p_j}{\rho_l} \right)^{1/2} \cdot \frac{\pi}{4} \cdot \left(\alpha \cdot D_j \right)^2$$

$$E_{sp} \cdot h_{i,j} \cdot w_j \cdot v_c = \Delta p_j \cdot \left(\frac{2 \cdot \Delta p_j}{\rho_l} \right)^{1/2} \cdot \frac{\pi}{4} \cdot \left(\alpha \cdot D_j \right)^2$$

$$h_{i,j} = \frac{\Delta p_j \cdot \left(\frac{2 \cdot \Delta p_j}{\rho_l} \right)^{1/2} \cdot \frac{\pi}{4} \cdot \left(\alpha \cdot D_j \right)^2}{E_{sp} \cdot w_j \cdot v_c}$$

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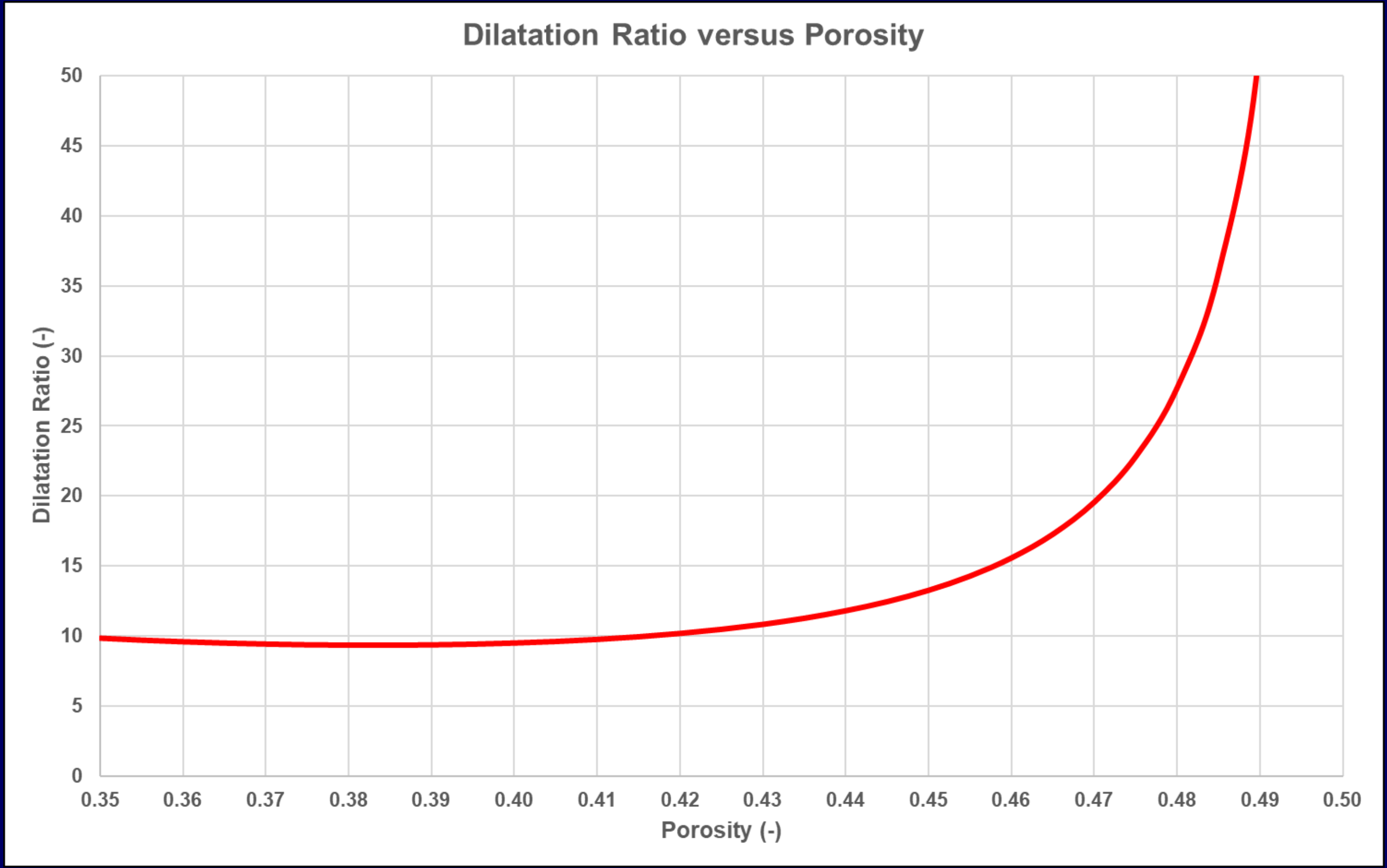
The specific energy/penetration depth

