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Distribution law analysis and calculating method for windage power in a geotechnical centrifuge

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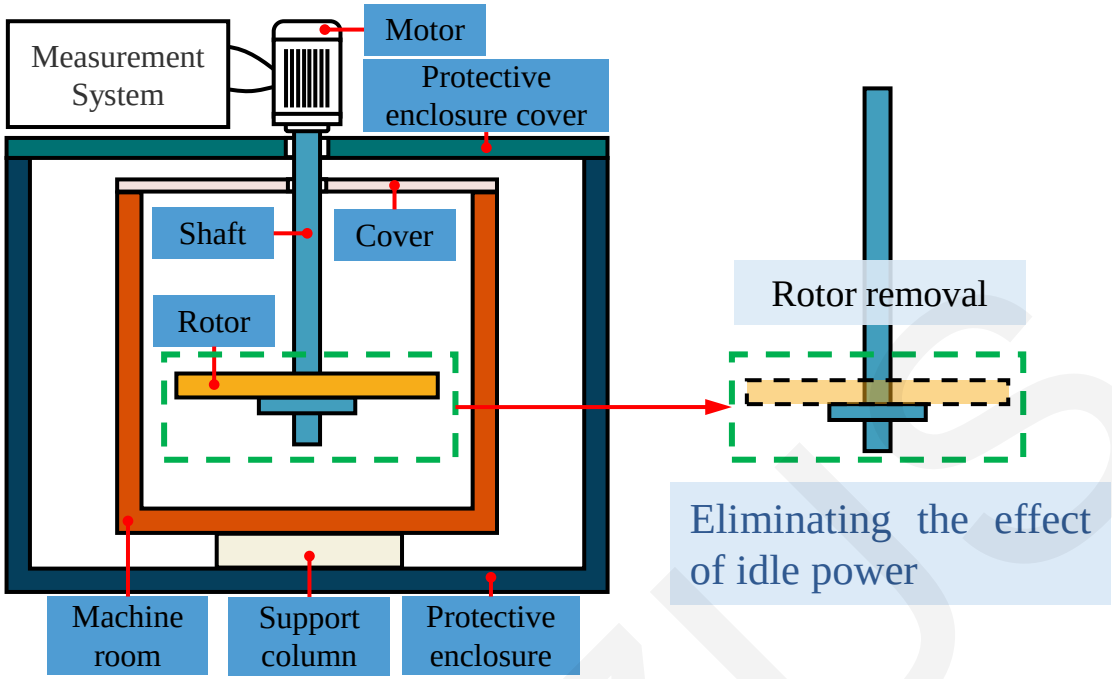
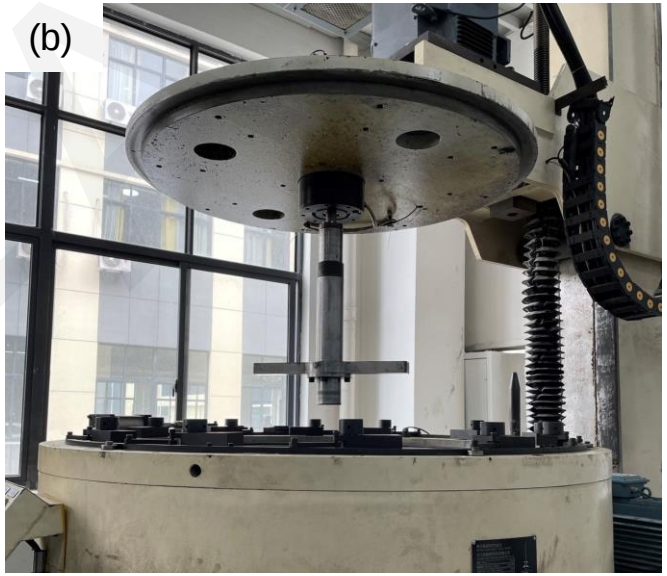
High-Reliability Windage Power Measurement Method



