2D analysis of a rotating cylinder in fluid flow using the turbomachinery module of *Code_Saturne*

*S. Allsop (IDCORE); C. Peyrard (EDF LNHE R&D); P. R. Thies (University of Exeter)

*steven-externe.allsop@edf.fr

Introduction

A new rotating mesh routine within the 'turbomachinery' module of *Code_Saturne* uses a geometry updating and mesh rejoining process at each timestep.

This poster presents a characterisation study of the routine using a 2D analysis of a rotating cylinder in fluid flow. Laminar and turbulent flow regiemes are applied, with forces and surface pressure distributions analysed.

Validations are carried out using experimental data and previous CFD studies.

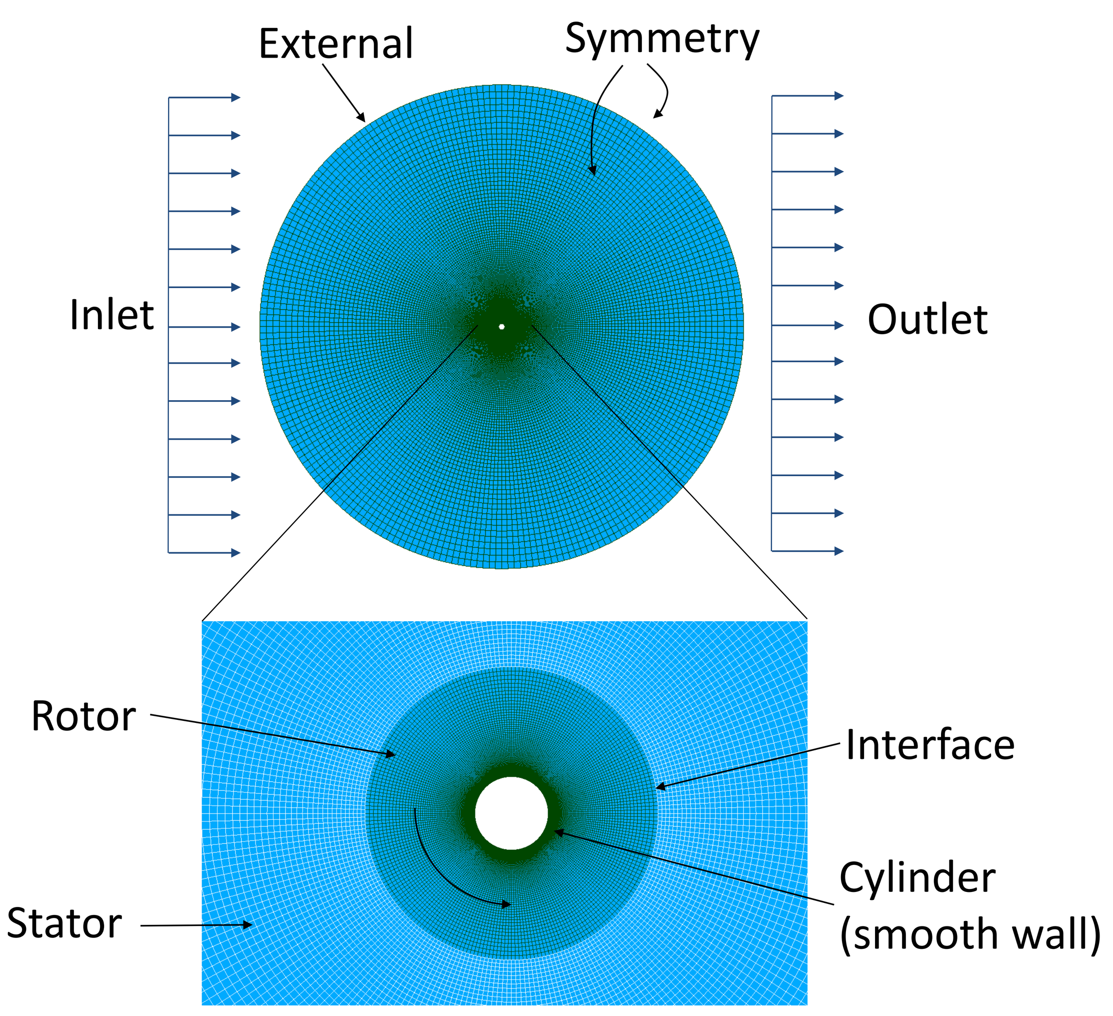
Model Setup

Geometry of the model consists of the following:

R_c = cylinder radius = 0.025m

R_i = interface radius = $4R_c$

R_{ext} = external radius = $80R_c$



Reynolds number	2.0E+02	6.0E+04	1.5E+05	-
Elements (Total)	145,000	177,000	190,000	-
Thickness of B.L.	1.2E-03	1.5E-05	7.5E-06	m
Timestep	3.5E-02	1.0E-04	5.0E-05	s
Y+	0.97	1.02	0.95	-
Courant no.	0.37	0.76	1.04	-

Methodology

Vortex shedding causes fluctuations in forces experienced by the cylinder.