$$E_{sp} = c_1 \cdot \frac{\rho_l \cdot g \cdot h_{i,j} \cdot v_c \cdot \varepsilon}{k_m}$$

$$h_{i,j}^2 = \frac{\Delta p_j \cdot \left(\frac{2 \cdot \Delta p_j}{\rho_l} \right)^{1/2} \cdot \frac{\pi}{4} \cdot \left(\alpha \cdot D_j \right)^2}{c_1 \cdot \rho_l \cdot g \cdot v_c^2 \cdot w_j} \cdot \frac{k_m}{\varepsilon}$$

The porosity and permeability



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The penetration depth/cavity width

$$\frac{k_m}{\varepsilon} = 10 \cdot k_i$$

$$h_{i,j}^2 = \frac{\Delta p_j \cdot \left(\frac{2 \cdot \Delta p_j}{\rho_l}\right)^{1/2} \cdot \frac{\pi}{4} \cdot \left(\alpha \cdot D_j\right)^2}{c_1 \cdot \rho_l \cdot g \cdot v_c^2 \cdot w_j} \cdot 10 \cdot k_i$$

The penetration depth/cavity width

$$w_j = \left(\frac{v_c}{v_1}\right)^{\beta} \cdot h_{i,j}$$

$$h_{i,j}^2 = \frac{\Delta p_j \cdot \left(\frac{2 \cdot \Delta p_j}{\rho_l}\right)^{1/2} \cdot \frac{\pi}{4} \cdot \left(\alpha \cdot D_j\right)^2}{c_1 \cdot \rho_l \cdot g \cdot v_c^2 \cdot \left(\frac{v_c}{v_1}\right)^{\beta} \cdot h_{i,j}} \cdot 10 \cdot k_i$$

The cavity width ratio

The penetration depth

$$h_{i,j}^{3} = 10 \cdot \frac{\left(\frac{2}{\rho_l}\right)^{1/2} \cdot \frac{\pi}{4} \cdot \alpha^{2}}{c_1 \cdot \rho_l \cdot g} \cdot \frac{\Delta p_j^{3/2} \cdot D_j^{2} \cdot k_i}{v_c^{2+\beta} \cdot v_1^{-\beta}}$$

$$= 8 \cdot \frac{\Delta p_j^{3/2} \cdot D_j^{2} \cdot k_i}{v_c^{2+\beta} \cdot v_1^{-\beta}}$$

