An Investigation of Wing-Body Junction Flows

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Abstract

- Junction flows, are a complex, coupled, and interacting flow field broadly seen across applications.
- There is some understanding of the individual components, there is very little predictive understanding of it: the focus of this research.
- Utilized a NACA 2415 wing section in tandem with various flow visualization techniques.
- Discovered that the horseshoe vortex is invariant, while the corner separation was highly dependent on the angle of attack and placement of the wing section in the flow.
- Further research should focus on corroborating these results.

Methods

- Prepared a NACA 2415 wing section of aspect ratio 4.32 and chord 117.413 mm.
- Wing was tested in College of Engineering's Boundary Layer suction tunnel.
- Micro-tuft flow visualization was performed to select parameter space for more advanced testing, validated using *XFLR*.
- Advanced testing utilized talcum streaks flow visualization.
- Performed an angle of attack sweep at multiple tunnel stations downstream of the inlet.

Results

- Micro-tuft visualization showed a parameter space varying angle of attack, α from zero to 15 degrees [Fig. 2].
- Moderate angles of attack sometimes produced corner separation [Fig. 1].
- Extreme angles of attack created large-scale flow separation and vortices [Fig. 3].
- Horseshoe size and strength varies based on angles of attack [Figs. 1 ,4a-4b].

Talcum Streak Visualization: Suction Side

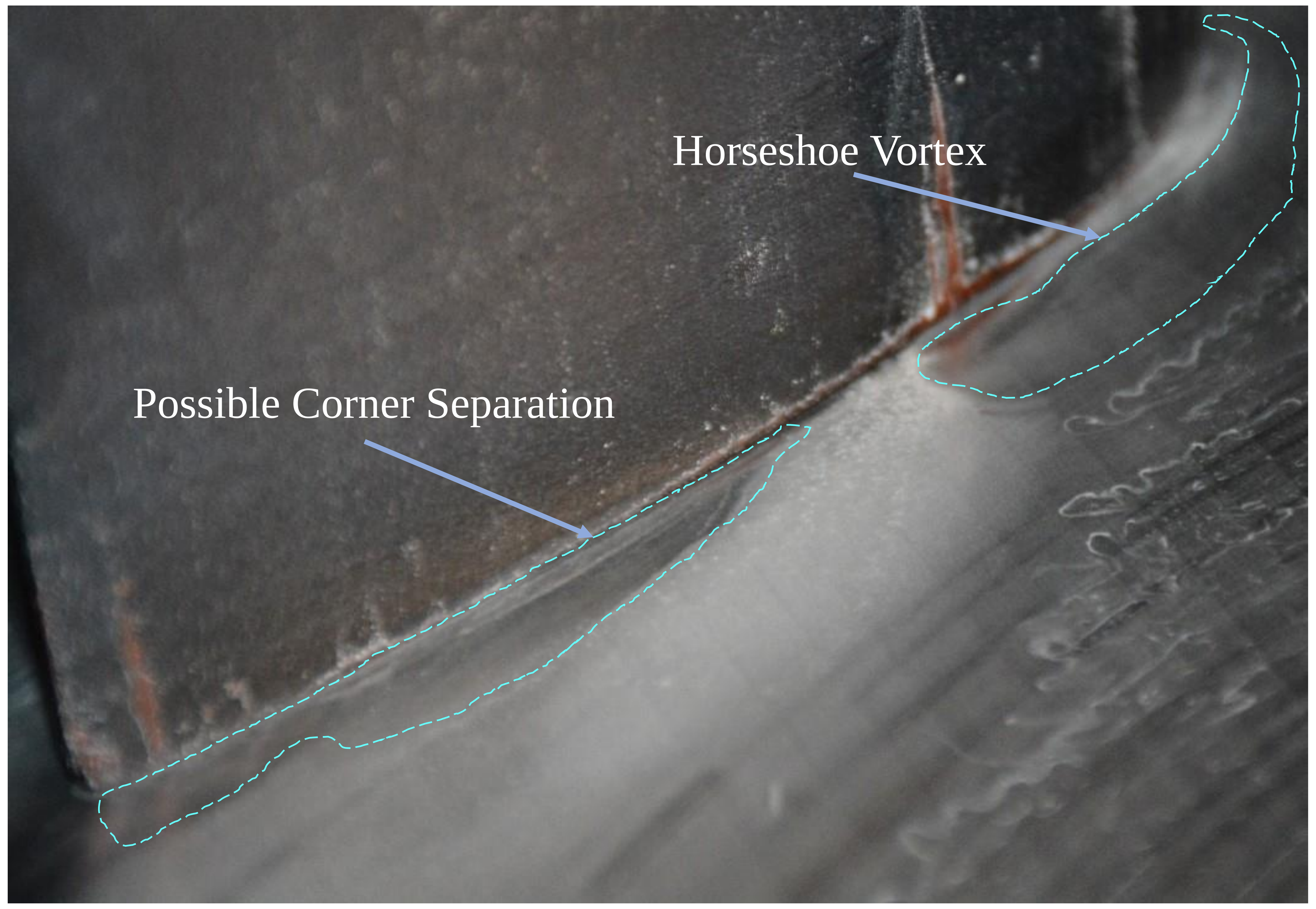

Figure 1: Horseshoe vortex and possible flow separation for case seven.

