# IMPROVED NUMERICAL PREDICTIONS FOR WIND TURBINE AIRFOILS

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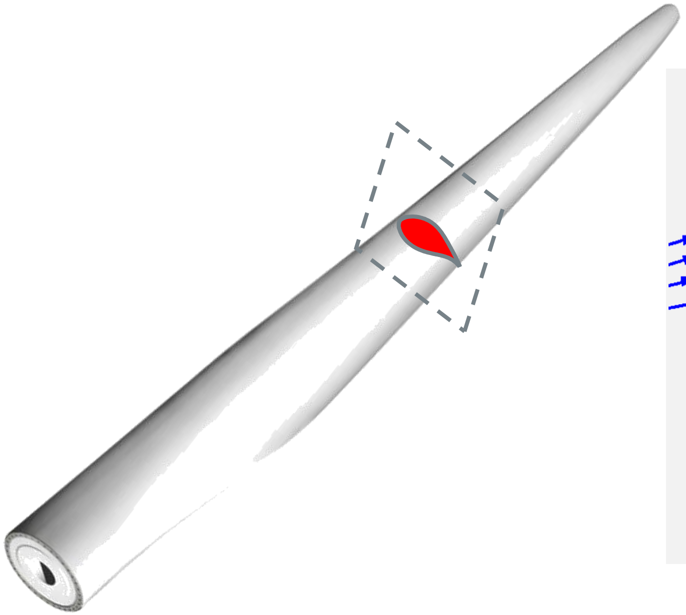
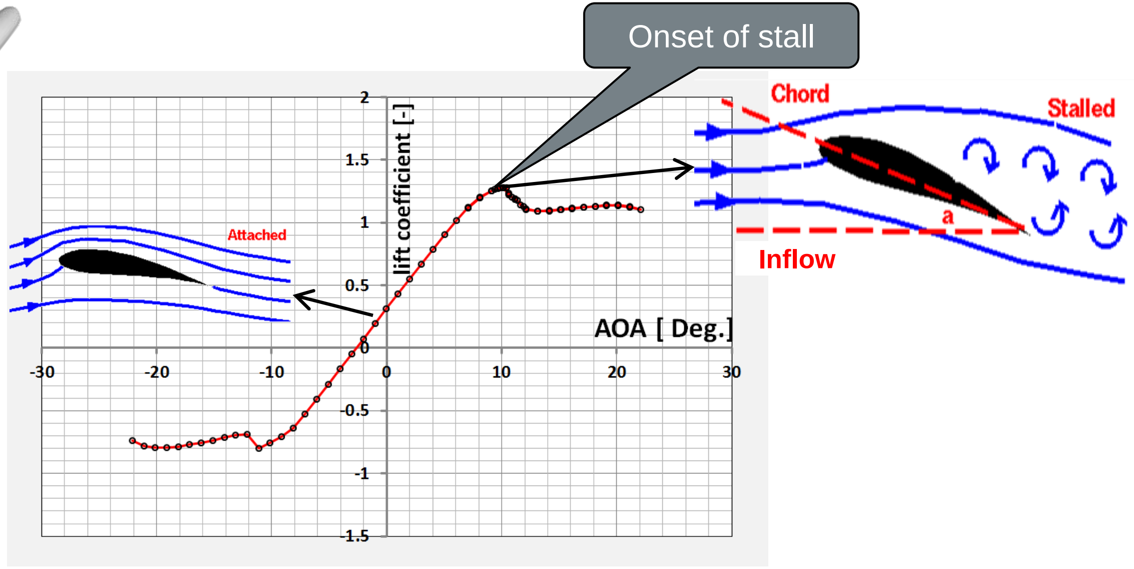
# Background

- Numerical predictions are becoming vital for wind turbine blade designs
- The key challenge will be accurately predicting the reality !!!






- RANS based CFD simulations have limitations in predicting the onset of stall when compared to the wind tunnel results

