# Drag Force On Janus Sphere: Effect Of Particle Position

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Area of Research → Fluid Mechanics

Specific Area of Research → Drag Force on Janus Sphere

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# Content

# Objectives

Investigate the drag experienced by a Janus sphere placed at different off-center positions in a square channel.

Computer stimulation to quantify the drag force experienced .

Understand the hydrodynamics around Janus spheres and compare it with homogeneous sticky or slippery spheres .

# Introduction

- Presence of a sphere and its effect on the velocity and flow in the channel.
- Investigates the pressure distribution, drag reduction, and the influence of different parameters on the flow characteristics.
- Motion affected by the particle to channel size ratio, position of sphere, hydrophobicity of its surface and Reynolds number.
- Correlation between the particle Reynolds number and the particle position and the drag coefficient .

# Methodology

1. CFD stimulation are performed
2. Drag Force at different off-Centered position are calculated
3. Governing Equation ,Boundary condition and Numerical Schemes are analysed.
4. Pressure ,Velocity ,Drag and Lift Coefficient of Janus particle are analysed

# Targeted Novelty

- Previous research explored particles behavior at low to medium Reynolds Number
- Other research observed movements near surface at various flow condition.
- Focus on Drag Force on Off-Centered Janus particle

# Subjective Novelty

- Drag Force in low to medium Reynolds number on Janus Particle
- Effect of free-slip and no-slip boundary condition on the slippery and sticky surface of the particle

## Parameters

- Particle Reynolds Number
- Particle to Channel size ratio
- Density
- Dynamic Viscosity

## Dependent Variable

- Drag Coefficient
- Lift Coefficient
- Ratio of Drag to Lift

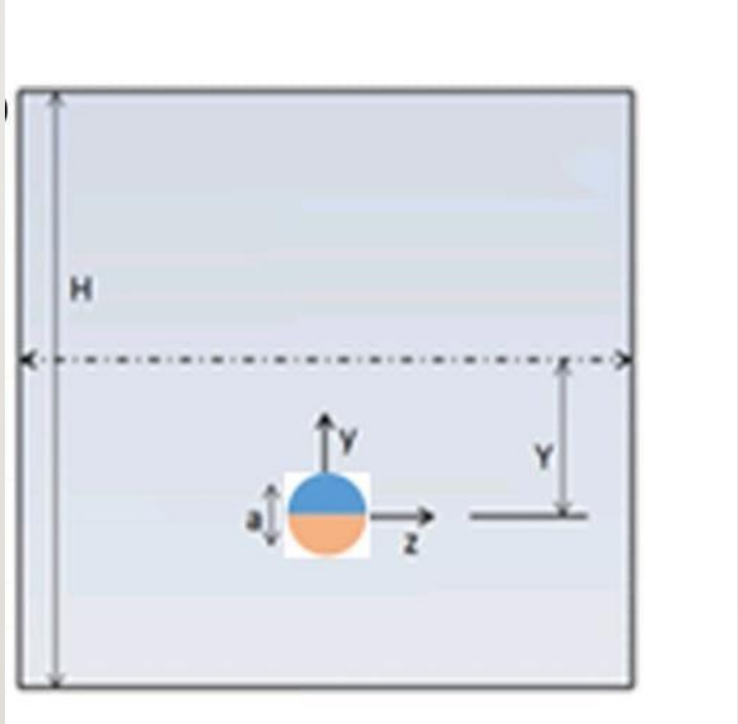
## Independent Variable

- Position of Janus Particle
- Particle Reynolds Number

# RESULTS AND DISCUSSION

- ❖Computational fluid dynamics (CFD) simulations conducted to calculate Drag force.
- ❖Two orientation possible :-