Parameter Space Selection: $\alpha = 10^{\circ}$

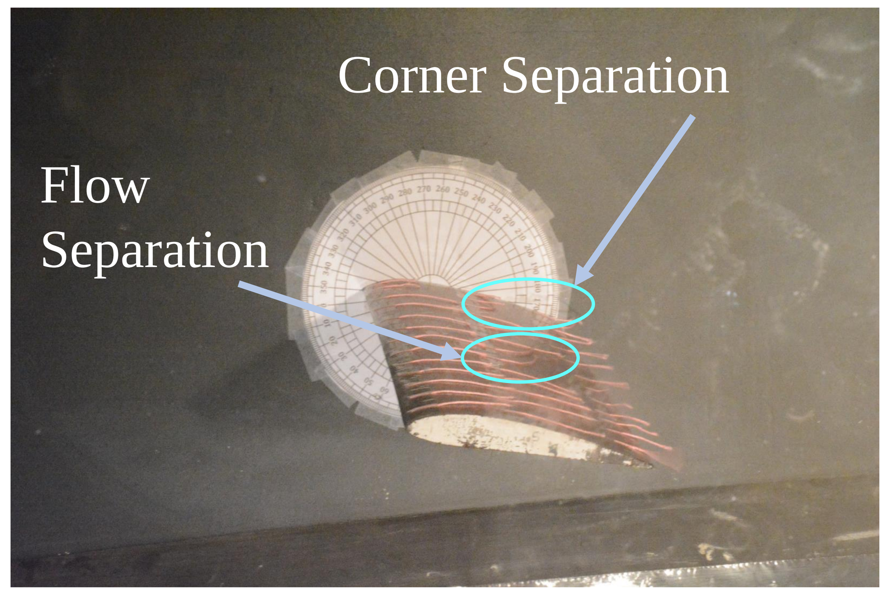

Figure 2: Multi-tuft visualization demonstrating corner separation.

Talcum Streak Visualization: Wake & Flow Separation

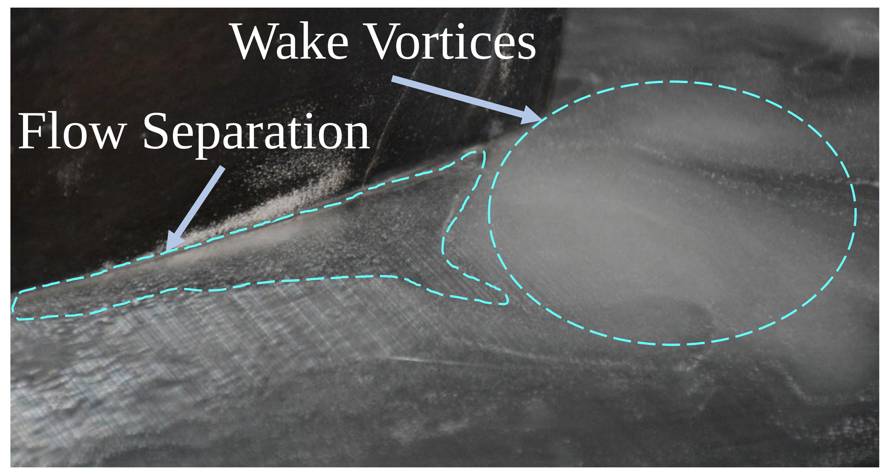

Figure 3: Trailing edge visualization for cases 14 and 15.