# Criticality of the lift prediction

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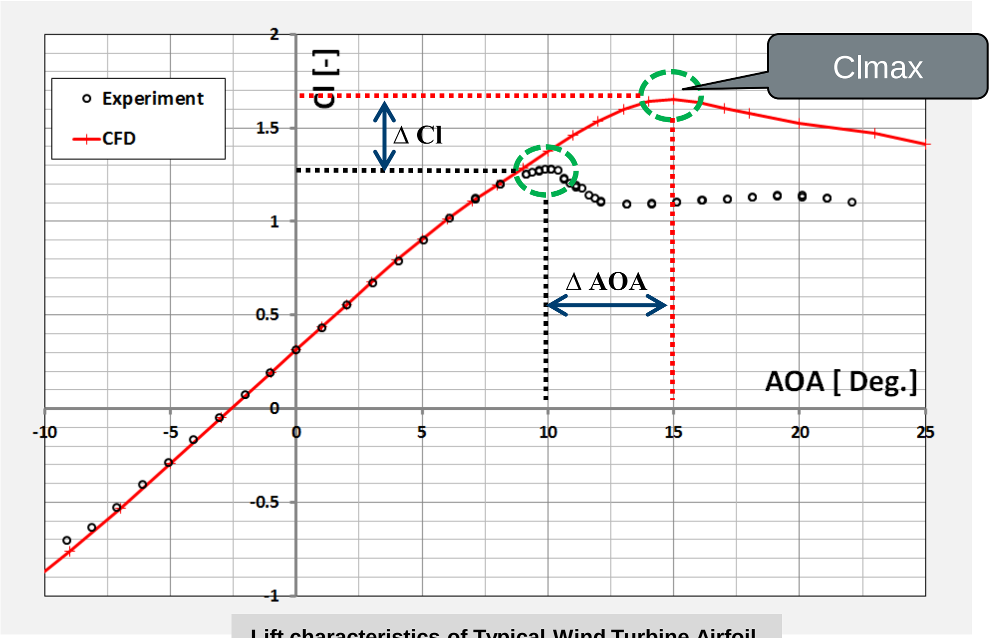
- Airfoil level : Crucial in airfoil design
- Blade level : Performance impact assessment for Add-ons, manufacturing variations, 3D shape effects(tip and root regions)  etc.
- Rotor level : Enabling towards “design to limits”

Prediction of on set of Stall → Stall margins → Loads → AEP & COE

# Numerical Predictions – Current status




Lift characteristics of Typical Wind Turbine Airfoil

- Overall the predictions are good in the linear regions
- CFD over predicts the onset of stall when compared to wind tunnel experiment
- $Cl_{max}$ and AOA for $Cl_{max}$ are over predicted by CFD
- Studies are carried out to improve the stall predictions

# Numerical Predictions – Improvements to the current model

- Solver : EllipSys2D, developed by Risoe/DTU
  - Turbulence : k-$\omega$ SST model
  - Transition : correlation based $\gamma$-Re$\theta$
- Modified the turbulence model constants in k-$\omega$ SST model
- Controlling the turbulence production terms that affects the predictions of maximum lift
- Developed a improved version called LM-modified
- Performance of the improved model is validated against the LM wind tunnel experimental results

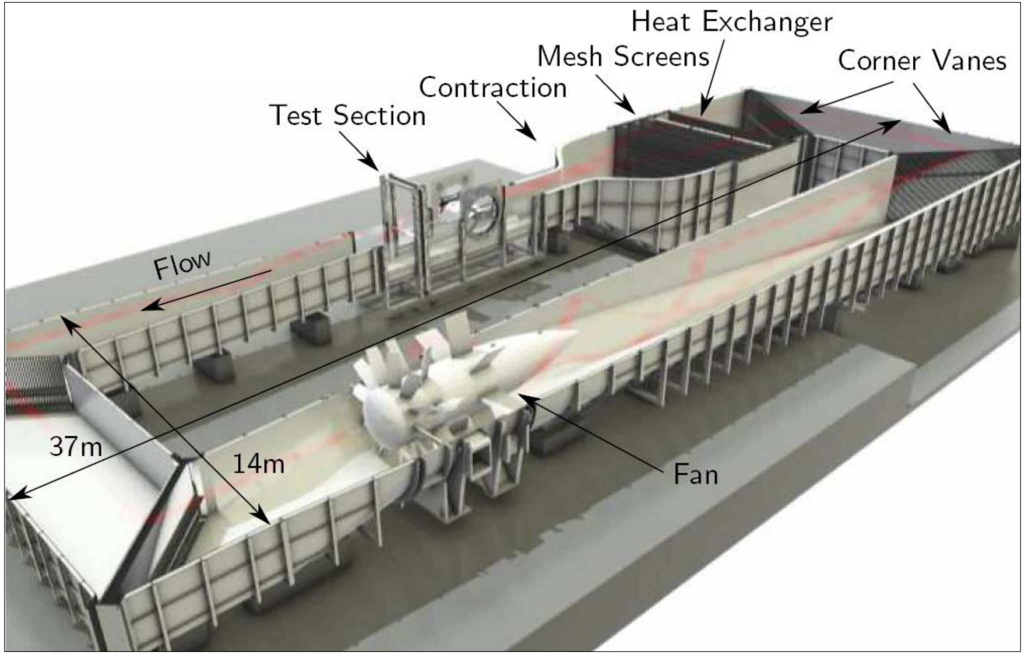
# Validation from LM Wind Tunnel

- Several airfoils tested in LM Low Speed Wind Tunnel (LM LSWT) and used for detailed Validation

