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Computational Modelling of Fine Sediment Release Using SEDMIX Device with Thrusters

LCH LABORATOIRE DE CONSTRUCTIONS HYDRAULIQUES

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Introduction

- ***Problem:*** Reservoir sedimentation occurs in dams worldwide, reducing the live storage available in the reservoirs.
- ***Possible solution:*** Jenzer-Althaus (2011) tested a water stirring device (called SEDMIX) that keeps sediments in suspension, enhancing its release through the power intakes of the dam reporting a high efficiency.
- ***Background studies:*** Numerical simulations for a prototype for the Trift reservoir have been carried out in the past by Amini et al. (2017) and Chraibi et al. (2018), obtaining good results for sediment evacuation and determining the optimal location and dimensions of the device.
- ***Objective of the current work***: Numerically test the performance of SEDMIX at the Trift reservoir implementing thrusters instead of the previous configuration with water jets using ANSYS 2019 R1 software .

Methodology

1. Compare the flow patterns in a regular tank obtained through numerical modelling (figure 1) with the experimental ones obtained by Jenzer-Althaus (2011).

- Considering various bottom clearances and a single phase flow, using the k-ε turbulence model and assuming a steady state flow.
- The jets were modelled as inner sources and the thrusters as a combination of inner sinks and sources to avoid refining elements.

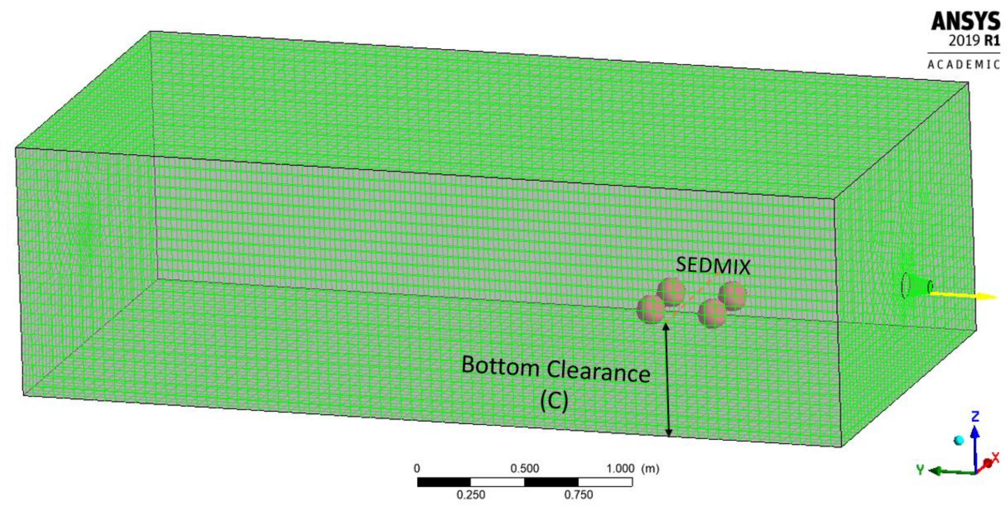

Figure 1: Numerical model of regular tank.

2. Determine the sediment release at Trift reservoir and compare it with the one obtained with jets.

- The geometrical dimensions and location of the device were the optimal found by Chraibi et al. (2018) (figure 2).
- A constant inflow Q_{in} of $21 m^3/s$, a relative pressure of 0 at the water intake and a multiphase flow were considered.
- It was assumed a concentration of 0.7 g/L of sediments, with a mean particle diameter (D_s) of 0.1mm, and a density (ρ_s) of 2600 kg/m^3.
- Three diameters of thrusters were considered. Each has its own thrust force (T) and rotational speed (n) that determined its maximum efflux velocity (U_0) as proposed by Albertson et al (1948) and its thrust coefficient (K_t) as suggested by Blaauw & Van de Kaa (1978):

$$U_0 \approx 1.60 \cdot n \cdot D \cdot \sqrt{K_t} \qquad K_t = \frac{T}{\rho \cdot n^2 \cdot D^4}$$

