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Airfoil Flow Optimized Control With an Upstream Cylinder

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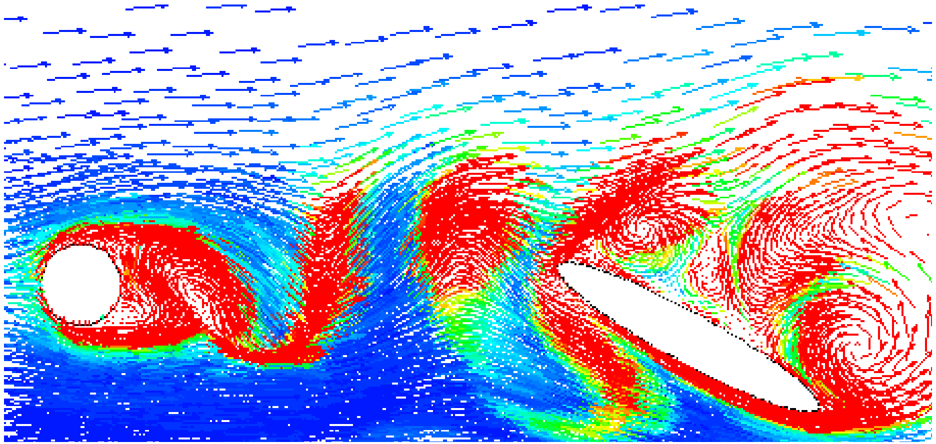
Airfoil Flow Optimized Control with an Upstream Cylinder

- An upstream object can affect the flow behavior of a downstream object
- Parameters are optimized to produce the greatest lift/drag ratio with a constrained lift coefficient
- The multi-variable optimization with constrained condition is achieved by neural network AI algorithms



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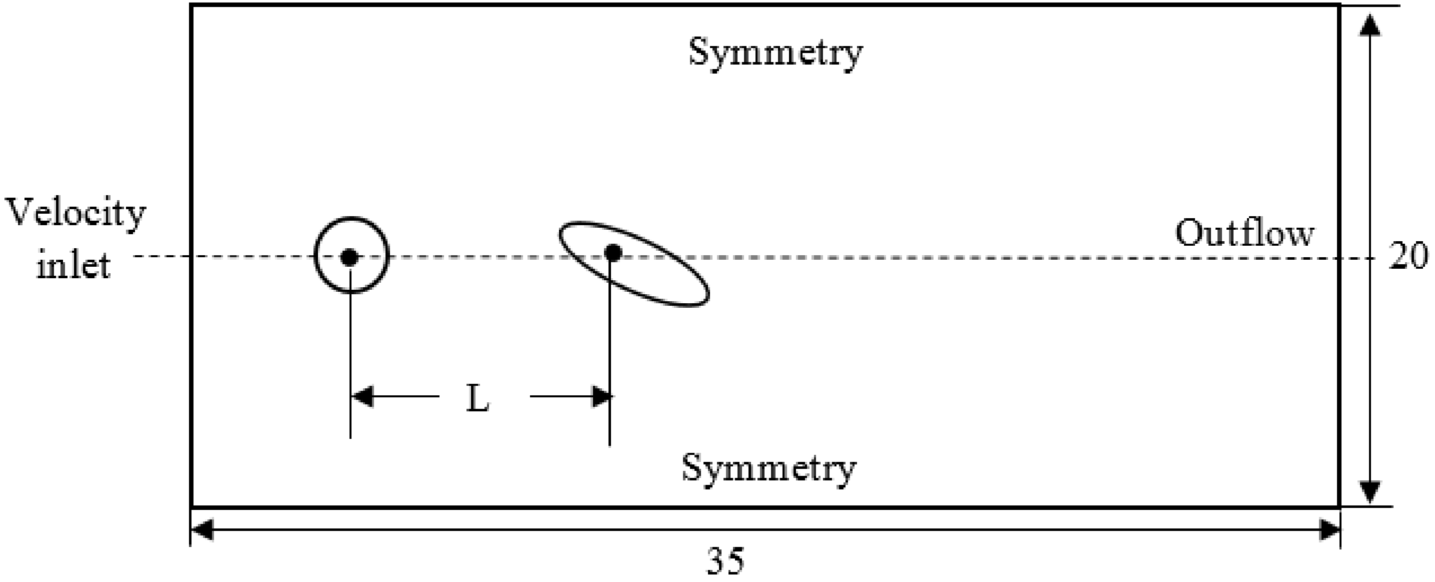