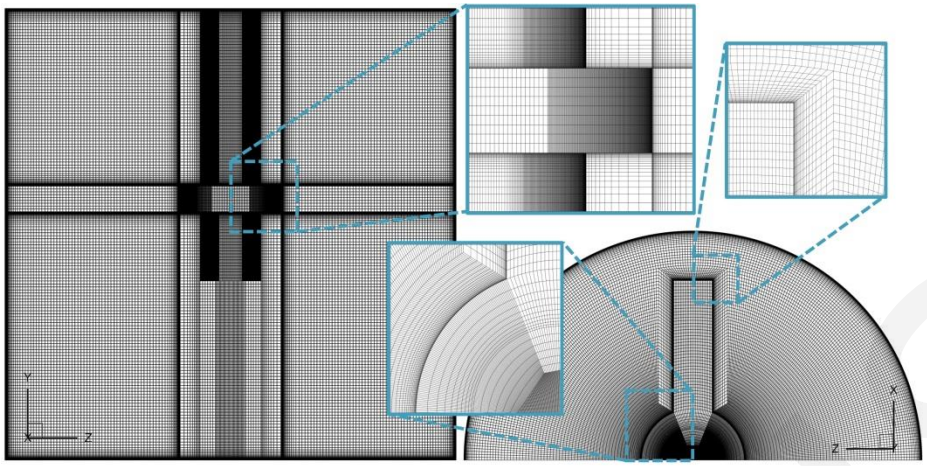


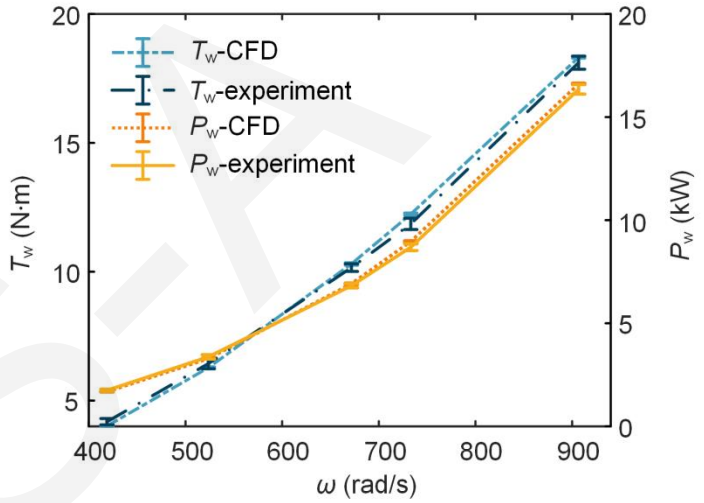
	ω (rad/s)							
	105.29	**209.03**	**313.98**	**418.68**	**523.56**	**671.6**	**733.04**	**906.75**
e_{P_w} (%)	83.08	22.3	8.57	2.91	3.12	1.46	1.87	1.4
e_{T_w} (%)	83.75	22.43	8.59	2.92	3.12	1.47	1.87	1.4

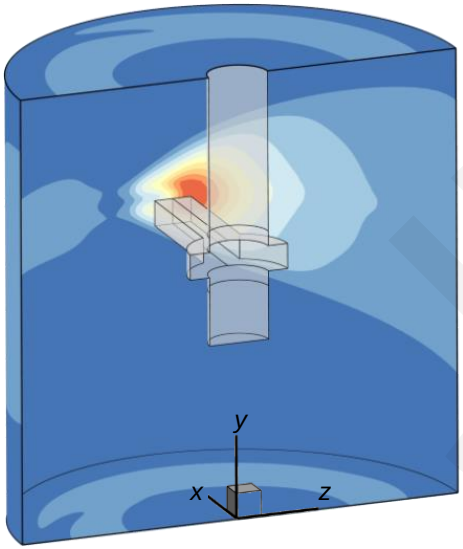
The indirect measurement method introduces significant errors at low speeds.