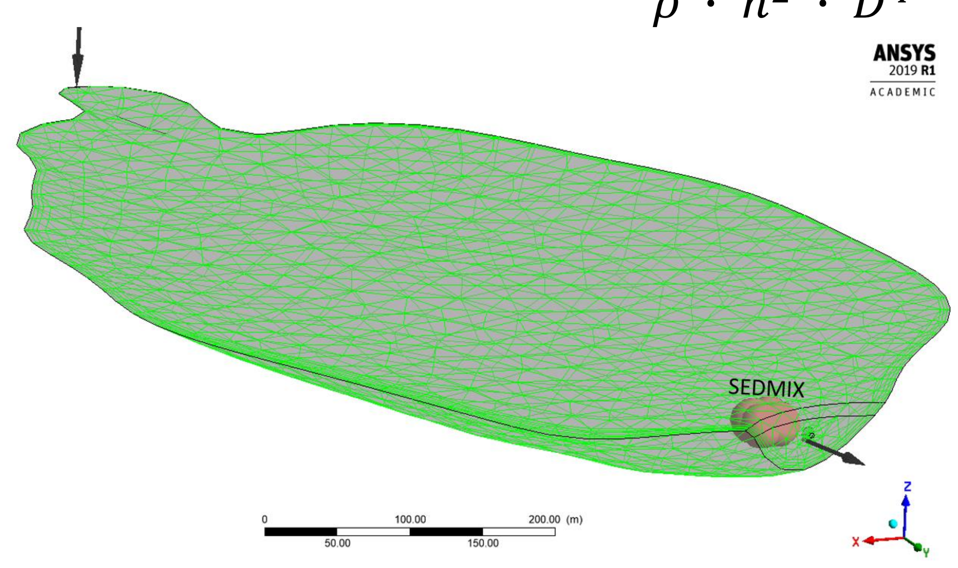

Figure 2: Numerical model of Trift reservoir

Results And Analysis

- The flow patterns obtained through numerical simulation of SEDMIX with water jets (figure 3a) are similar to the ones obtained by Jenzer-Althaus (2011) (figure 3b).
- With thrusters maintaining the same induced flow as the one considered for the jets, the flow velocity provided by them is too small to reproduce the flow patterns expected (figure 3c).
- Adjusting the thrusters to a higher velocity, a similar flow pattern was obtained (figure 3d).

