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Computational Fluid Dynamic Modelling of the Desander: A Case Study from Pakistan

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Abstract : A CFD model was developed for a desander on the waterway of the Madyan Hydro Power Plant (MHPP), which is under construction in northeast Pakistan. An underground desander was designed to settle the sediments before the headrace tunnel, which is 14 km long. The desander chamber consists of 2 caverns, each including 2 basins with flushing-type desander, adopted in the feasibility design on the left bank of the river. A 3D flow simulation was developed to interpret the desander performance according to flow velocity. Then, a particle-based model was developed to check the sediment particle sizes in different areas of the desander. 11 Scenarios were defined for different configurations of the desander, including the transition vertical slope, symmetric and asymmetric entrance, the basin net length, and tranquilizer racks specifications. The model's runtime using a medium-class supper computer was several days for each scenario because of the required time interval for the defined pixel size of the 3D model. It also needed to extend the duration time of the modeling to the travel time of sediment particles along the desander. The results of the 3D models for different entrance transition slopes showed that a high slope transition zone is not acceptable due to the turbulence/vortex at the transition. The sediment drainage channel was extended to the transition with an expanding side slope upstream to have a better trapping performance for bigger particles. The desander configuration and the net length were modeled in different scenarios to reach the design particle size removal criteria of 0.2 and 0.3 mm. The results show that the desander design configuration in the feasibility stage with a net length of 204 meters and transition angle of 34° is an overdesign configuration. On the other hand, reducing the desander net length to less than 135 meters does not fulfill the design criterion of 0.2 mm particle size removal. The Scenarios included asymmetric and symmetric entrance transition zone configurations for the four basins. The CFD results confirmed the symmetric desander configuration, with a net length of 135 m and a transition angle of 34° to the horizon, as the optimum configuration. The configuration provides a removal efficiency of 97% for a particle size of 0.2 mm. The CFD results also show that horizontal tranquilizing racks are risky and do not help sediment trapping in the basin. However, the horizontally inclined tranquilizer decreases the turbulence by transferring the flow energy into the main basin. Nonetheless, more evaluation is needed to optimize the transition zone length by using a tranquilizer at the entrance and evaluating the tranquilizer racks with vertical alignments by building a convenient physical model.

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