1. Free-slip hemisphere faces the channel centerline and case
2: No-slip hemisphere faces the channel centerline



# Pressure and Velocity Field

➢ POSITION OF PARTICLE INFLUENCES SURROUNDINGS FLOW FIELD

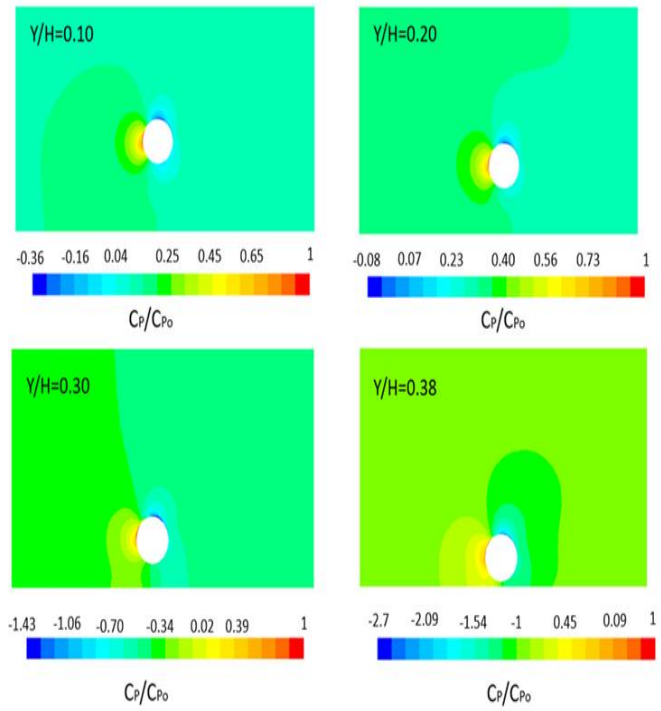



Fig. 3 Nondimensional pressure distribution $\left(\frac{C_p}{C_{p0}} = \frac{P-P_{exit}}{P_s-P_{exit}}\right)$ on the xy plane for $Y/H = 0.10, 0.20, 0.30$ and $0.38$ at $Re_p = 10$ for case 1

## Case 1

- Minimal Impact on velocity beyond Midplane
- Free slip hemisphere allows flow passage

## Case 2

- Flow separation on no-slip hemisphere ,formation of Vortex at ReP=50
- Closer to channel centerline Vortex magnitude and Size are Higher

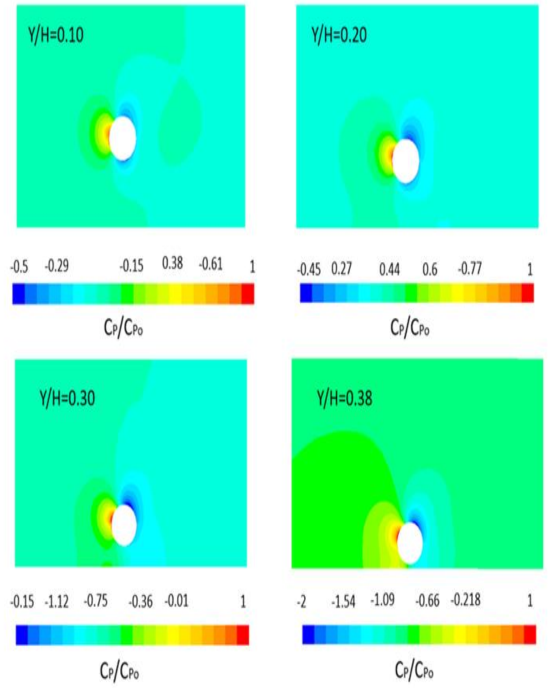



Fig. 4 Nondimensional pressure distribution $\left(\frac{C_p}{C_{p0}} = \frac{P-P_{exit}}{P_s-P_{exit}}\right)$ on the xy plane for $Y/H = 0.10, 0.20, 0.30$ and $0.38$ at $Re_p = 10$ for case 2