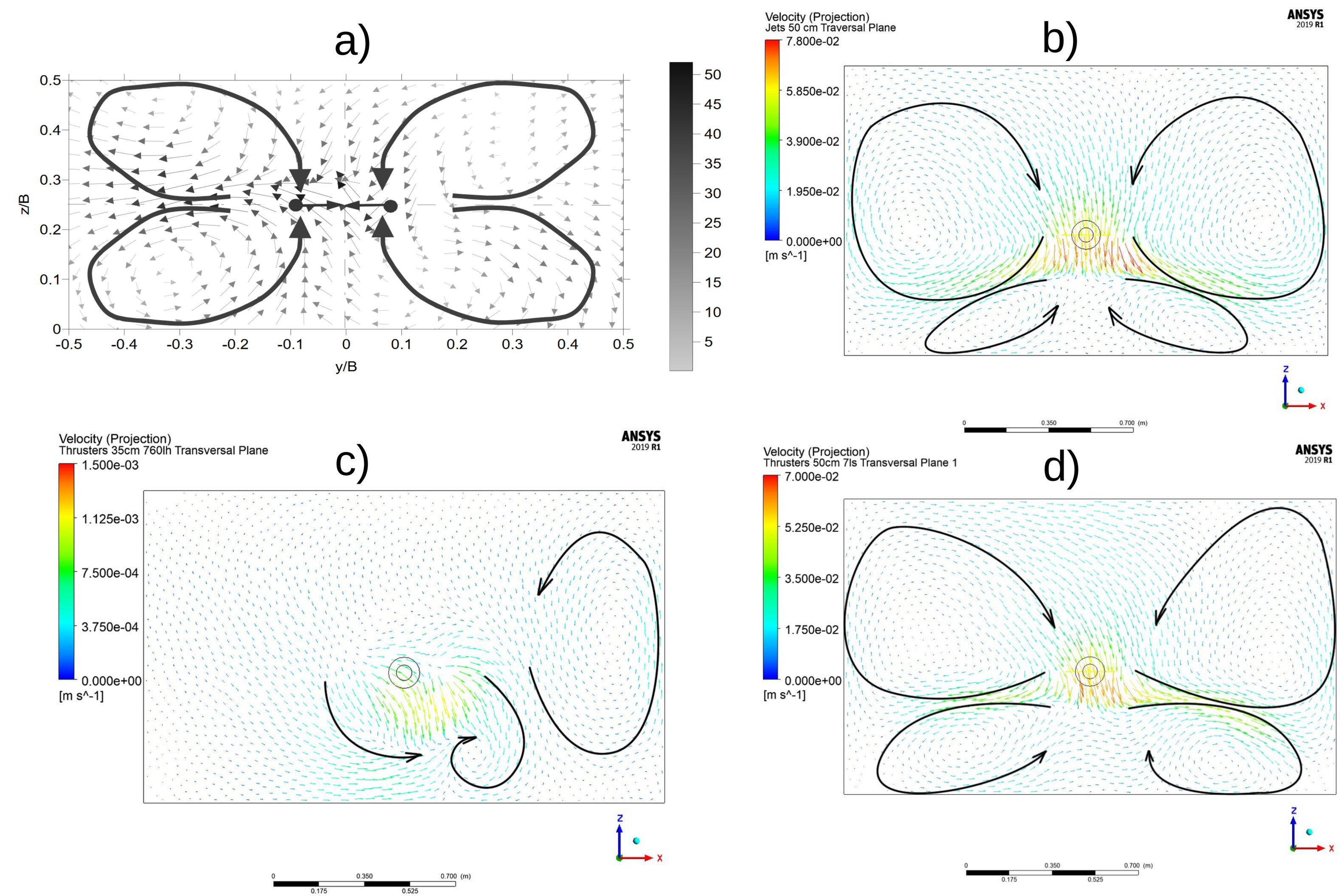

Figure 3: Flow patterns obtained for a bottom clearance of 0.5 m: a) Experimentally (jets). b) Numerically (jets). c) Numerically (thrusters 760 l/h). d) Numerically (thrusters 7.2 l/s).

- The set of thrusters of 0.42m were successfully calibrated to obtain the optimum sediment release (73% of increment in evacuation), with a global induced flow of ~12.8 m^3/s (3.2 m^3/s per thruster) (figure 4).
- With this flow, the variation of the sediment velocity along the water column located at the vortex center resembles the one obtained for water jets, as shown in figure 5.

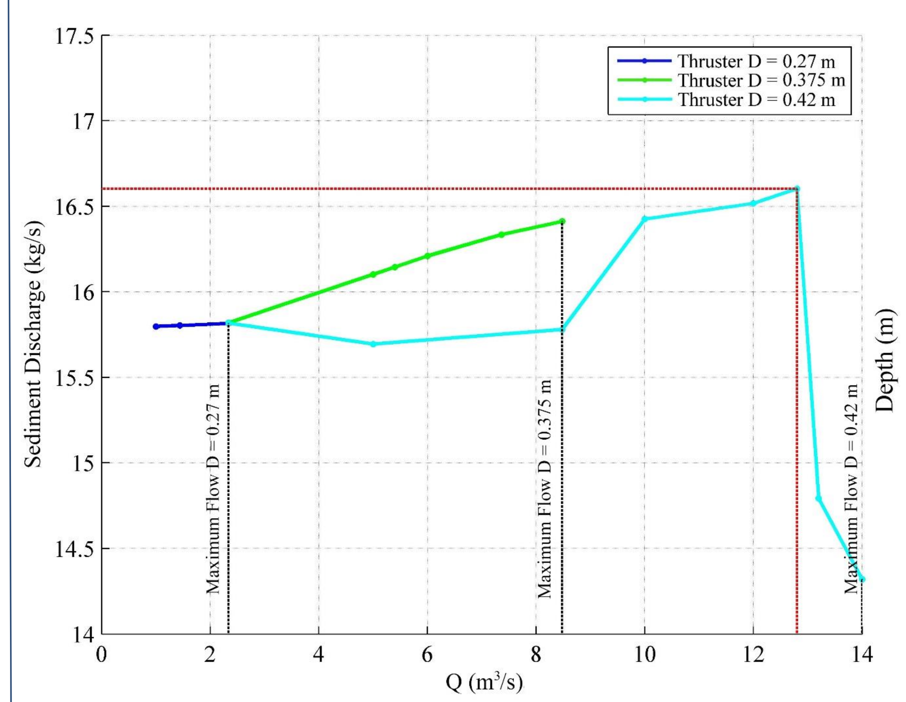

Figure 4: Sediment discharge with SEDMIX using thrusters of various diameters.