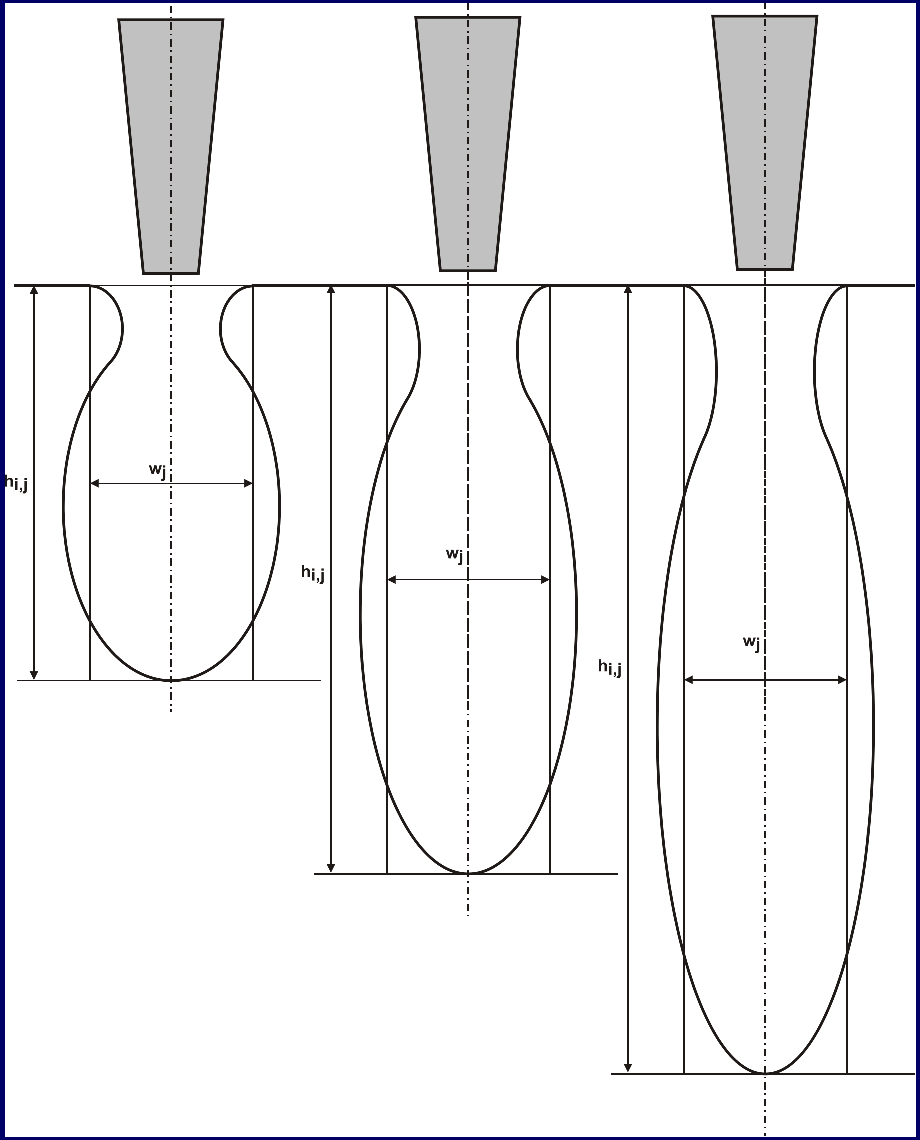
The penetration depth and cavity width

$$h_{i,j} = 2 \cdot \frac{\Delta p_j^{1/2} \cdot D_j^{2/3} \cdot k_i^{1/3}}{v_c}$$

and

$$w_j = 2 \cdot \Delta p_j^{1/2} \cdot D_j^{2/3} \cdot k_i^{1/3}$$

Jetting in a draghead, different velocities



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The draghead production

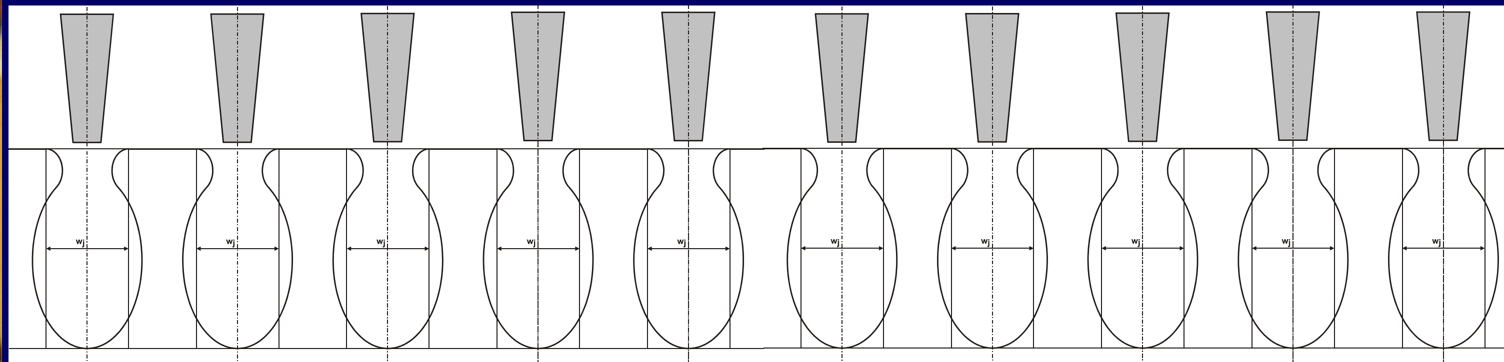
$$2 \cdot \Delta p_j^{1/2} \cdot D_j^{2/3} \cdot k_i^{1/3} > \frac{w_{dh}}{n_j}$$