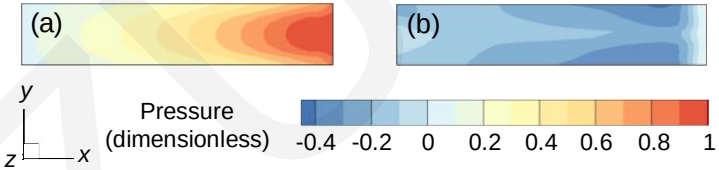
Accurate Calibration of CFD Models

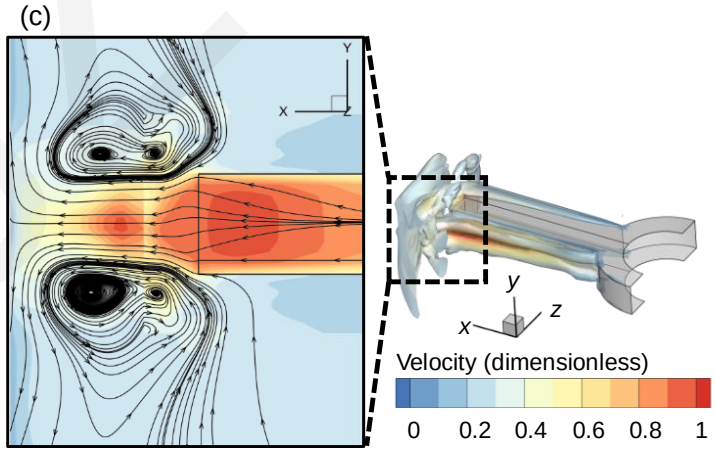
Model validation by GCI

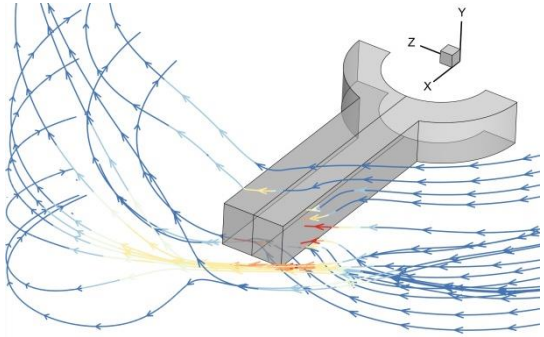








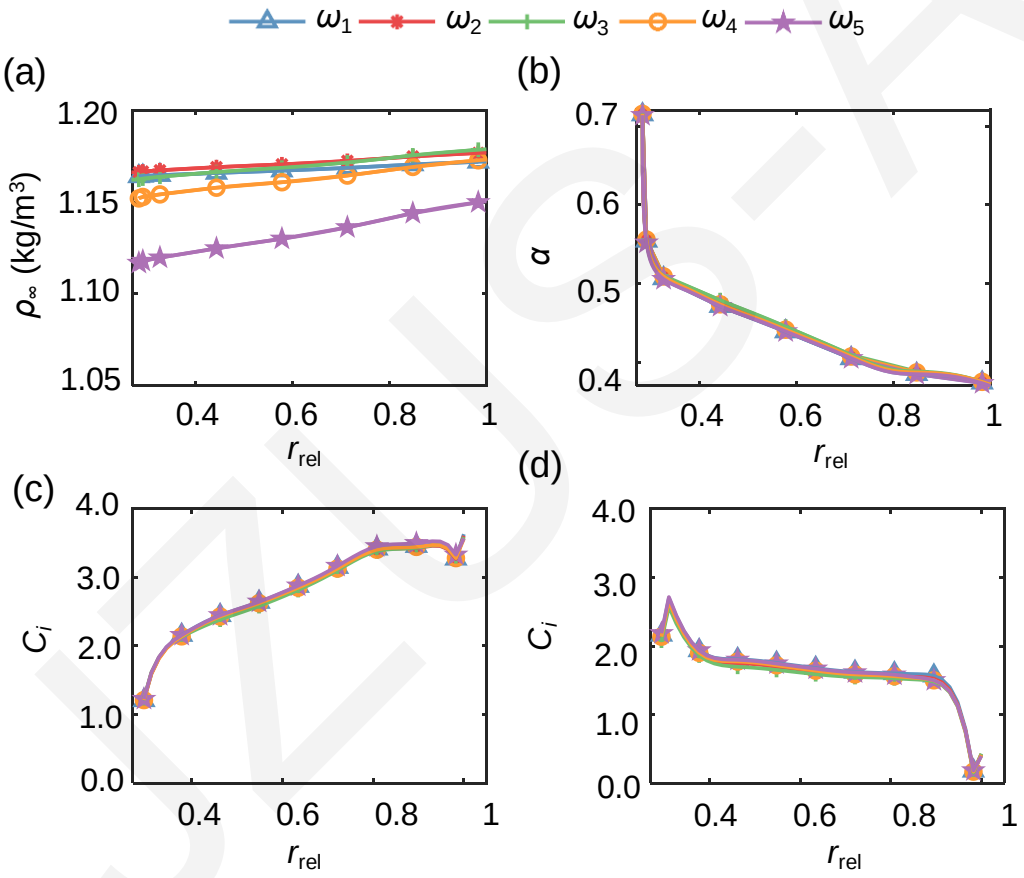




Wall shear stress
(dimensionless)
0.1 0.3 0.5 0.7 0.9 1

α & C_i Independent of Angular Velocity

Variation rules of ρ_∞ (a), α (b), and C_i (c) on the windward wall and C_i (d) on the leeward wall along with r_{rel} at different ω