For the reference case, the configuration is the same dimensions and airfoil with no cylinder

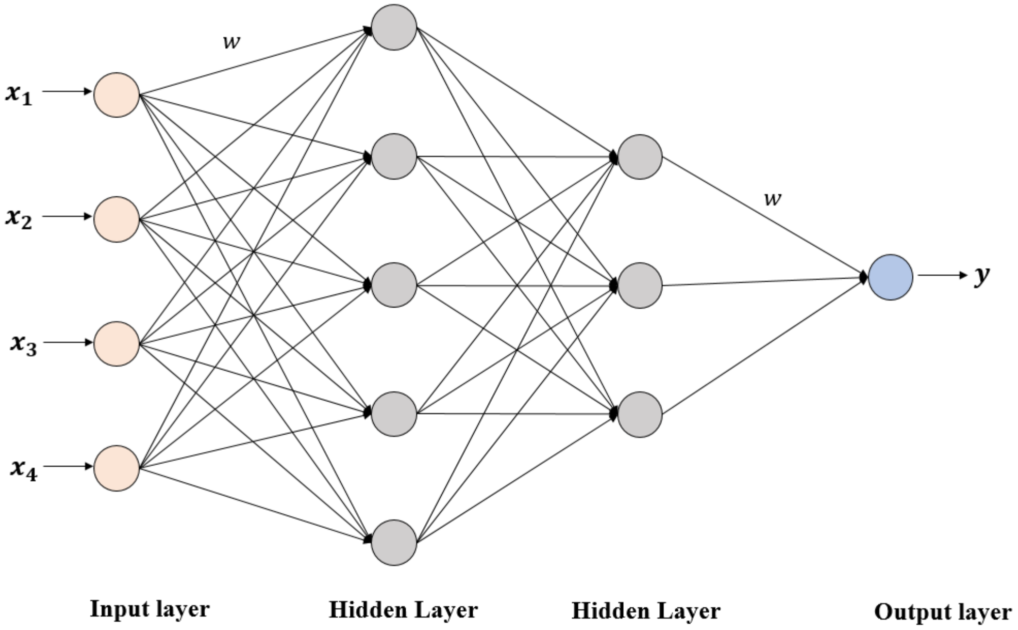
Motion of the cylinder is defined by: $y(\mathrm{t}) = A\sin(2\pi f\mathrm{t})$

Airfoil Flow Optimized Control with an Upstream Cylinder

- 60 control cases were selected using the orthogonal test method
- Control parameters:
  - Oscillating frequency (f = 0.5, 1, 2, 4, 6)
  - Oscillating amplitude (A = 0.01, 0.02, 0.03, 0.05, 0.06)
  - Cylinder diameter (d = 0.1, 0.2, 0.3, 0.4, 0.5)
  - Distance between cylinder and airfoil (L = 1.25, 1.5, 2, 3, 4)
  - Reynolds Number (Re = 100, 500, 1000, 2000)

Airfoil Flow Optimized Control with an Upstream Cylinder

- A BPNN was used in conjunction with a genetic algorithm to optimize parameters
- The GA optimized the lift/drag ratio with the condition $C_L \geq 0.4$