$$\Rightarrow \qquad w_j = \frac{w_{dh}}{n_j}$$

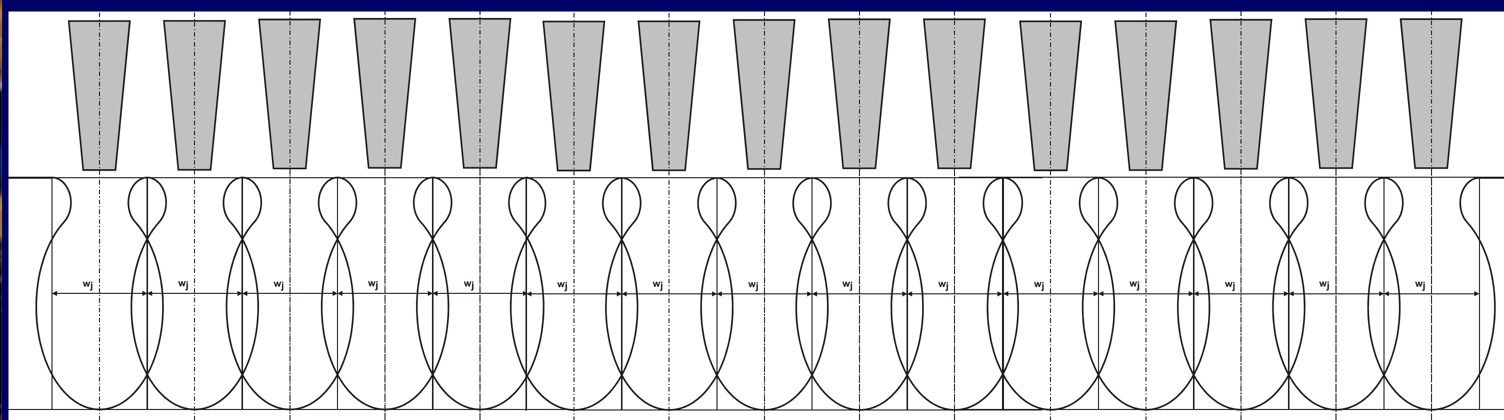
$$2 \cdot \Delta p_j^{1/2} \cdot D_j^{2/3} \cdot k_i^{1/3} < \frac{w_{dh}}{n_j}$$

$$\Rightarrow \qquad w_j = 2 \cdot \Delta p_j^{1/2} \cdot D_j^{2/3} \cdot k_i^{1/3}$$

The jetting in a draghead



No overlap



Overlap

The draghead production

$$Q_{s,dh} = h_{c,max} \cdot w_j \cdot v_c \cdot n_j$$

or

$$Q_{s,dh} = h_{i,j} \cdot w_j \cdot v_c \cdot n_j$$

$$= 2 \cdot \Delta p_j^{1/2} \cdot D_j^{2/3} \cdot k_i^{1/3} \cdot w_j \cdot n_j$$

