Wind Resistance and Flow Characteristic Analysis of Geotechnical Centrifuges Based on Computational Fluid Dynamics

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ABSTRACT

Wind resistance is one of fundamental parameters in geotechnical centrifuge designs. The reasonable estimation of wind resistance is essential in selection of motor and cooling system of a geotechnical centrifuge. Generally, simplified theoretical formulations with rigid rotation assumption of fluid are used in wind resistance calculation. But determination of some parameters is rather subjective in these formulations, making the calculation less reliable. Moreover, the validity of rigid-motion assumption to high velocity and/or big volume geotechnical centrifuges is also susceptive.

In this paper, numerical simulation on fluid inside the geotechnical centrifuge chamber is carried out based on CFD. The chamber space is divided into a rotating domain near the arm and a stationery domain surrounding it. Stable MRF (multiple reference frames) method is used to describe the relative motion between centrifuge arms and chamber wall. k-ε RNG model is used for turbulence in the simulation.

Using this method, wind resistance of a certain centrifuge with different angular velocities is calculated and compared with experimental and analytical theoretical results. Relatively good consistence is found in these results, with largest relative error less than 15%, verifying the reasonability of both analytical and numerical methods. Also, fluid field in the chamber is analyzed; the results show that rigid-rotation assumptions used in traditional simplified modeling can reflect real fluid flow to a great extent for low and middle velocity centrifuge.

In this paper, traditional wind resistance formulae are examined for low and middle speed centrifuges based on CFD. Also, a good foundation has been laid for high reliability simulation of more complex centrifuges with high speeds, which can eliminate the subjectivity in simplified formulations.

REFERENCES

[1] J. Nicolas Font, Design of geotechnical centrifuges, Centrifuge 88, Corte. Balkema, Rotterdam, 1988

[2] Y. H. Yin, Y. D. Liu, X. L. Wang, et al., "Load rotational moment and power of centrifuges with rotational arms". Proceedings of 3rd International Conference on Mechanical and Electronics Engineering. Hefei, China, 2011.

[3] T. D. Xu, P. A. Du, L. Wang, et al., "Optimization design of wind resistance for precision centrifuge based on CFD". China Journal of Engineering Design, Vol. 21(6): pp. 572-577, (2014).