The magnitude and frequency of these fluctuations are analysed and tanslated into non-dimensional lift, drag and pressure variations.

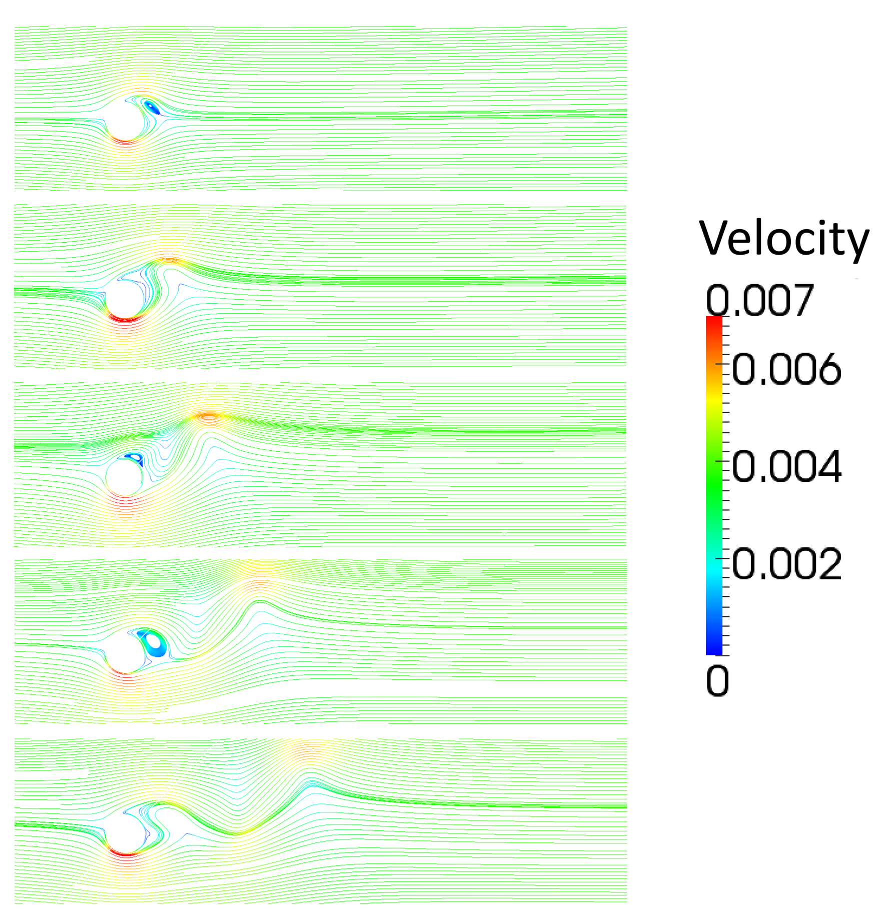


Figure 1: Velocity streamlines under laminar flow at α=1

Results: Laminar Flow

Reynolds number = 200

Lift coefficients show excellent agreement with experimental data. Best results for observed using a 2nd order Euler time scheme.