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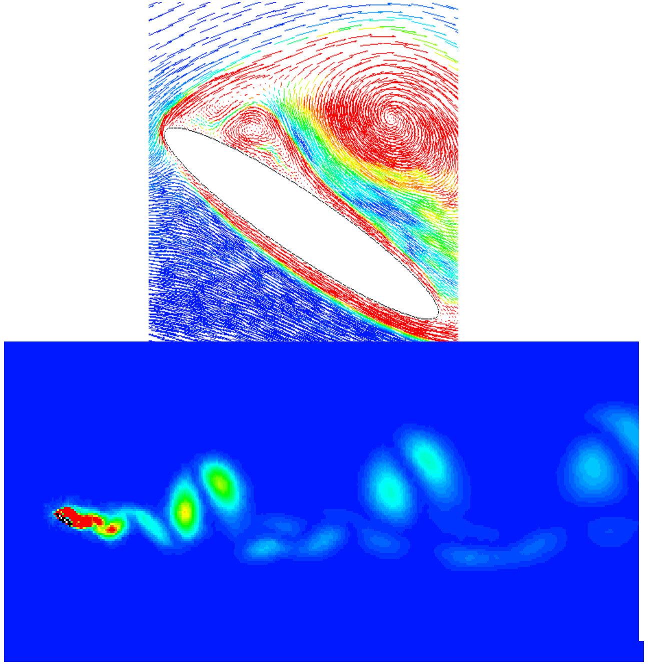
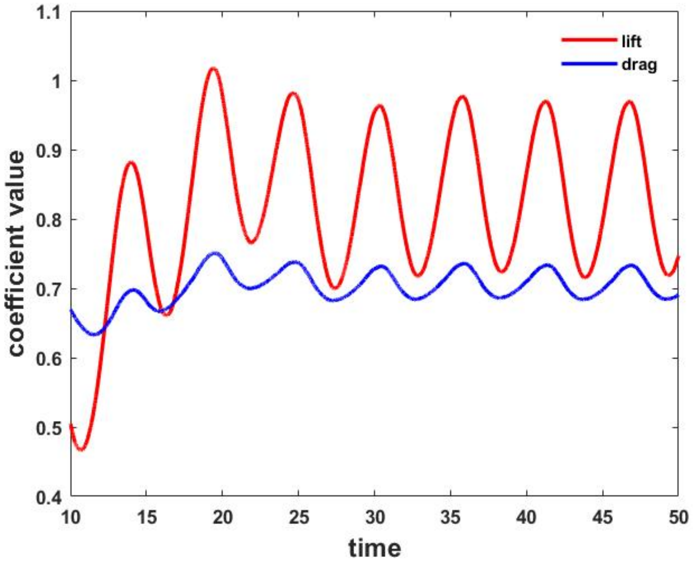
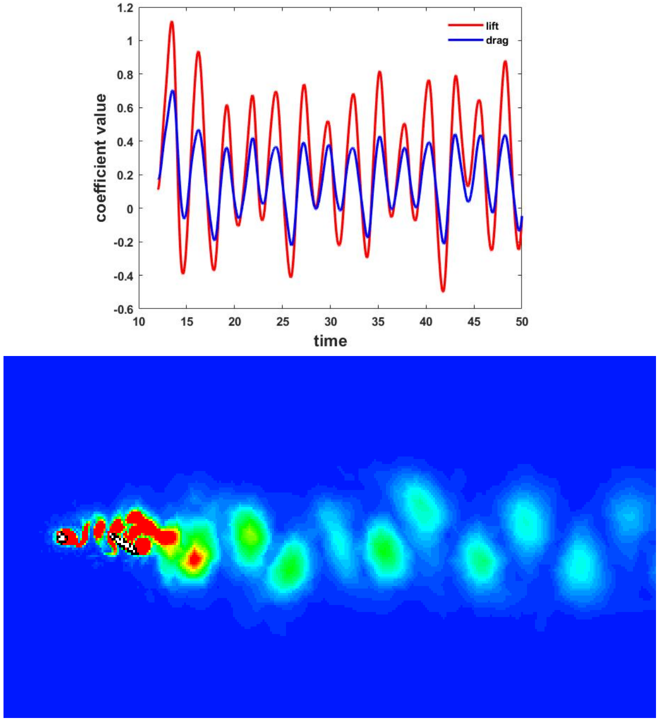


