A PFEM solution when a High Froude number Viscous Flow past a Circular Cylinder.

Leo M. González*, Juan M. Giménez†

* Escuela Técnica Superior de Ingenieros Navales, Universidad Politécnica de Madrid
Avd. Arco de la Victoria 4, Madrid, Spain
e-mail: leo.gonzalez@upm.es

† Centro de Investigación de Métodos Computacionales (CIMEC) - UNL/CONICET, Predio Conicet-Santa Fe Colectora Ruta Nac. 168 Paraje El Pozo, Santa Fe, Argentina.
e-mail: jmarcelogimenez@gmail.com

ABSTRACT

In this paper, a new generation of the particle method known as Particle Finite Element Method (PFEM-2) [1], which combines convective particle movement and a fixed mesh resolution, is applied to a 2D monophasic flow past a circular cylinder intersecting or close to a free surface at Reynolds 180 [2]. To accomplish this task, different improved versions of discontinuous and continuous enriched basis functions for the pressure field have been developed [3] to capture the free surface dynamics without artificial diffusion or undesired numerical effects. The well-known numerical properties of PFEM-2 such as using larger time steps when compared to other similar numerical tools which implies shorter computational times while maintaining the accuracy of the computation will be checked in this case.

In particular, for this free surface cylinder, the wake behavior for Froude numbers between 0.3 and 2.0 and for gap ratios between -0.5 and 2.5 are examined. The PFEM-2 technique allows for a very little diffusive computation of the free surface evolution, even while breaking and fragmentation may occur. Vorticity shed by the cylinder, vortex generation due to free surface breaking, mixing processes, and drag and lift coefficients behavior are quantified. It has been found that, for small gap ratios, the classical von Karman vortex shedding from the cylinder does not take place for most of the Froude numbers considered. In turn, moderate vortex shedding occurs, departing not from the cylinder but originating from wave breaking at the free surface. This shedding takes places simultaneously with the transport of free surface fluid elements into the bulk of the fluid. In some combinations of Froude number and submergence ratio, a vorticity layer remains spatially localized between the cylinder and the free surface and a large recirculating wake area develops, which eventually gets detached after several shedding cycles, being advected downstream.

REFERENCES

[1] S. Idelsohn, E. Oñate, F. Del Pin, The particle finite element method a powerful tool to solve incompressible flows with free-surfaces and breaking waves., *International Journal of Numerical Methods* 61 (2004) 964-989.

[2] Bouscasse, B., Colagrossi, A., Souto-Iglesias, A., and Marrone,S., 2014. “Viscous flow past a circular cylinder below a free surface”. In 33rd International Conference on Ocean, Offshore and Arctic Engineering (OMAE), ASME, ed.

[3] J.M Giménez, L. M. González, An extended validation of the last generation of particle finite element method for free surface flows, Journal Computational Physics 284 (2015) 186–205.