

## Application of Surface Modification for Airplanes Winglets

S. Zaharah Ibrahim<sup>1\*</sup>, M. Shahril Osman<sup>1\*</sup>, N. Miyanaga<sup>2\*</sup>, Amir Azam Khan<sup>1\*</sup> and M. Danial Ibrahim<sup>1\*</sup>

<sup>1)</sup> Department of Mechanical and Manufacturing Engineering, Faculty of Engineering, Universiti Malaysia Sarawak, 94300 Kota Samarahan, Sarawak, Malaysia

<sup>2)</sup> Department of Fundamental Science and Engineering, Faculty of Science and Engineering, Waseda University, 3-4-1 Okubo, Shinjuku-ku, Tokyo 169-8555, Japan

\*Corresponding author for [zaharah1927@gmail.com](mailto:zaharah1927@gmail.com)

### 1. Introduction

Studies on aerodynamics of airplane wings have been conducted for many years. However, most of the studies focus on the wing shapes, angle of attacks<sup>[1][2]</sup> and the differences on the winglet designs<sup>[3]</sup>. There are not many researches conducted which is related to surface modifications although it has been proven to be beneficial in many fields<sup>[4]</sup>.

Therefore, the main goal of this project is to study on the aerodynamic properties of winglets with surface modifications. The pressure, velocity and drag force acting on the models are also to be determined.

### 2. Methodology

The analyses are conducted using a CFD commercialized software, Solidworks, by designing four rectangular models representing the winglet surface with different surface structures. The surfaces are equipped with dimples, rivets, rivets with heights. A smooth surface is also included in the numerical designs as control parameters. The initial temperature and pressure being set are 293.2 [K] and 101.325 [kPa], respectively.

Table 1: Results comparison

Features	Pressure (kPa)	Velocity (km/h)	Temp (K)	Lift force (N)	Drag force (N)
Dimples	143.15 (41.28%)	882.67 (-1.93%)	293.92 (0.25%)	-2.78	11.33
Rivets with height	146.29 (44.38%)	883.311 (-1.85%)	292.66 (-0.19%)	-31.77	106.06
Rivets	144.92 (43.03%)	895.90 (-0.46%)	292.79 (-0.14%)	3.04	34.28
Smooth	144.18 (42.29%)	899.71 (-0.03%)	293.22 (0.007%)	-0.65	1.04

### 3. Results and Discussion(s)

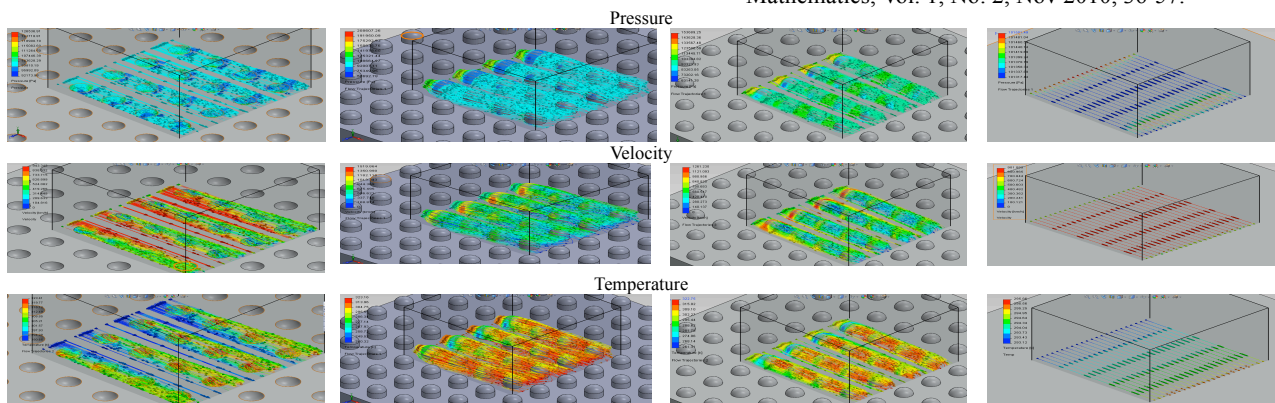
Based on Fig.1, for rivets, the air flow across the surface is constantly flowing at high velocity between 700 [km/h] up to 981 [km/h]. These rivets also generate high lift force, which is useful during cruising. According to Table 1, the lowest temperature is 292.7 [K] on rivets with height surface. This is believed to be because the rivets are like small-imitated aerodynamic wings. These wings promote fast flow thus giving better aerodynamics.

### 4. Conclusion

From the study, rivets showed a result better compared to dimples, rivets with height, and smooth surface. It has the highest lift force and high velocity across the surface. For future studies, similar modifications on winglets will be applied.

### 5. References

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(a) Dimples (b) Rivets with heights (c) Rivets (d) Plain surface  
Figure 1: Pressure distribution, velocity gradient and temperature distribution for models with modified surfaces