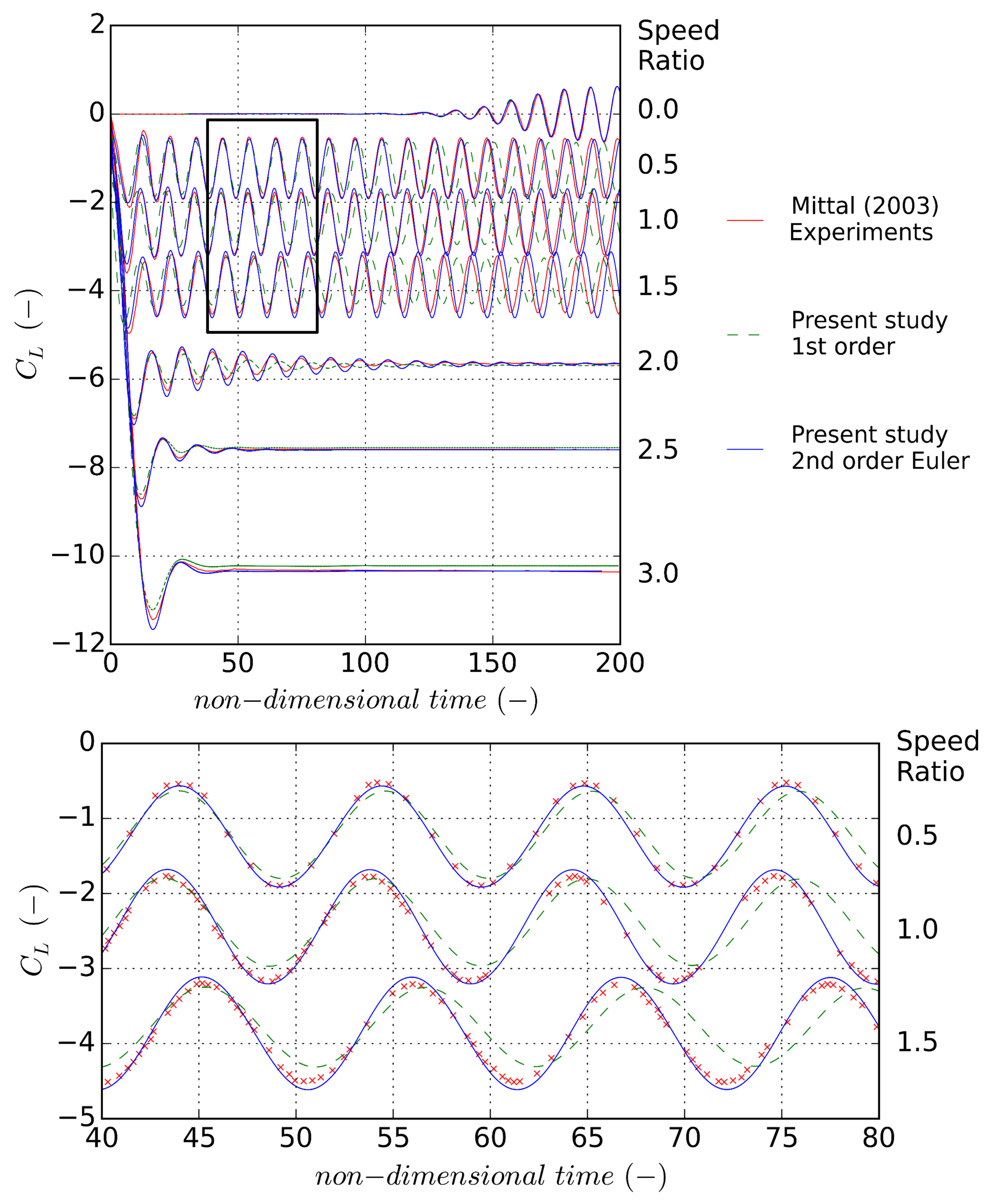


Figure 2: Lift coefficient variation with time at different speed ratios and comparison against experiments (zoom in bottom)

Results: Turbulent Flow

Reynolds number = 6.0E+04

Lift and drag show reasonable agreement with experimental and previous CFD studies.