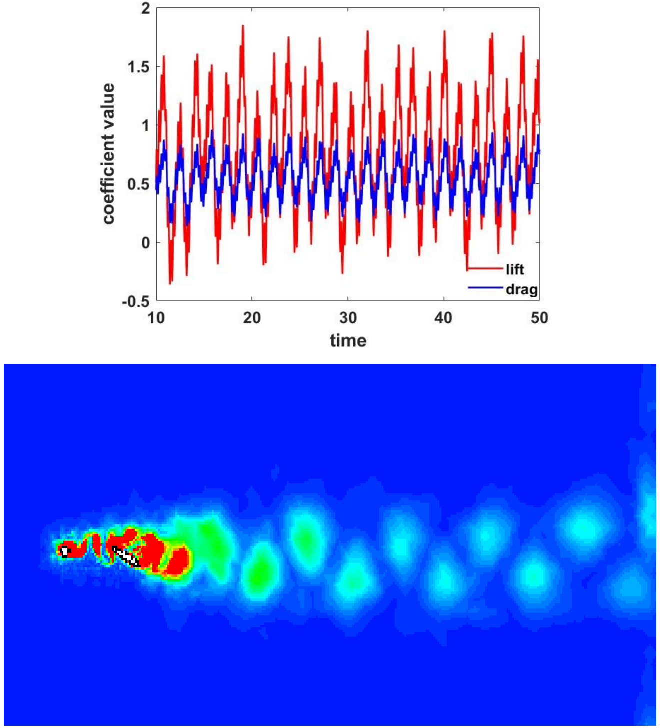


- $\frac{C_L}{C_d}$ for the reference case is 1.1779
- The average lift coefficient is 0.82969
- The average drag coefficient is 0.79436