- **Test section :**
  - Width : 1.35 m
  - Height : 2.70 m
  - Length : 7 m
  - Max wind speed : 105 m/s
  - Reynolds number up to 6.0e6

- **Measurement setup :**
  - Cl and Cm :
    - Airfoil Pressure
  - Cd :
    - Wake Rake and Airfoil Pressure

**Airline Layout : Top view : 37x 14 m**



# Validation for various airfoil thickness

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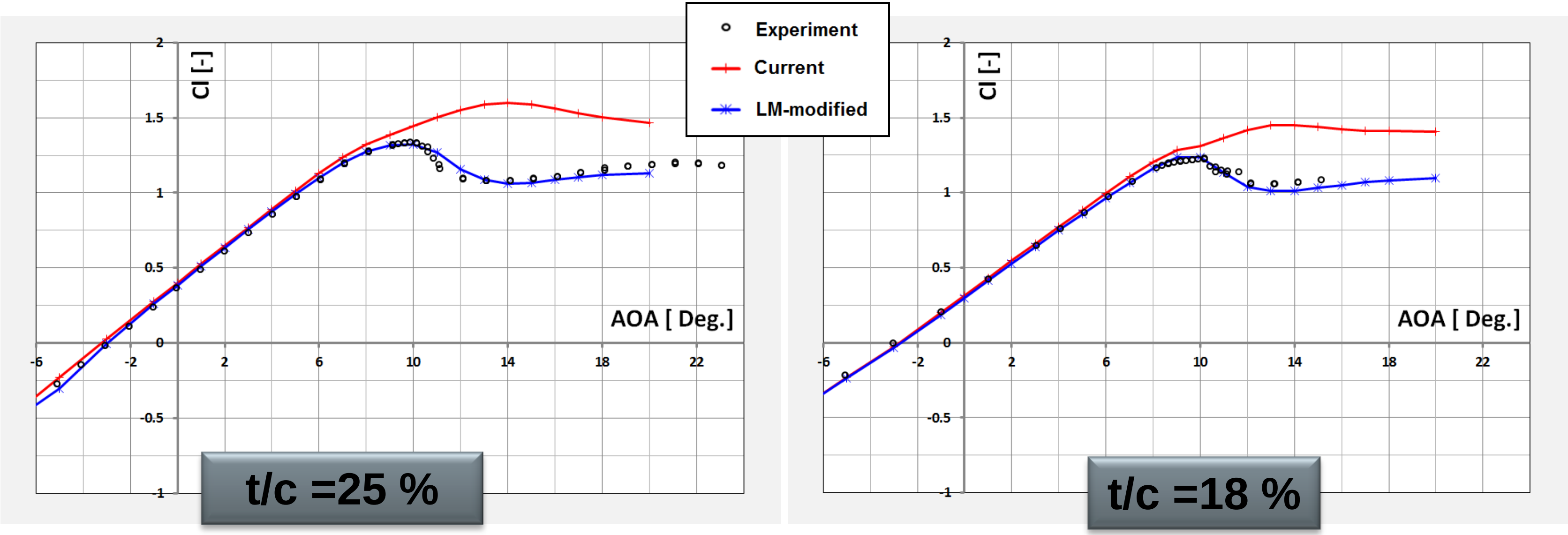


» With the modified model by LM, the stall predictions are improved

» This model works well for a wide range of airfoil thickness

» The state of art numerical models enables improved confidence level in the prediction capability with reduced uncertainty

# Outcomes

- **Best in class prediction method**
- **With the improved prediction model, for the airfoil development process**
  - The cost reduced by ~ 30%
  - Cycle time reduced by ~50%
- **Reliable airfoil designs**
- **Supporting the continuous effort towards the reduction in COE**

# Summary

- RANS based numerical modelling has limitations in predicting the onset of stall
- With the modified model by LM, the stall predictions are improved
- This model works well for a wide range of airfoil thickness
- The state of art numerical models enables improved confidence level in the prediction capability with reduced uncertainty

# Q & A

# Thank you for your time


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