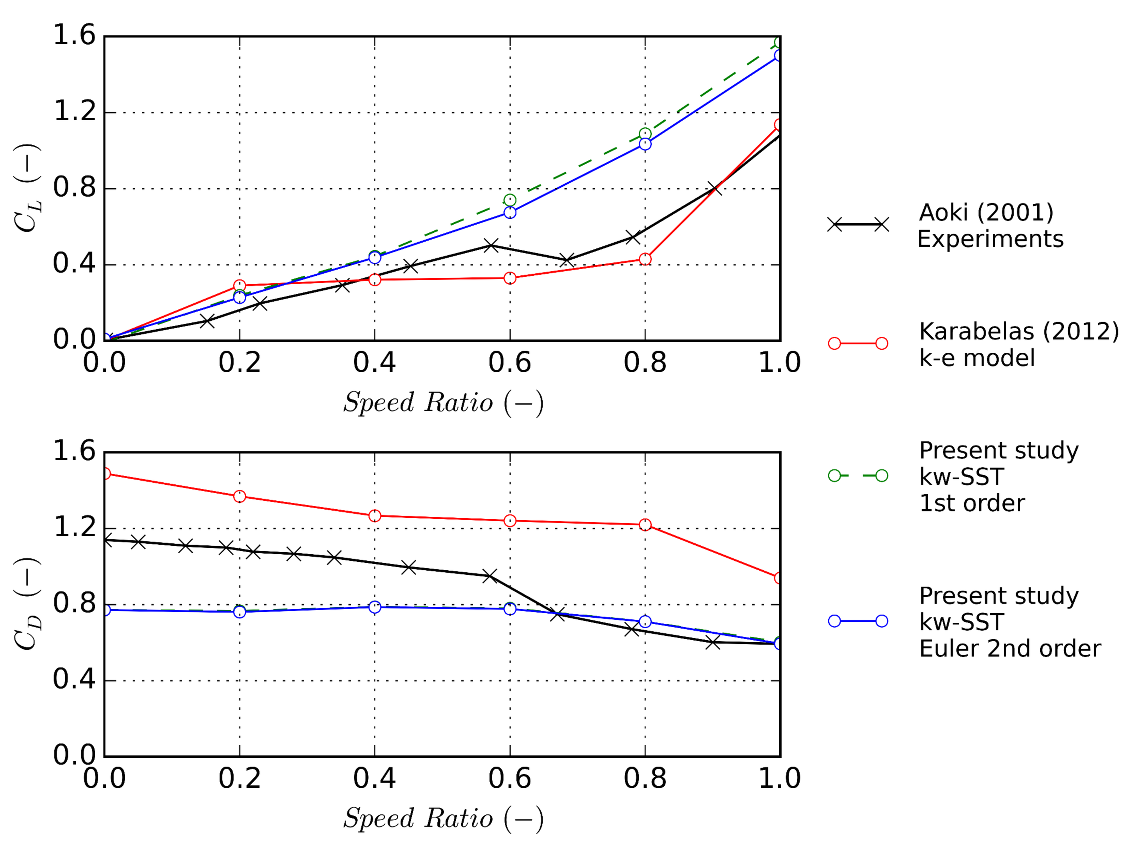


Figure 3: Lift (top) and drag (bottom) coefficients with speed ratio comparing with a previous CFD study and experiments

Lift over predictions up to 80% for α > 0.6

Drag under predictions up to 30 % for α < 0.4

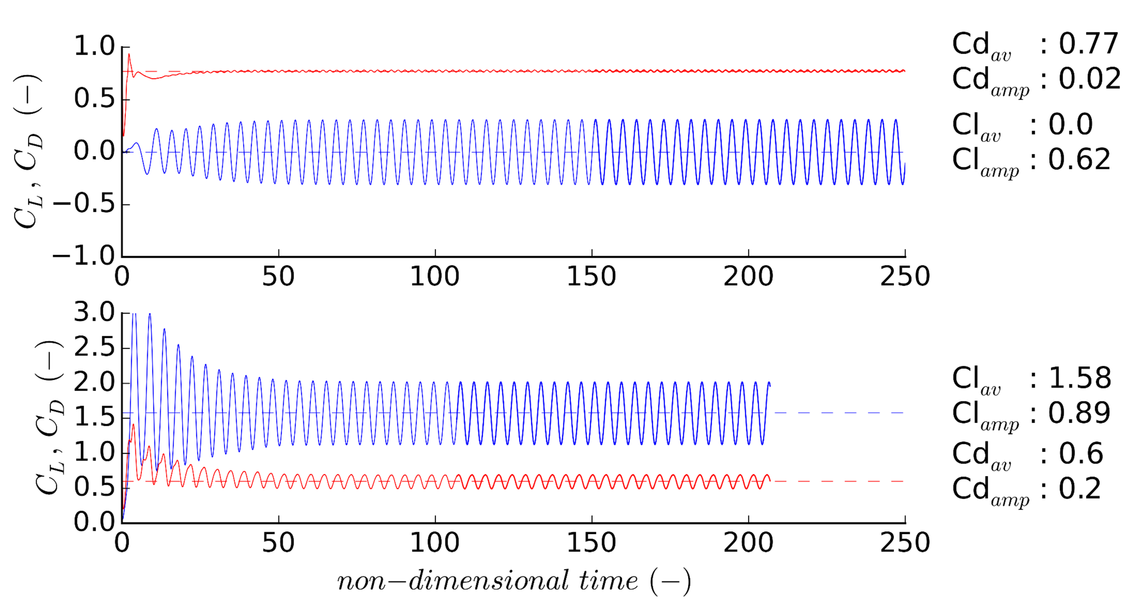


Figure 4: Time variation of lift and drag, with average and amplitude values for α = 0 (top) and α = 1 (bottom)

Discussion

Investigation shows in no rotation case, pressure is less negative behind the cylinder by upto 50% compared with experimental data.