Talcum Streak Visualization: Leading-Edge

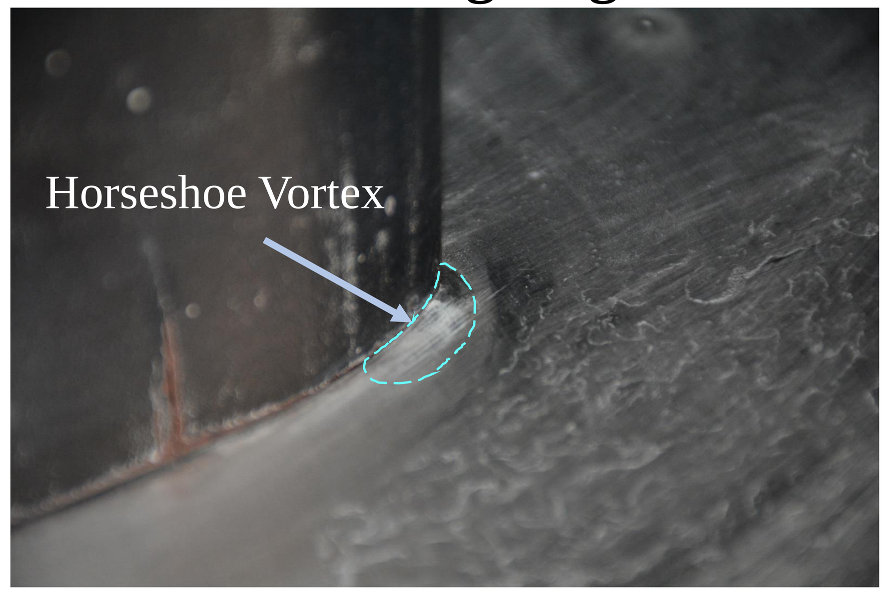

Figure 4a: Horseshoe vortex visualization from case five.

Talcum Streak Visualization: Looking Downstream

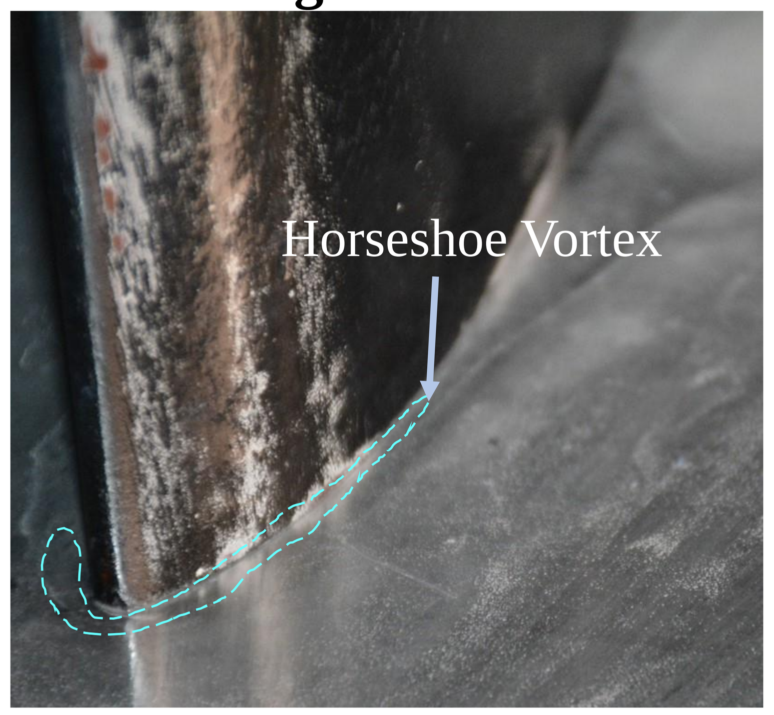

Figure 4b: Horseshoe vortex visualization for cases 14 and 15.

Results, cont.

Table 1: Wind tunnel parameters of the talcum streak oil-flow visualization experiment.

Experiment Number	Dynamic Pressure (Pa)	Tunnel Speed (m/s)	Angle of Attack (degrees)	Wing Section Location
1	Not Available	~13	-11.96	Upstream
2	Not Available	~13	-11.96	Upstream
3	Not Available	~13	-17.34	Upstream
4	93.4	12.3	31.00	Downstream
5	93.7	12.4	23.19	Downstream
6	94.4	12.4	18.32	Downstream
7	94.7	12.4	0.000	Downstream
8	95.4	12.5	0.000	Upstream
9	95.4	12.5	6.927	Upstream
10	95.4	12.5	6.927	Upstream
11	Not Available	~13	6.927	Upstream
12	95.2	12.5	11.08	Upstream
13	93.7	12.4	11.08	Upstream
14	94.4	12.4	13.93	Upstream
15	95.2	12.5	13.93	Upstream

Conclusions

- Horseshoe vortex is always present with respect to the parameter space.
- Boundary layer thickness and angle of attack are tied to corner separation onset.
- Findings limited by lack of literature data verification, will be performed in future research [1,3-5].
- Further research will study Reynolds number effects and utilize state-of-the-art full flow-field measurement techniques.

References

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