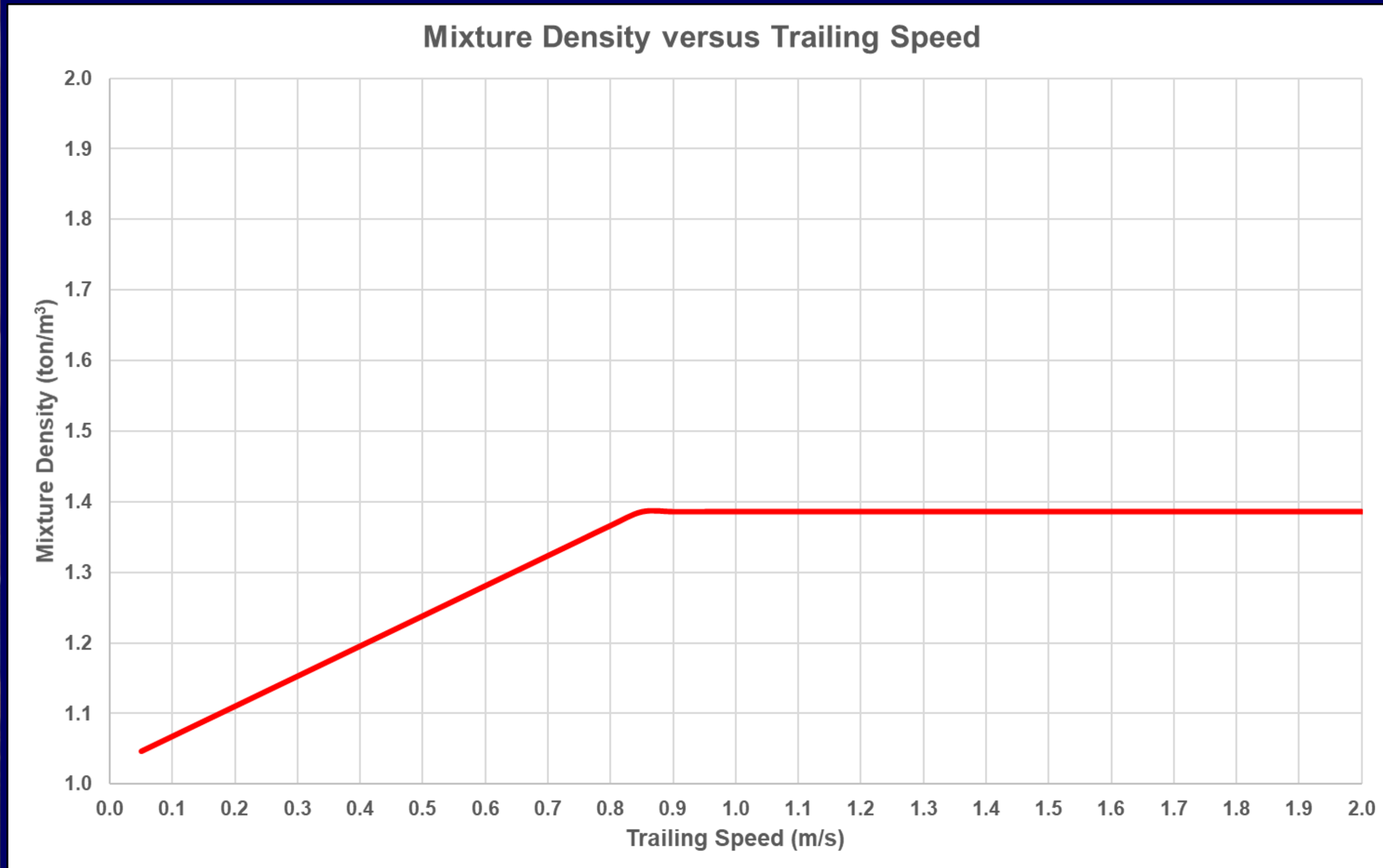
The draghead concentration and density

$$C_{vs} = \frac{Q_{s,dh} \cdot \left(1 - n_i\right)}{Q_m}$$

$$= \frac{2 \cdot \Delta p_j^{1/2} \cdot D_j^{2/3} \cdot k_i^{1/3} \cdot w_j \cdot n_j \cdot \left(1 - n_i\right)}{\frac{\pi}{4} \cdot D_p^2 \cdot v_{ls}}$$

$$\rho_m = C_{vs} \cdot \rho_q + \left(1 - C_{vs}\right) \cdot \rho_l$$

Draghead mixture density, jetting



Cutting forces

$$F_h = \frac{c_1 \cdot \rho_l \cdot g \cdot v_c \cdot h_{i,c}^2 \cdot w_{dh} \cdot \varepsilon}{k_m}$$

with: $c_1 = 0.0427 \cdot e^{0.0509 \cdot \varphi}$

$$F_v = \frac{c_2 \cdot \rho_l \cdot g \cdot v_c \cdot h_{i,c}^2 \cdot w_{dh} \cdot \varepsilon}{k_m}$$

with: $c_2 = 0.0343 \cdot e^{0.0341 \cdot \varphi}$

Cutting forces and moments

$$F_h = \frac{c_1 \cdot v_c \cdot h_{i,c}^2 \cdot w_{dh}}{k_i}$$

$$F_v = \frac{c_2 \cdot v_c \cdot h_{i,c}^2 \cdot w_{dh}}{k_i}$$

$$F_G \cdot L_G = F_h \cdot L_h - F_v \cdot L_v$$

$$h_{i,c}^2 = \frac{F_G \cdot L_G \cdot k_i}{v_c \cdot w_{dh} \cdot \left(c_1 \cdot L_h - c_2 \cdot L_v\right)}$$