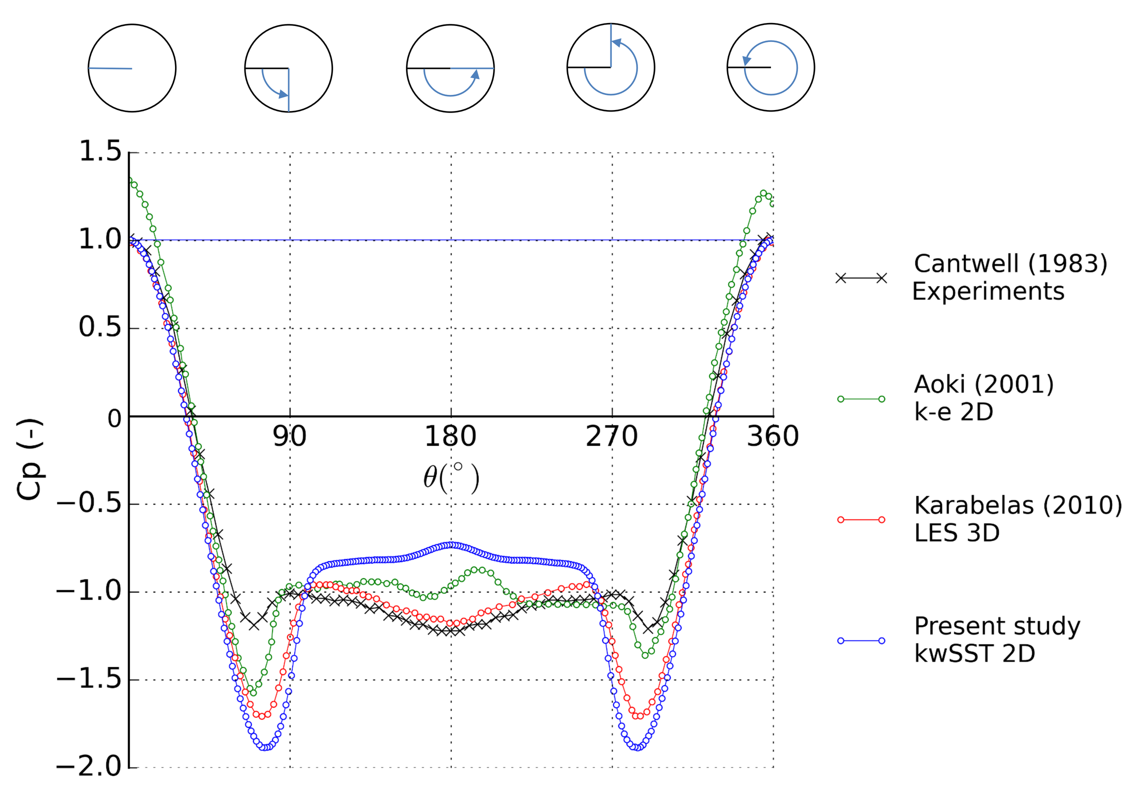


Figure 5: Surface distribution of pressure (East = 0°, South = 90°) comparison with experiments, 2D and 3D CFD studies with no rotation, Reynolds number = 1.4E+05

Conclusions

This characterisation study of the rotating mesh routine concludes:

- Laminar flow – excellent agreement with experimental data and previous studies, particularly with a 2nd order Euler timescheme.
- Turbulent flow – underpredictions in the drag coefficients is found in the model at low speed ratios. Surface pressure distribution shows less negative values behind the cylinder.
- Studies into different turbulence model yields similar results. No rotation model requires further investigation into reasons for low drag predictions.

Acknowledgements

IDCORE is funded by the Energy Technology partnership and the RCUK Energy programme (Grant number EP/J500847/1), in collaboration with EDF R&D LNHE.

References

S. Mittal & B. Kumar (2003) « Flow past a rotating cylinder », Journal f fluid mechanics, vol.476, pp.303-334.

K. Aoki & T. Ito (2001) « Flow characteristics around a rotating cylinder », Procs to school of engineering, University of Tokyo, vol.26, pp.29-34.

S. J. Kerabelas et al. (2010) « Large Eddy Simulation of high Reynolds number flow past a rotating cylinder », International journal of heat and fluid flow, vol.31, pp.518-527.

S. J. Kerabelas et al. (2012) « High Reynolds number turbulent flow past a rotating cylinder », Journal of applied mathematical modelling, vol.36, pp.379-398.

B. Cantwell & D. Coles (1983) « An experimental study of entrailment and transport in the turbulent near wake of a circular cylinder », Journal of fluid mechanics, vol.136, pp.321-374.

Idcore Industrial Doctoral Centre for Offshore Renewable Energy · The University of Edinburgh · University of Strathclyde Glasgow · University of Exeter · EDF