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EFFECTS OF GREEN VALVE ON AIR ENTRAINMENT IN HOPPER OVERFLOW

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INTRODUCTION

When a dredge mixture deserts a hopper through its overflow structure, often significant volumes of air are entrained into the mixture. The air entrainment is a result of "hydraulic jump" turbulence generated in the core of the (often circular) overflow structure. The near-field sediment processes are important as they feed the more far-reaching dredge plumes. Once discharged, the trapped air tends to segregate from the overflow plume owing to its buoyancy and the rising of bubbles towards the surface of the sea is reported to have a pronounced effect on near-field dispersion and to obstruct settling of the mixture sediments (Parys et al., 2000). The near-field dispersion weakens the strength of the density current which is highly undesirable as it increases the foot-print of the dredge plume. Plumes with high levels of turbidity may have severe impacts on coastal environments, and dredge operations are therefore often forced to reduce production rates to reduce dredge plume foot-prints in order to comply with environmental regulations. One of the more recognized measures in reducing plume footprints is combating air entrainment with the so-called green valve device, also known as the environmental valve (Jan de Nul, 2003). The green valve is rigged within the shaft of the overflow structure and the fundamental idea is to increase the hydraulic resistivity inside shaft leading to increased submergence of the overflow, which results in less air entrainment (Jain et al. 1978).

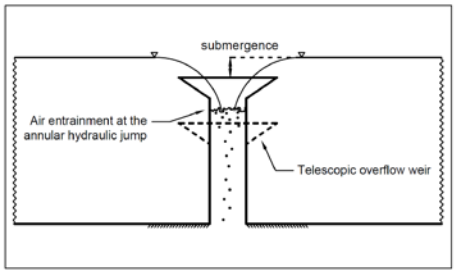

Figure 1 - Schematic representation of the overflow structure

PRESENT WORK & RESULTS

The hydraulics of the classic drop shafts (being in close resemblance to the hopper overflow structures) has been studied for better understanding of the air entrainment process and the driving parameters. A two-phase numerical model, based on the Volume of Fluid (VOF) method (Hirt and Nichols, 1981), has been established to simulate the process of overflow and the air entrainment in circular drop shafts, which has been verified successfully with the experimental data (Whillock and Thorn, 1973). The model has been used to simulate the performance of the so called Green Valve, as being a mitigation method in reducing the air entrainment in overflow pipes. The numerical results confirm the effectiveness of the valve in reducing the rate of entrainment of the air bubbles into the overflow. The model also provides information about the draw backs of this mitigation method, which is mainly the reduced rate of the overflow. The results however show that reduction in the overflow rate can be acceptable considering the significant reduction in the air entrainment.

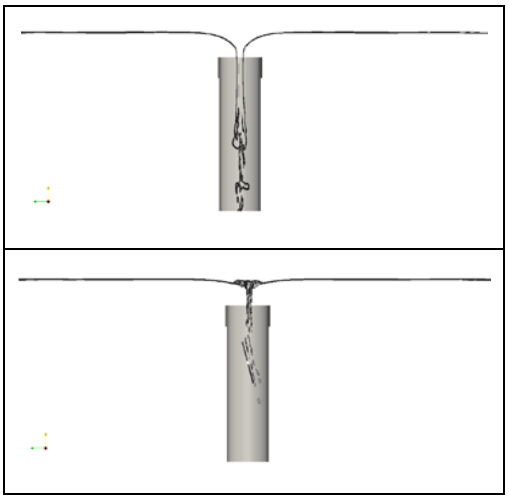

Figure 2 – Air-water interface from the CFD results, Top: without valve, Bottom: with valve

REFERENCES

Hirt, C. and Nichols, B. (1981). "Volume of fluid (VOF) method for the dynamics of free boundaries." Journal of Computational Physics, 39(1), 201-225.

Jain, A., Garde, R., and Raju, K. R. (1978). "Air entrainment in radial flow towards intakes." Journal of the Hydraulics Division, 104(9), 1323-1329.

Jan de Nul (2003). "SPECIALISED ALTERNATIVE DREDGING METHODS." 3er Congreso Argentino de Ingenieria Portuaria.

Parys, M. V., Dumon, G., Pieters, A., Claeys, S., Lanckneus, J., Lancker, V. V., and Vangheluwe, M. (2000). "Environmental monitoring of the dredging and relocation operations in the coastal harbours in Belgium: MOBAG 2000." WODCON XVI, Vol. 32, Kuala Lumpur, Malaysia.

Whillock, A. and Thorn, M. (1973). "Air Entrainment in Dropshafts.