Mixture density

$$C_{vs} = \frac{h_{c,max} \cdot w_{dh} \cdot v_c \cdot \left(1 - n_i\right)}{\frac{\pi}{4} \cdot D_p^2 \cdot v_{ls}}$$

or

$$C_{vs} = \frac{\begin{pmatrix} 2 \cdot \Delta p_j^{1/2} \cdot D_j^{2/3} \cdot k_i^{1/3} \cdot w_j \cdot n_j \\ + h_{i,c} \cdot w_{dh} \cdot v_c \end{pmatrix} \cdot \left(1 - n_i\right)}{\frac{\pi}{4} \cdot D_p^2 \cdot v_{ls}}$$

$$\rho_m = C_{vs} \cdot \rho_q + \left(1 - C_{vs}\right) \cdot \rho_l$$

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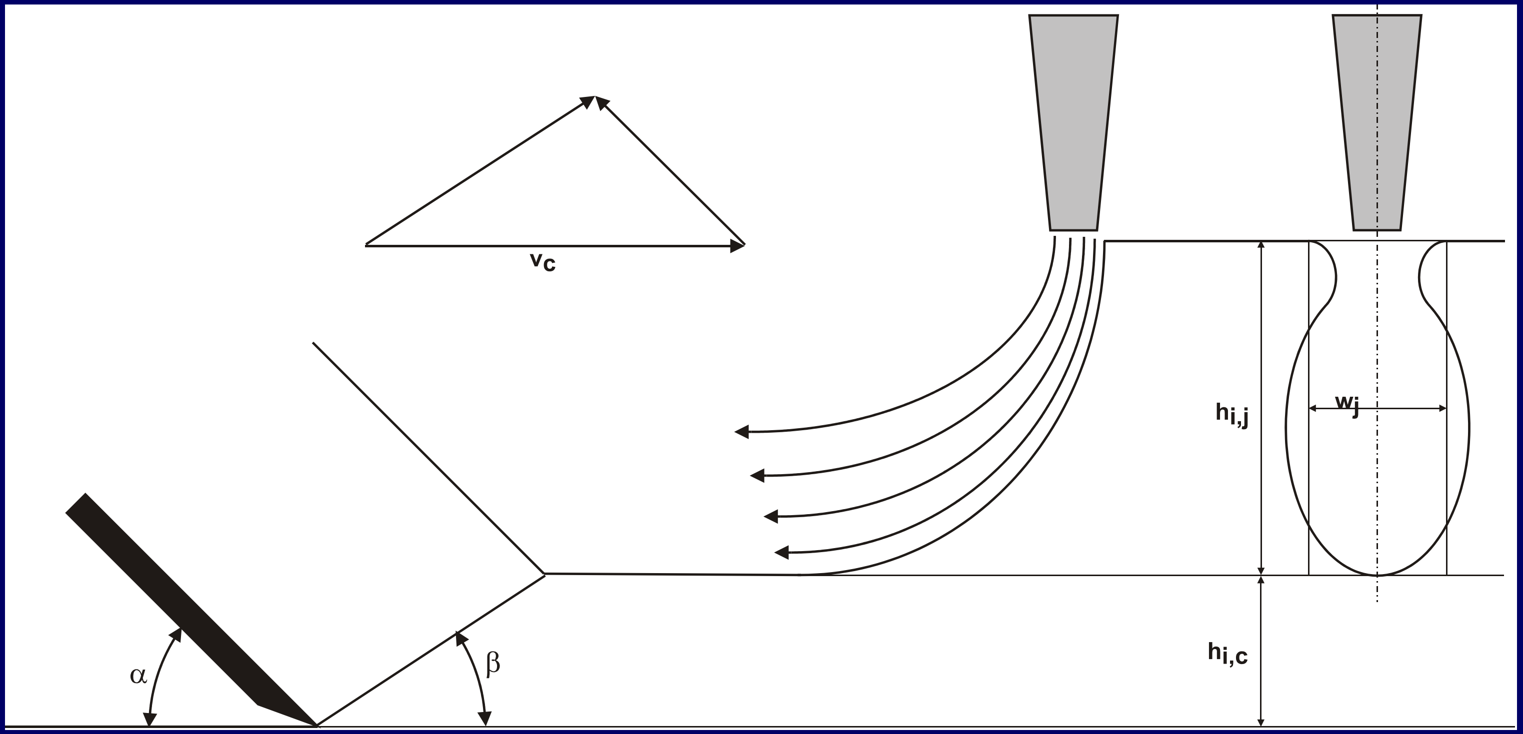
The cutting and jetting in a draghead