Airfoil Flow Optimized Control with an Upstream Cylinder



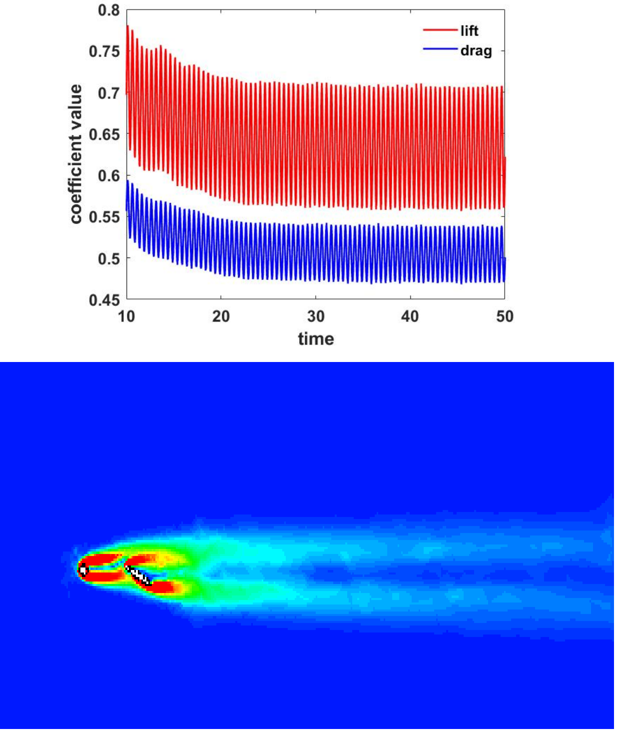
f = 0.5



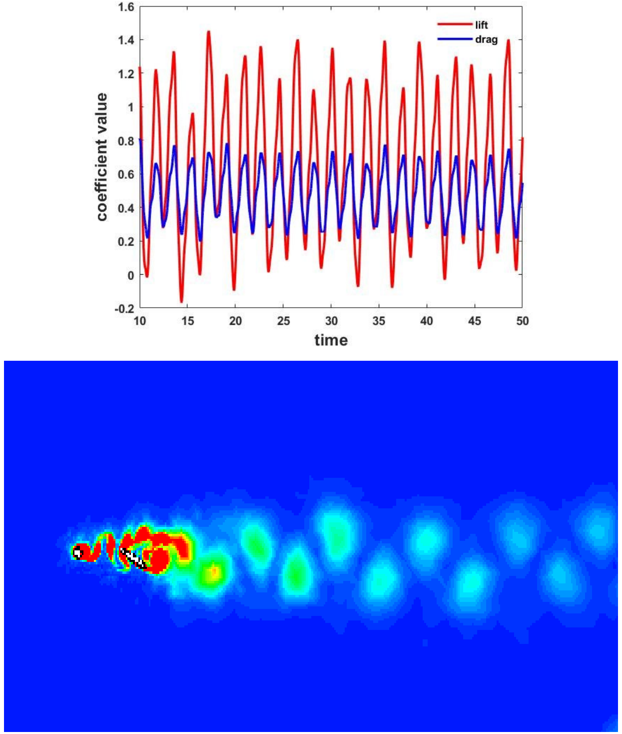
f = 4

➢ The lift/drag ratio and lift coefficient increased with higher frequency

Airfoil Flow Optimized Control with an Upstream Cylinder



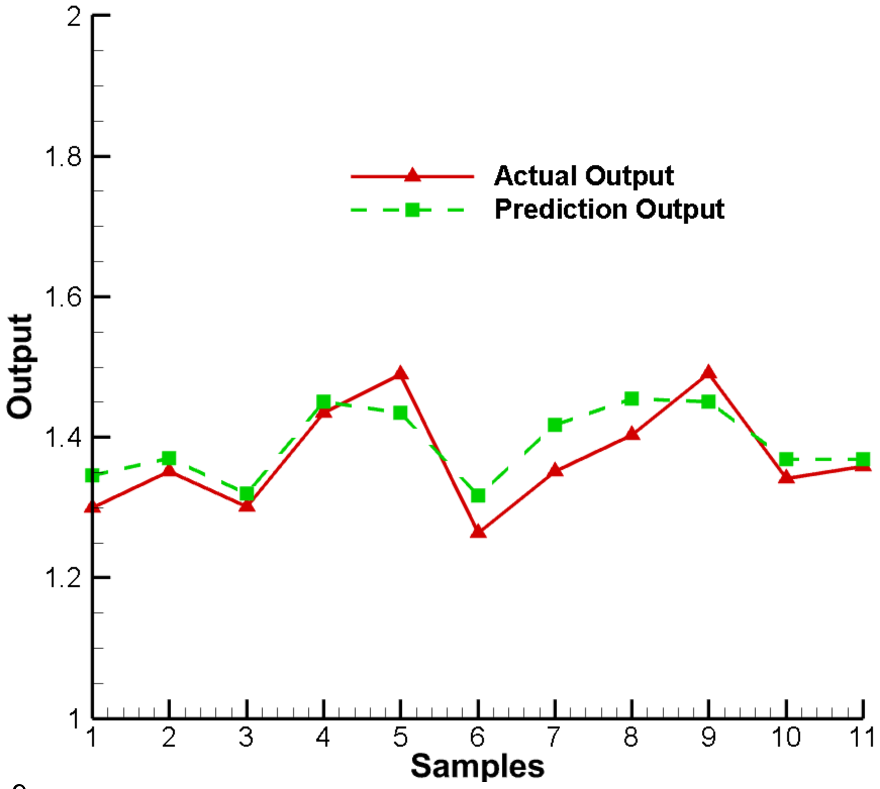
Re = 100



Re = 1000

- The lift/drag ratio and lift coefficient increased with higher Reynolds Number

Airfoil Flow Optimized Control with an Upstream Cylinder



- The BPNN predicted lift/drag ratio values within 10% of the actual values

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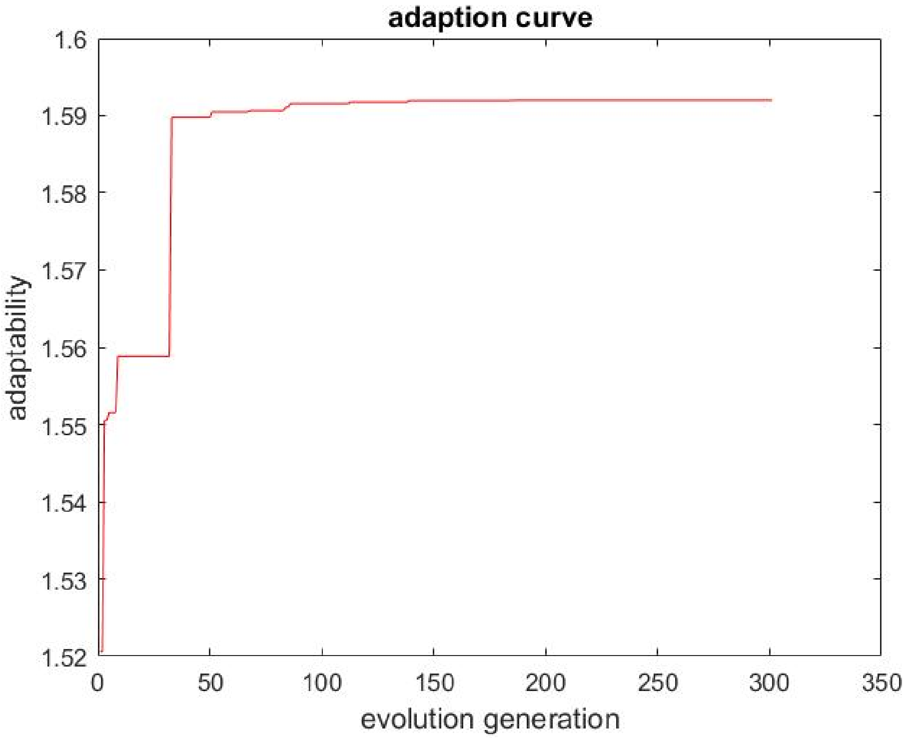