# Drag Coefficient

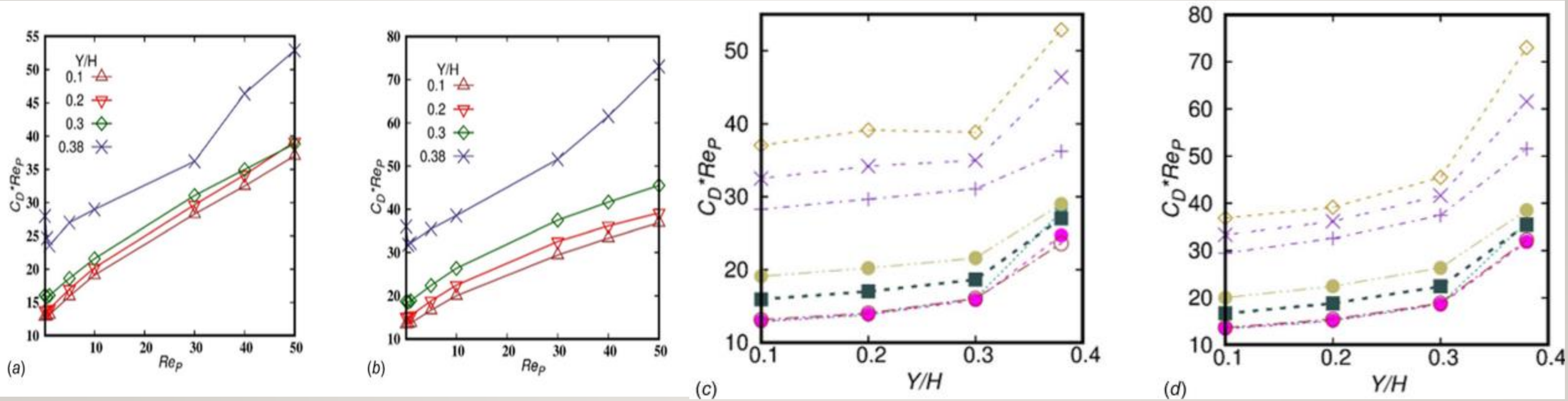
## Case 1

- Drag Coefficient Decreases as Reynolds Number Increases
- CD appears larger at position closer to Ceterline
- Viscous Drag decreases as particle move from centerline to wall

## Case 2

- CD is higher than case 1 at high Reynolds No.
- Higher Viscous Drag than case 1 at same Y/H and Reynolds No.
- Force acts along Tangential and Normal to surface due to Viscous and Pressure Drag

# Local Drag Coefficient Variation




Case 1

Case 2

Case 1

Case 2

Reynolds Number

Janus Position

# Drag Coefficient and Lift Coefficient

## Case 1

- Exhibit nonzero lift force directed toward centerline
- All CD/CL are positive indicating lift force always towards Centerline
- At higher Reynolds No. Lifts force comparable to Drag force in magnitude

## Case 2

- Direction of Lift force is not fixed , varies with position in channel.
- Change in sign of CD/CL indicates direction of Lift force changes
- CD decreases monotonically with Y/H

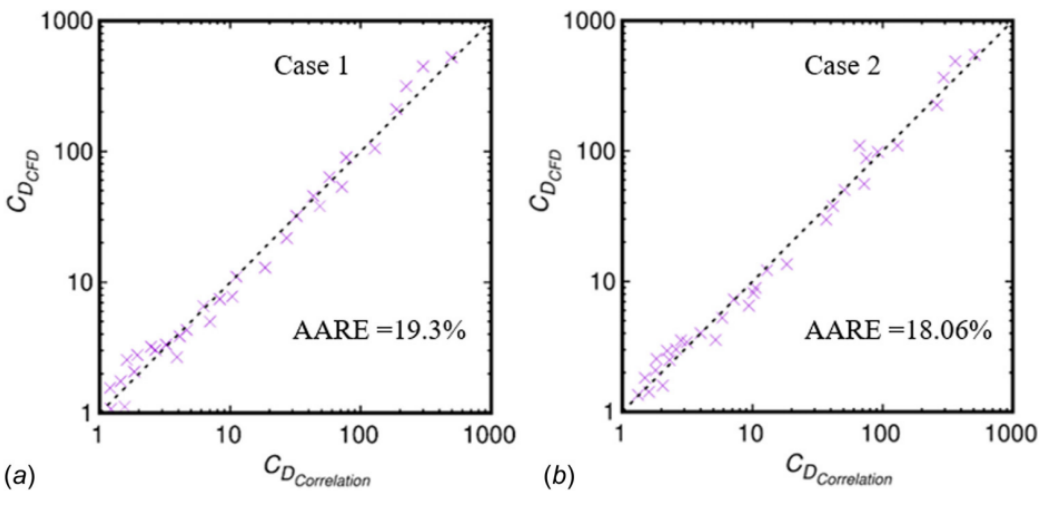
# DRAG COEFFICIENT CORRELATION

## Case 1

- Correlation Equation : CD= 13.4 *(Y/H)^0.73 *Re^0.84
- AARE = 19.3%

## Case 2

- Correlation Equation CD= 22.69 * (Y/H) ^0.50 * Re ^0.85
- AARE : 18.06 %



# CONCLUSION

- Janus sphere placed between channel centerline and wall at Two different orientation
- Drag Coefficient ,Viscous and pressure decreases when position is changed to wall
- Local drag Coefficient independent of Y/H but increases near wall.
- Lift coefficient is negligible at low Reynolds No. compared to high Reynolds No.

# Literature References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# THANK YOU