Mixture density, cutting + jetting , β=1.0

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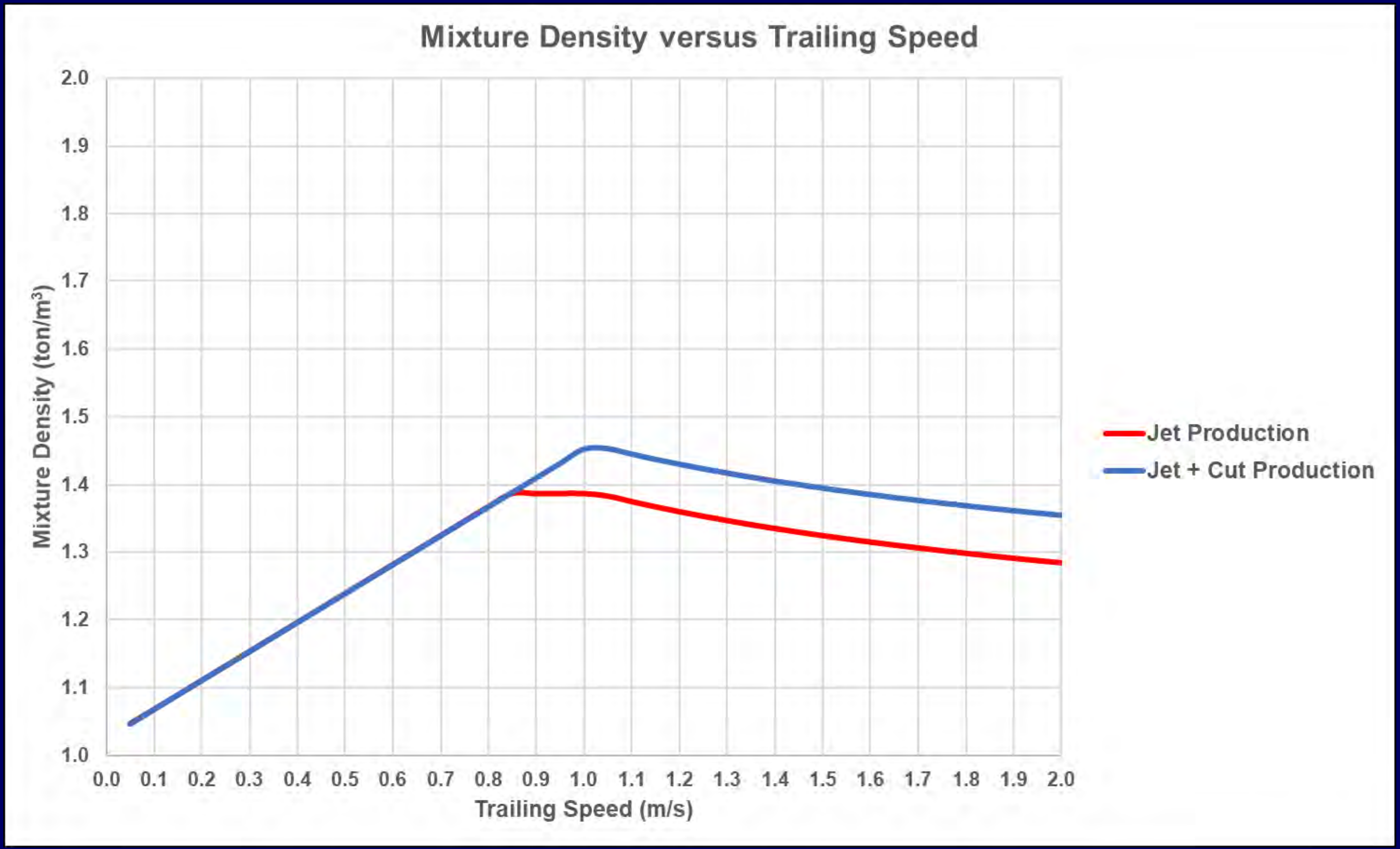
Mixture density, cutting + jetting, $\beta=0.5$



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Mixture density, cutting + jetting, β=1.5

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Conclusions

- The model derived results in acceptable mixture densities.
- The relation between cavity width and penetration depth may be more complicated if more experimental data is available.
- The assumption, using the specific energy of the cutting process, gives good results.

Questions?