- The GA predicted the optimal lift/drag ratio for $C_L \geq 0.4$
- The optimal case had the following parameters and output:
  - f = 4.0414
  - A = 0.0522
  - d = 0.5410
  - L = 1.20033
  - C_L = 0.5968
  - $\frac{C_L}{C_d}$ = 1.5920

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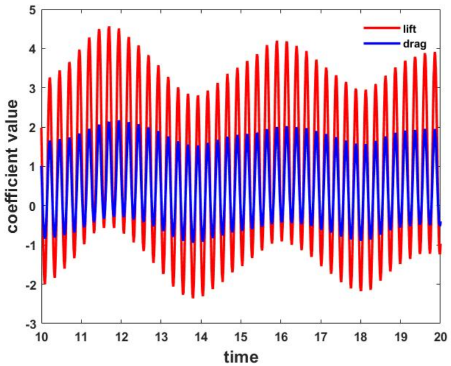

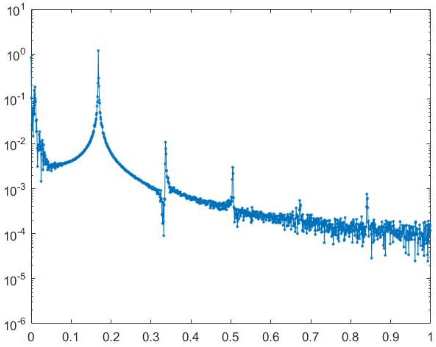

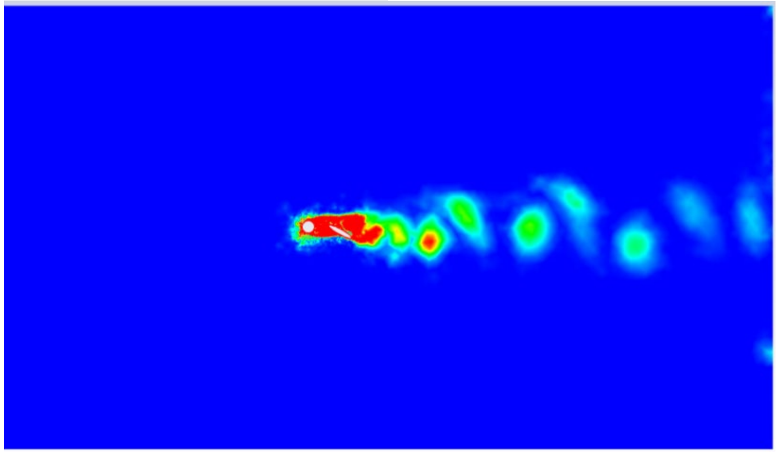

- The prediction case produced a lift/drag ratio of 1.7319 which was slightly greater than the GA prediction
- The actual lift/drag ratio of the prediction case is 50% greater than the reference case

Conclusion

- The BPNN and genetic algorithm combination was effective in predicting the optimal case for the lift/drag ratio with a lift coefficient constraint
- Reynolds number has a positive correlation with lift/drag ratio
- Higher values for frequency would likely show an increase and then decrease in the lift/drag ratio, indicating an optimal value for the frequency
- The lift/drag ratio of the optimized case is 1.5 times the reference case, a significant improvement due to flow control by adding an oscillating cylinder upstream of the airfoil.

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