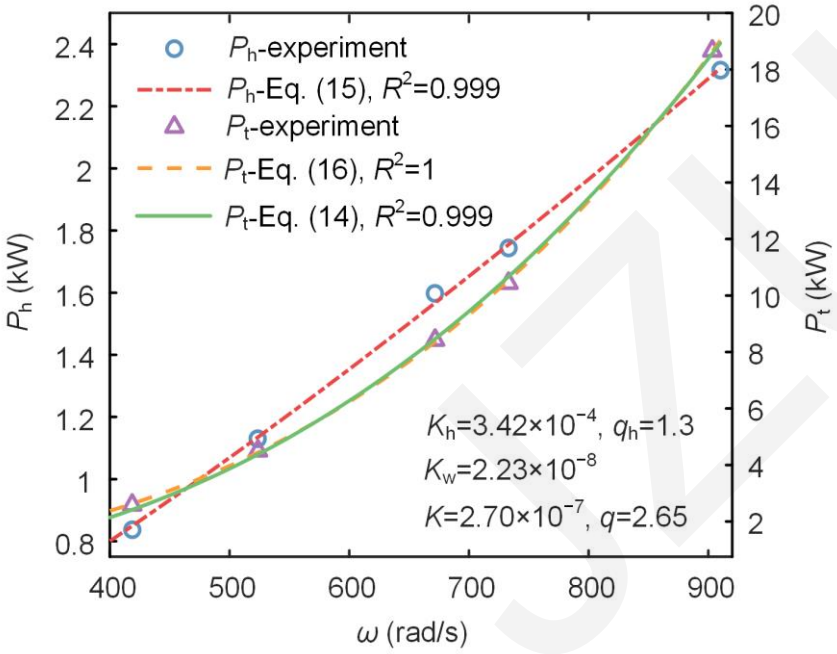
The velocity coefficient (α) and windage coefficient (C_i) are a function of the device geometry and size, and are independent of the angular velocity.

New Equation for Windage Power Calculation

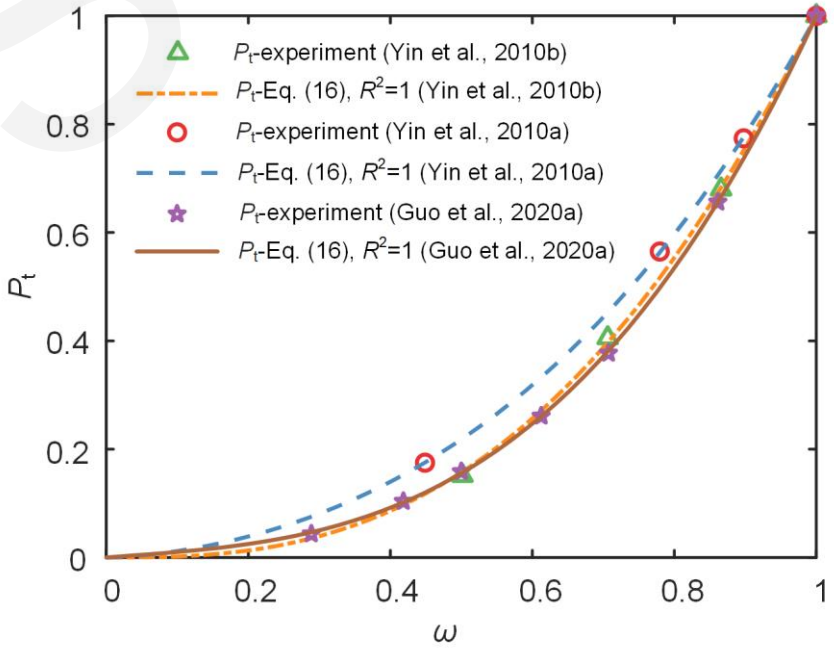
Windage power: $P_{\mathrm{w}} = \frac{1}{2}\bar{\rho}_{\infty} b r_{\mathrm{a}}^{4} \omega^{3} \Phi \qquad \Phi = \int \varphi \mathrm{d}r_{\mathrm{rel}} \qquad \varphi = C_i\left(r_{\mathrm{rel}}\right)\left[\alpha\left(r_{\mathrm{rel}}\right)\right]^{2} r_{\mathrm{rel}}^{3}$

Total power: $P_{\mathrm{t}} = P_{\mathrm{w}} + P_{\mathrm{h}} = K_{\mathrm{w}}\omega^{3} + K_{\mathrm{h}}\omega^{q_{\mathrm{h}}}$

The idle power P_h and the total power curve.



Total power data from the literature fitted via new equation.



The new equation exhibits well adaptability and accuracy.

Conclusions

1. **Indirect measurement errors significantly impact windage power assessment.**
2. **The velocity and windage coefficients depend on device geometry rather than angular velocity, simplifying tests and designs by allowing angular velocity to be disregarded.**
3. **Windage power is directly proportional to the cube of angular velocity when idle power effects are eliminated.**