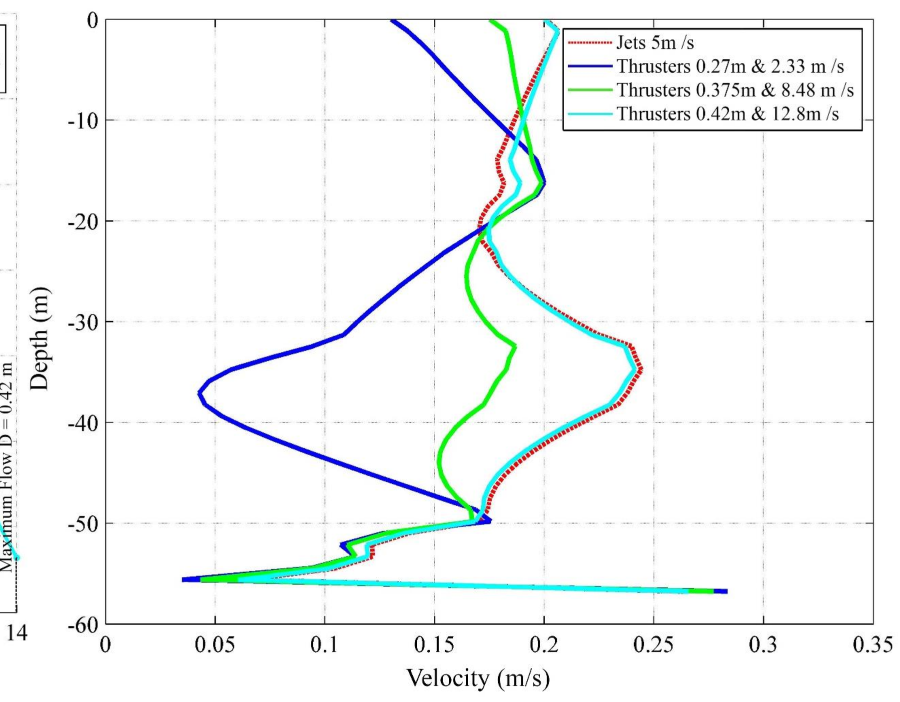

Figure 5: Variation of sediment velocity with depth for jets and thrusters.

Figure 6: Installation of SEDMIX.

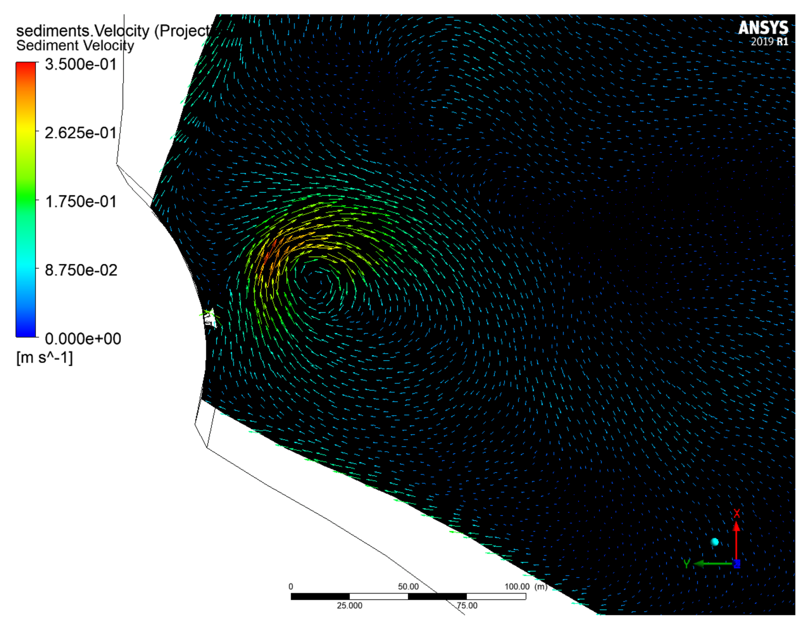

Figure 7: Rotational flow generated when using SEDMIX with thrusters.

Conclusion

- The numerical simulations showed similar patterns when using jets and thrusters, however, a higher induced flow is needed by the thrusters to be able to replicate the recirculation flow generated by the jets.
- For the Trift reservoir, the optimal thruster had a diameter of 0.42 m with a induced flow of 3.2 m^3/s.
- Since the use of thrusters means no dealing with head losses, the power requirements could be less and the operational costs could be lower compared to the use of water jets.
- The experimental study of the device using thrusters is highly advised and the hydrodynamic behaviour in the reservoir should be further studied.

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